Environmental Impact Assessment (Draft) Vol. 1 of 6

June 2020

India: Bengaluru Metro Rail Project

Phase 2B (Airport Metro Line)
KR Puram to Kempegowda International Airport

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

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

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

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	-	milliequivalents per Litre
mg/kg	-	milligram/kilogram
ml	-	millilitre
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 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 kmph 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 of IT Industry all along outer ring road between K.R. Puram and Nagawara. The existing ring road having 6 lane main carriage way with service roads is not able to cater to the needs. 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, the construction of Airport Metro line along the ORR and airport road has been proposed, starting from KR Puram along ORR and ending at Kempegowda International Airport (KIA) via Hebbala Junction.

B. Project Description

2. The present proposal is for implementation of Phase 2B metro line on the ORR from KR Puram to Hebbal Junction and Hebbal Junction to KIA along Bellary Road for operational length of 36.44 km and line length of 38.00km up to the depot. The corridor proposed is from terminal station at KR Puram to KIA Terminals station. The other stations are Kasturi Nagar, Horamavu, HRBR Layout, Kalyan Nagar, HBR Layout, Nagawara, Veerannapalya, Kempapura, Hebbal, Kodigehalli, Jakkur Cross, Yelahanka, Bagalur Cross, Bettahalasuru, Doddajala, and Airport City.

3. The project proposals involve construction of elevated viaduct generally passing on median of the road along ORR and the space between main highway and service road along Airport road. 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. From the 2 stations inside the airport area one will be at grade (Airport City Station) and one will be below ground level (KIA Terminals).

4. Total of 17 stations are proposed along the Phase 2Bline and 7 stations out of 17 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. It is also proposed for construction of Metro Rail Depot Structures, site development works, internal roads and drainage works in the depot at Baiyappanahalli and near KIA.

6. For the convenience of implementation, the proposed Phase 2B metro project corridor has been divided into four different Contract Packages as given in Table E-1.

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

Sl. No.	Package No.	General Description	Length (M)	Number of Metro Stations
1	P1	Construction of elevated structure (Viaduct & Stations) from KR Puram to Kempapura Cross Metro Station (includes 281 m. of Viaduct beyond Phase-2A and 650 m of link line connectivity to Baiyappanahalli), road widening, utility diversion and allied works.	11003	8 Nos. of elevated stations viz. Kasturi Nagar Station, Horamavu Station, HRBR Layout Station, Kalyan Nagar Station, HBR Layout Station, Nagawara Station, Veerannapalya Station and Kempapura Station.
2	P2	Construction of elevated structure (Viaduct & Stations)from Kempapura Cross Metro Station to Bagalur Cross Station including 250 m length of pocket track, road widening, utility diversion and allied works.	11678	5 Nos. of elevated stations viz. Hebbal Station, Kodigehalli Station, Jakkur Cross Station, Yelahanka Station & Bagalur Cross Station.
3	P3	Construction of elevated structure (Viaduct & Stations) from Bagalur Cross Station to Kempegowda International Airport including road widening, Utility diversion and allied works.	15011	2 Nos. of elevated stations viz. Bettahalasuru Station and Doddajala Station.
4	P4	Construction of Metro Rail Depot structures, site development works, internal roads & drainage works in Depot at Baiyappanahalli and near Kempegowda International Airport.		

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 under the Environment (Protection) Act, 1986. Therefore, the proposed Phase 2B 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 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 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 and 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, as 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 following 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

Sl. No.	Subject	Authority Granting Clearance	When required	Responsibility	Applicability
3	No Objection Certificate (NOC) for Construction camp, Labor camp, Crushers, Batching Plants, Wet Mix Macadam plants, 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
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	Bruhat Bengaluru Mahanagara Palike (BBMP)	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 8representative air pollution sensitive locations such as schools, colleges, hospitals, hostels and libraries adjacent to the proposed Phase 2B metro alignment in November 2019. Air Monitoring was carried out for parameters PM2.5, PM10, NOx, SO2, CO and Pb. The results show that PM2.5

and PM10 exceed the WHO guideline values, all the parameters are within permissible limits. The survey for ambient noise levels has been conducted at 8 representative locations sensitive to noise pollution along the alignment. The monitoring results indicate that the equivalent noise levels at most of the eight locations are exceeding the limits prescribed by CPCB for the respective zones.

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 events have been recorded at three locations out of five monitored locations with a maximum trigger of 3.32 mm/s. 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.

15. 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 3541 trees are observed along the alignment and station locations.

E. Environmental Impacts and Mitigation Measures:

16. The implementation of proposed metro project from KR Puram to Kempe Gowda International Airport (Airport Metro Line) causes some impacts during various stages of project implementation. The impacts by project have been identified and discussed under pre-construction, construction and operation phase of project. These impacts could be largely mitigated through engineering designs, good construction practices accompanied by a site-specific mitigation measure. Following are some of the environmental impacts of proposed metro project on the natural environment and nearby communities:

- It is estimated that approximately 313,519 Sqm (Government land – 105,500 Sqm and Private land – 208,019 Sqm) of land to be acquired along the alignment of the proposed Phase 2B corridor. Most of the land acquired is for viaduct, metro stations and depot which are integral parts of the proposed project. The acquisition of land for construction of metro stations lead to minimal changes in land use.
- Approximately 3541 trees are impacted by the project, sincere efforts shall be made to transplant many of these trees. Every tree impacted is compensated at the rate of ten saplings or 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.
- Generation of dust by the project activities like site preparatory earthworks; demolition of existing structures; foundation excavation works; erection and use of heavy equipment & machinery; loading, transporting and unloading soil and construction materials and material handling; traffic diversion; etc. 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.
- 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.
- Project corridor alignment has more than 54 air and noise sensitive receptors such as schools, colleges, hostels, hospitals, libraries. Dust mitigation by regular sprinkling

of water, provision of dust screens, establishing construction establishments away from settlements and sensitive receptors shall be taken up.

- 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; etc.
- Approximately 273,586 Cum of excavated earth and 14,096 Cum of concrete debris would be generated from the structure demolition, excavations for piles and pile cap and excavation of a 300 meter long underground tunnel section. Unserviceable debris materials shall have to be disposed in borrow pits or abandoned quarries in an environmentally sustainable manner. Handling and transportation of the excavated soil debris from construction site to disposal sites will generate dust in the vicinity of project area during construction phase. This dust can be effectively controlled by adopting specific mitigation measures.
- There are 6 major water bodies in the vicinity of project corridor. There are no significant adverse impacts by the project on these water bodies. However, appropriate mitigation measures will be taken up to avoid and reduce the impact during construction phase. Runoff water from elevated viaduct super structure will be guided to recharge pits to facilitate the infiltration of runoff water into the ground along the at-grade median.
- Waste water will be generated at construction camps and labour camps, if disposed of without treatment, will cause water pollution in the nearby water bodies. The waste water from construction establishment will be treated to the standards prescribed by CPCB and disposed of suitably. The waste water from metro stations will be disposed of into sewer drains after suitable treatment.
- Traffic along outer ring road will get disrupted during the construction phase due to traffic diversions. During construction, the operating traffic and nearby public will suffer from inconveniences such as additional time, fuel, cost and distance. Traffic management plans shall be prepared for diverting and managing vehicular traffic such that traffic flow is not affected.
- The project would impact on the livelihood, public services, health and safety of community and labourers, temporarily during construction of the project. Inconveniences caused by utility shifting, excavations, unplanned stacking of excavated earth and traffic diversions in the vicinity of project corridors.
- During construction of project, there will be accidents envisaged by lack of knowledge on handling of new equipment, working without proper personal protective equipment and without possessing first aid facilities at work sites.

F. Information Disclosure, Consultation, and Participation:

17. Consultations during environmental and social impact assessment have been conducted with project affected people (PAPs) and stakeholders. Suggestions and options given during consultations improves 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 consultations were conducted at Benniganahalli, Muthu Mariayamma Temple Jyothi Nagar, KR Puram along Outer Ring Road and at Kogilu Cross, Yelahanka along Airport Road to elicit the concerns of project affected public and stakeholders. As per SPS, 2009 of ADB the draft EIA report will be made publicly available at least 120 days before the board consideration of the project.

G. Environmental Management Plan:

18. 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.

19. 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 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.

20. The contractor is primarily responsible for daily onsite implementation of environmental monitoring and management works during implementation of metro project to ensure achieve high level of safety and quality 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.

21. The staff of PIU, DE, independent external monitoring agency and the Contractor will 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.

22. The budgetary provision of Rs. 24,99,87,676for the implementing EMP of the project has been made.

H. Conclusion and Recommendations:

23. The project will cause temporary negative impacts during construction phase. However, adequate mitigation measures have been framed and recommended to avoid and reduce the impacts of project during construction phase of project implementation. Noise and vibration impacts during operation phase of metro project are found to be of significance, however these can be mitigated through the design of the metro line.

24. 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.

25. This report is a draft EIA and will be subjected to further revision after getting feedback from relevant stakeholders and refinement of impact analysis.

I. INTRODUCTION

A. Background

26. 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 wider roads connectivity to different parts and suffers from traffic congestion due to narrow roads. There are no good transit corridors between different parts of the city and connectivity to the 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 cause significant social and environmental impacts. Further, widening of roads is not a complete solution as the number of vehicles is increasing uncontrollably, adding to the city's problems such as congestion, air pollution, noise pollution and associated social problems.

27. 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, 2011[1], 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.

28. Rapid development of IT industries in Electronic City and Whitefield areas of Bengaluru, has contributed to the phenomenal growth of IT Industry all along Outer Ring Road (ORR) between Central Silk Board (CSB) and Nagawara. With these developments, road traffic on this road has unmanageably increased and the ring road having 6 lane main carriage way with service roads is not able to cater to the needs. This corridor between KR Puram and Nagawara provides employment to IT professionals, various support services and indirect employment. The biggest challenge these people are facing is the long time spent commuting thereby bringing down their efficiency and also affecting the overall economic efficiency in this corridor.

29. Though the Phase1 has been completed and Phase2 of the metro network has been planned, this corridor has been left untouched by both developments. Hence, the construction of Phase 2B Airport Metro line starting from KR Puram to KIA via Hebbal Junction, with an operational length of 36.44km and the line length of 38.00km has been proposed. The DPR was prepared during October 2019 incorporating the requirements prescribed in the Metro

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

Rail Policy - 2017 issued by Ministry of Housing and Urban Affairs (MOHUA), Government of India (GOI). The route is planned to be connected by metro as an extension of the already sanctioned Phase 2 of BMRCL and is named as Airport (Phase 2B) Metro Line.

B. Objective of the Project:

30. The proposed Phase 2B Airport 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.

31. Phase 2A ORR Metro Line and Phase 2B Airport Metro Line are proposed for funding from the Asian Development Bank (ADB).

32. For the convenience of implementation, the proposed Phase 2B metro project corridor has been divided into four different Contract Packages as given in Table 1-1.

Table 1- 3: Packagewise details of Proposed Phase-2B metro project

Sl. No.	Package No.	General Description	Length (M)	Number of Metro Stations
1	P1	Construction of elevated structure (Viaduct & Stations) from KR Puram to Kempapura Station (includes 281 m. of Viaduct beyond Phase-2A and 650 m length of link line connectivity to Baiyappanahalli), road widening, utility diversion and allied works.	11003	8 Nos. of elevated stations viz. Kasturi Nagar Station, Horamavu Station, HRBR Layout Station, Kalyan Nagar Station, HBR Layout Station, Nagawara Station, Veerannapalya Station and Kempapura Station.
2	P2	Construction of elevated structure (Viaduct & Stations) from Kempapura Station to Bagalur Cross Station including 250 m length of pocket track, road widening, utility diversion and allied works.	11678	5 Nos. of elevated stations viz. Hebbal Station, Kodigehalli Station, Jakkur Cross Station, Yelahanka Station & Bagalur Cross Station.
3	P3	Construction of elevated structure (Viaduct & Stations) from Bagalur Cross Station to Kempegowda International Airport including road widening, Utility diversion and allied works.	15011	2 Nos. of elevated stations viz. Bettahalasuru Station and Doddajala Station
4	P4	Construction of Metro Rail Depot structures, site development works, internal roads & drainage works in		

Sl. No.	Package No.	General Description	Length (M)	Number of Metro Stations
		Depot at Baiyappanahalli and near Kempegowda International Airport.		

C. Project Proponent

33. 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.

34. 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

35. The Environmental Impact Assessment (EIA) Notification of 2006 and its subsequent amendments under the 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 2B 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.

36. 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).

37. 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:

38. 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 2B metro project stretch from KR Puram to Kempegowda International Airport (Airport Metro Line) per ADB Safeguard Policy Statement, 2009 required for Category 'A' projects. 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

39. 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

40. The Detailed Project Report for constructing and commissioning Phase 2B Airport Metro Line was prepared by BMRCL in September 2017 based on the experience it gained while implementing the Phase1 of Namma Metro. The DPR was revised in January and October 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

41. Though the Phase1 is operational and Phase2 has been planned it is necessary to look into providing the connectivity between KIA Terminals and KR Puram for a length of 38.00km (36.44 km from Jyothipuram to KIA Terminals) to facilitate hassle free and comfortable movement along this corridor. The proposal is for implementation of Phase 2B metro line from KR Puram to KIA via Hebbal Junction. The corridor proposed is from end station of Phase 2A at Jyothipuram to terminal station of Phase 2B at KIA Terminals. The other stations are Kasturi Nagar, Horamavu, HRBR Layout, Kalyan Nagar, HBR Layout, Nagawara, Veerannapalya and Kempapura in Package – I; Hebbal, Kodigehalli, Jakkur Cross, Yelahanka and Bagalur Cross in Package II and Bettahalasuru, Doddajala, Airport city and KIA terminals in Package III of Phase 2B. The alignment of proposed Phase 2B Metro line with metro stations and some photos of ORR and airport road are given in Figure 2.1 and Figure 2-2 respectively.

42. The proposed Phase 2B metro line will mostly be an elevated standard gauge corridor with double line section generally passing on median of the road along ORR and the space between main highway and service road along Airport road. A 300 m long section near the Yelahanka Air Force Station will be constructed underground. The 15 stations outside of the airport area are 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. From the 2 stations inside the airport area one will be at grade (Airport City Station) and one will be below ground level (KIA Terminals). The design of these stations is done by Bangalore International Airport Limited (BIAL) in order to fully integrate in their surroundings, figure 2-1 and 2-2 provide schematic drawings of KIA terminals station.

Figure 2- 1: Top view KIA Terminals Station

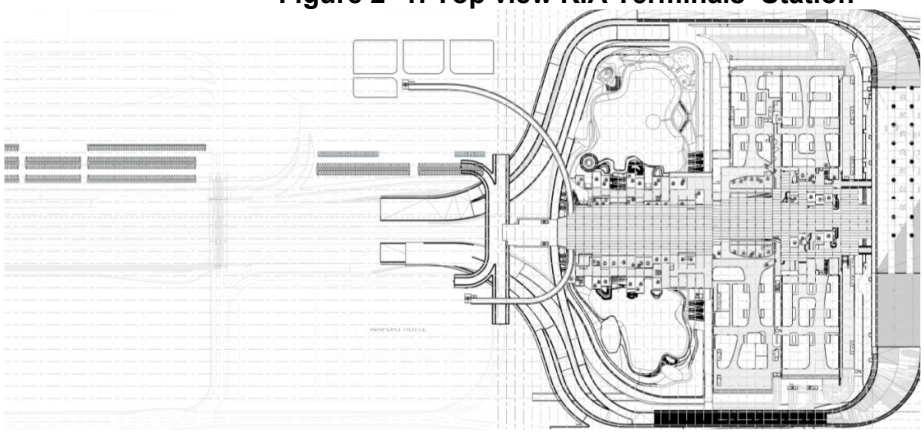
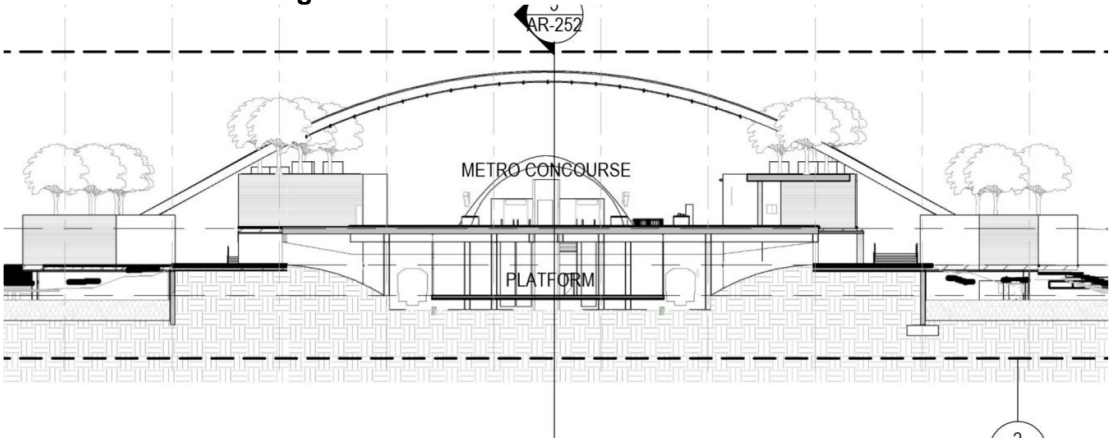


Figure 2- 2: Front view KIA Terminals Station



43. Total of 17 stations are proposed along the Phase 2B line and 7 stations out of 17 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.

44. Provision of 6m wide service road has been proposed around the stations for integration with BMTC buses to ensure last mile connectivity for commuters. It is also proposed for construction of Metro Rail Depot Structures, site development works, internal roads and drainage works in the depot at Baiyappanahalli and near KIA.

B. Alignment of the Proposed Metro

45. Horizontal Alignment –The proposed metro alignment starts after Jyothipuram station of Phase 2 (R1- Extension) as an extended corridor of Phase 2A (Central Silk Board to KR Puram), then it turns right and follows the ORR on the left side of existing flyover and joins ORR median at Kasturinagar. Further alignment will generally follow median of the ORR up to Kempapura station. After Kempapura station, the alignment takes right turn to enter Hebbal bus depot area where Hebbal station is located and reaches NH-44 before Kodigehalli station

and further continues till Doddajala on the 5m wide strip of land reserved for high speed rail corridor between main road and service road on NH-44. Before Doddajala station, the alignment takes a right turn and moves parallel to railway line for a short length after crossing the railway line and takes a right turn to reach airport road median and continues along the road median up to KIAL boundary. After KIAL boundary, the alignment takes left turn and continues off road up to KIA terminal station. The road alignment is fairly straight without sharp curves and the metro alignment is planned with minimum radius of the horizontal curve as 127.50 m.

46. Design Speed - The maximum sectional design speed will be 90 km/h. 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. Considering the maximum allowable cant of 125 mm and can't deficiency of 100 mm on Metro tracks, the safe speed on curves of radii of 400 m or more is 80 km/h. On the same criteria for curves with radius of 127.5 m, speed of 46 km/h shall be permitted. Since no curves sharper than 127.5m radius are planned, check rails are not required for any of the curves on this corridor.

47. Vertical Alignment - Track supporting structures on elevated sections are to permit a vertical clearance of 5.50m above road level for movement of vehicular traffic. To meet this requirement with the box girder/ U-girder design and construction of an elevated pedestrian walkway below the viaduct, the rail level is planned to be generally 13.5 m above the road level. This will also permit construction of elevated pedestrian walkways and footbridges (connecting bridges) for platform interchange for commuters at stations below the viaduct. Between Yelahanka Station and Bagalur Cross Station a section of the alignment will be constructed underground in order not to interfere with the operations of the Yelahanka air force station. The construction will be a combination of closed and open boxes with a depth of 8.25 meter and a width of 10.5 meter length of the underground section will be 300 meter excluding ramps. Figure 2-1 to 2-3 provide details of the underground construction.

Figure 2- 3: Cross section underground closed box

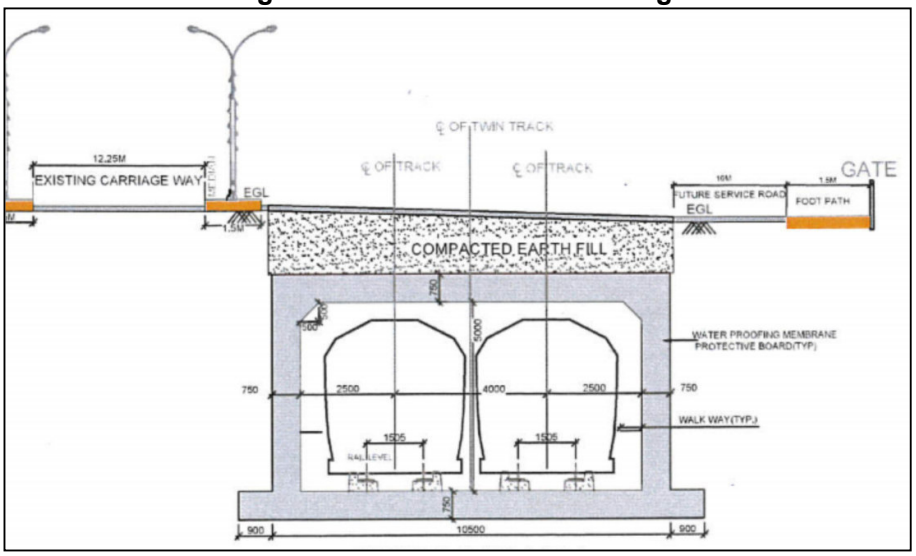
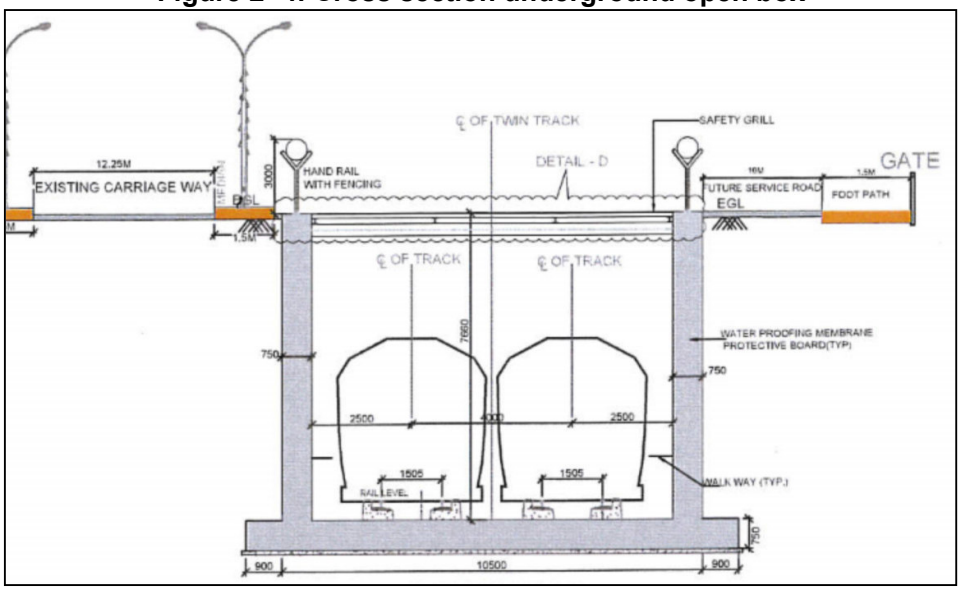
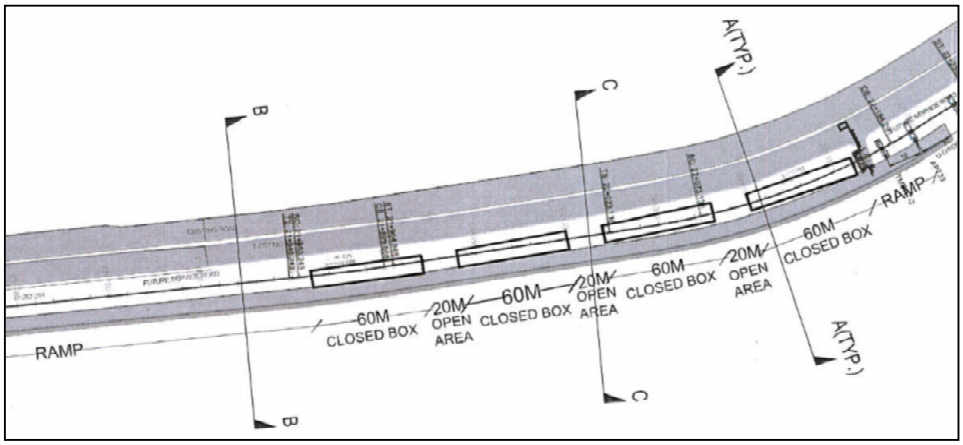


Figure 2- 4: Cross section underground open box



48. 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 4.20 m in depots as per provisions of schedule of dimensions (SOD) of BMRCL 2015, for curves of radius less than 120.0 m to 100.0 m.

Figure 2- 5: Top view undergound section



49. Track Structure - 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.

50. 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 baseplate to baseplate 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.

51. 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.

Figure 2- 6: Proposed Phase 2B Metro line and Metro Stations

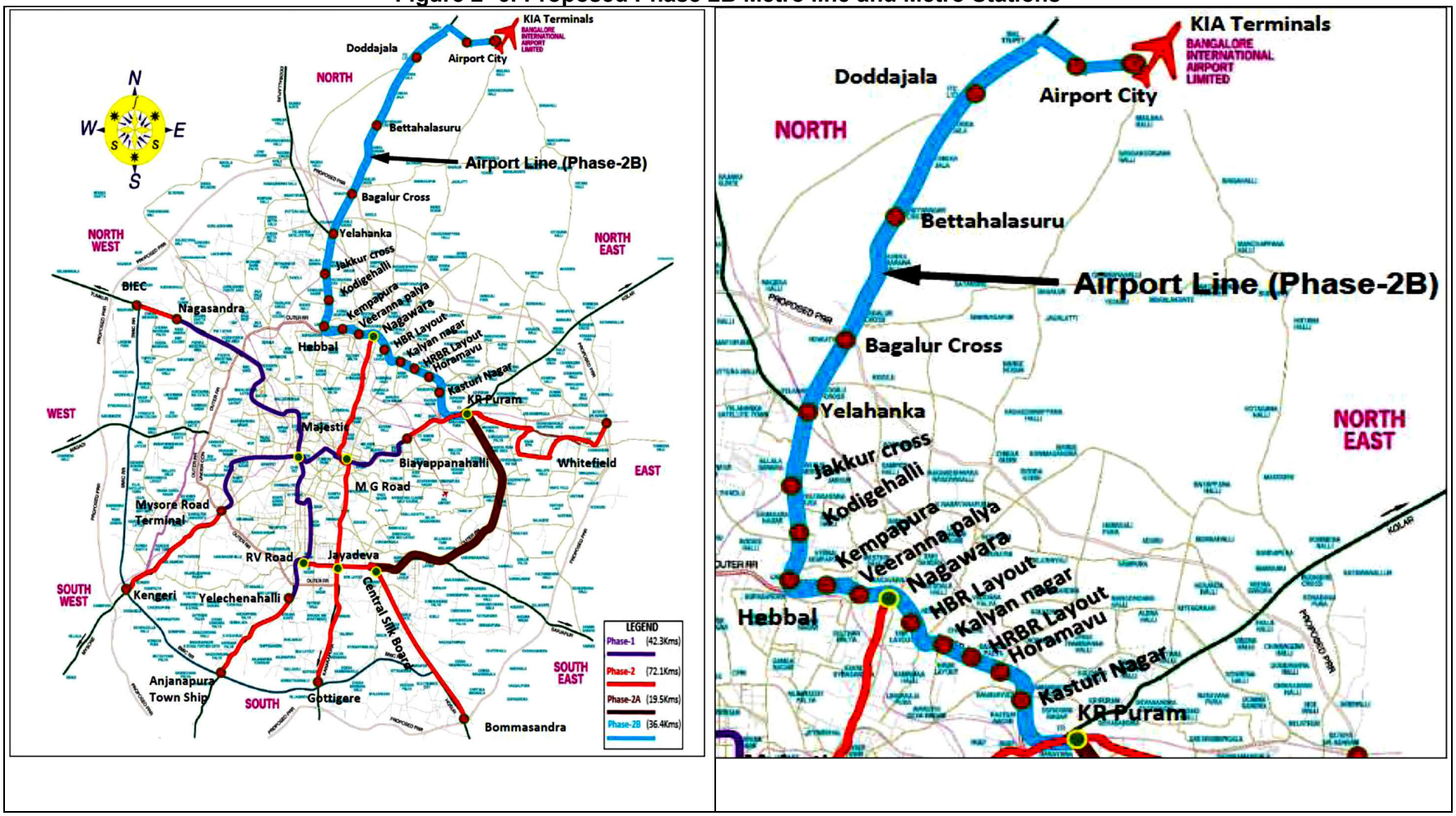


Figure 2- 7: Photos of Outer Ring Road where metro corridor is proposed

52. Gauge - Standard gauge (1435mm) is commonly used for metro railways worldwide. 1 in 7 and 1 in 9 turn-outs, 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 turn-outs 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.

53. A linking line starts from the existing ramp of phase-2 Reach-1 extension at Baiyappanahalli as 'Y' junction after crossing railway line connects the proposed Airport line at ORR after the flyover. Two pocket tracks of 250m (near Yelahanka station) and 200m (between Veeranapalya and Kempapura stations) length are planned for turn back, emergency stabling facilities and operational convenience. Seventeen stations have been proposed on this line of which 15 will be elevated, including interchange station at Nagawara. Phase 2B line will be mainly served by proposed depot at Doddajala near Airport and by Baiyappanahalli depot in emergencies. Nagawara station which is located on the Airport line of Phase-2B between KR Puram & Hebbal is proposed as interchange station to Reach-6 (UG) between Gottigere- Nagawara. Stations at Hebbal, Yelahanka, Bagalur cross station and Doddajala station are planned as future interchange stations. Third line takes off from Airport road median well before Airport City metro station to reach Depot which is located on the right side of NH 44 near Trumpet toll plaza.

i. Viaduct Structure

54. The most widely used precast segmental box girder with post tensioning superstructure was selected for the viaduct of 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.

C. Depot Planning

55. The 38.00 km length of phase 2B corridor presents the need for depot facilities to be provided at either end of the corridor to ensure seamless operation and maintenance services with a proposed headway for the line. Therefore, a full-fledged depot is proposed at airport end to be constructed in a phased manner.

56. There is a proposal for switch-over of Baiyappanahalli depot from E-W corridor to ORR corridor by remodelling it. This also proposed to augment stabling capacity at Baiyappanahalli depot from the existing 16 lines to 42 lines to cater to complete operational needs of Phase 2A ORR line and partial requirement of Phase 2B Airport line. Considering the augmentation plan at Baiyappanahalli, the construction of the Airport depot facility is proposed in two phases. In the first phase 12 stabling lines will be constructed and a combined shed with 4 inspection lines and 2 repair lines and pit wheel lathe PWL line by the year 2023. In the second phase, two more repair lines and test track of 750 m length shall be constructed. The balance O&M requirement for this section will be supplemented by the facility at Baiyappanahalli depot.

57. Traffic demand along the airport corridor could exceed the proposed PHPDT by the year 2041. Hence, it is imperative to ensure provision for additional 15 stabling lines at the airport depot to cater to 2 min headway in the critical sections of this corridor.

D. Rolling Stock, Traction and Signaling

58. The rolling stock for this metro line is planned as per MOHUA guidelines except with following deviations:

i) 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.
ii) In place of front evacuation, side evacuation has been planned.

59. These are being proposed for the following reasons:
i) BMRCL Rolling Stock in Phase1 and Phase2 has minimum coach width of 2880 mm and axle load 15 tonne. Thus, any change in the coach width will lead to change of SOD.
ii) 15 tonne train is more energy efficient in comparison to 16 tonne train.
iii) With the Phase1 experience, side evacuation is preferred option from the of view of ease of maintenance and operation.
iv) Baiyapanahalli Depot at Phase1 has been constructed with SOD of Phase-1 and Phase2. 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

60. The travel model generated for the Revised Master Plan for Bengaluru2031[2] has been used for the estimation of ridership for the proposed metro corridor from KR Puram to Airport via Hebbal. This metro line has been incorporated in the model. That assessment has been 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 ridership on the proposed metro corridor is important to assess the modal 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.

61. The DPR traffic study it is estimated that the daily ridership on this Metro corridor will be 4,33,972 in 2024, when the project is planned to be completed and it will rise to 8,35,623 by 2031 and to 11,14,240 by 2041. Similarly, the PHPDT will be 21,112 by 2024 which will increase to 35,705 by 2031 and to 46,252 by 2041.The total ridership station wise ridership is tabulated in Table 2-1 below.

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

Sl.No.	Station Locations	2024	2031	2041
0	KR Puram	51,983	89,845	116,398
1	Kasturi Nagar	13,794	22,924	29,695
2	Channasandra	12,790	25,507	33,041
3	HRBR Layout	14,488	28,893	37427
4	Kalyan Nagar	19,777	32,582	42206
5	HBR Layout	17,811	40,271	52,166
6	Nagawara	50,470	77,165	99,959
7	Veeranna Palya	19,535	32,923	42,648
8	Kempapura	24,013	35,960	46,583
9	Hebbal	60,987	105,406	136,542
10	Kodigehalli	20,228	51,137	66,243
11	Jakkur Cross	16,699	40,345	52,263
12	Yelahanka	30,647	58,526	75,813
13	Bagalur Cross	8,382	25,145	36,688
14	Bettahalasuru	8048	24,145	35,228
15	Doddajala	5,365	16,096	23,485

[2] Revised Master Plan (RMP) for Bengaluru - 2031 (draft) prepared by Bangalore Development Authority.
Source: DPR for Phase 2B of Bangalore Metro, Volume 1 prepared by BMRCL October 2019.

Sl.No.	Station Locations	2024	2031	2041
16	Airport City	10,842	32,527	47,458
17	KIA Terminals	48,113	96,225	140,396
	Total	**433,972**	**835,622**	**1,114,239**

Source: DPR for Phase 2B of Bengaluru Metro, Volume 1.

F. Passenger Carrying Capacity

62. 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 sqm (AW3) and exceptional dense crush load of 8 persons/sqm (AW4).

63. 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

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

Table 2- 3: Carrying Capacity of Mass Rail Vehicles Exceptional Dense Crush @8 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	273	147	293	862	1718
Total	180	316	197	343	1148	2004

65. Normal (AW2) - 4 P/Sqm. of standee area

66. Exceptional Dense Crush (AW4) - 8 P/Sqm. of standee area

G. Power Requirements:

67. 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.

68. 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 2-4.

Table 2- 4: Power Requirements for Airport Line

K R PURAM TO AIRPORT				
Description	**Values**			
Traction power requirements	**Year 2024**	**Year 2031**	**Year 2041**	**Units**
No of cars per rake	6	6	6	(2DMC+2TC+2MC)
Tare weight of train	222	222	222	T
Passenger weight	130	130	130	T
Total Train weight	352	352	352	T
Length (Route km)	39.487	39.49	39.49	km
Headway (during peak hours)	5 & 10	3 & 6	2.5 & 5	mts
Specific Energy Consumption (SEC)	75	75	75	KWhr/1000 GTkm
Power demand from one train set	0.79	0.79	0.79	MW
No. of train sets in operation during peak hour	18	30	36	Train sets
Total traction demand	14.22	23.70	28.44	MW
Less Regeneration @20%	2.84	4.74	5.69	MW
Depot traction power requirement	1.0	1.0	1.0	MW
Net traction power requirement	12.38	19.96	23.75	MW
Total traction power requirement (MVA) assuming 5% energy losses and .95 pf for traction loads.	**13.68**	**22.06**	**26.25**	**MVA**
Station auxiliary power requirement				
Elevated station load	0.25	0.25	0.25	MW
Property development load	0.10	0.10	0.10	MW
Total elevated station auxiliary load	0.35	0.35	0.35	MW
No. of elevated stations	17	17	17	
Way side traction station, auxiliary load requirement	0.10	0.10	0.10	MW
No. of way side traction stations	8	8	8	
Total auxiliary power requirement	6.75	6.75	6.75	MW
Depot auxiliary power requirement	1.0	1.5	1.7	MW
Total auxiliary power requirement	7.75	8.25	8.45	MW
Total auxiliary power requirement (MVA) assuming 5% energy losses and .85 pf for auxiliary loads.	**9.57**	**10.19**	**10.44**	**MVA**
Total traction & aux power requirement (MW)	20.13	28.21	32.20	MW
Total power requirement (MVA) assuming 5% energy losses and .95 & .85 pf for traction & aux loads respectively	**23.25**	**32.25**	**36.69**	**MVA**

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

H. Sub Stations

69. Total 20 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 and at the depot. 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 23.25MVA 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

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

"No Project" Scenario

71. 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.

72. 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.

73. 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.

74. 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 Phase 2B corridor is projected to be 21,112in 2024 and 35,705 in 2031and is likely to increase to 46,252by2041. Therefore, road based public transport will not be able to meet the demand.

Advantages of a Metro system

75. 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:

i. Requires 1/5th energy per passenger km compared to road-based system
ii. Causes no air pollution in the city
iii. Causes lesser noise level
iv. Occupies no road space if underground and only about 2 metres width of the road if elevated
v. 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.
vi. Is more reliable, comfortable and safer than road-based system
vii. Reduces journey time by anything between 50% and 75% depending on road conditions.

Types of Metros and their Capacity

76. 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

77. 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.

78. 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.

79. 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

80. 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:

81. Metro lite 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.

82. 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.

83. 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.

84. The corridor from Phase 2A to 2B will cover a total distance of 56km. Metro lite 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.

85. 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 2B metro line.

Alignment Alternatives

86. 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, whitefield and KIA, 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 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.

87. 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

88. The proposed corridor follows the alignment of existing ORR from Kasturi Nagar to Hebbal and thereafter Metro alignment follows the National Highway-44 (NH-44). The land required to locate viaduct pier is available almost for full length of the corridor. The ORR has 6-lane carriageway with service roads on either side. The minimum total road width is over 41m and maximum road width is about 76m at Kalyan Nagar and 73m at the HRBR layout stretch where the median between main road and service road is developed as a park. The minimum width of the median is about 1.5 m 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 at the major road intersections at HRBR layout, Nagawara and Veeranna Palya while three road underpasses are available at Rammurthy Nagar, Horamavu and Hennur. 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 6.5-9.5m available between the two arms of the split flyover. Even at the underpasses, the metro piers can run at the middle.

89. 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.

90. Construction of metro line at-grade between KR Puram and Hebbal (along ORR) is ruled out as two lines of metro will occupy about 10 m of the road width making the remaining road grossly inadequate for the flow of traffic on this important Ring Road. However, construction of metro line at-grade between Hebbal and Airport Terminal may be possible by acquiring an additional strip of 5 m wide land along NH-44. Acquisition of additional 5 m wide strip of land between Hebbal and Yelahanka is not feasible due to large scale development along the highway but may be feasible between Yelahanka and Trumpet Junction as there is relatively less development along the highway. The length of metro line between Yelahanka and Airport Terminal is 18.125 km having 5 stations. The cost comparison of constructing Elevated and at-grade metro line between Yelahanka and Airport Terminal has been carried out. The at-grade alignment has been determined to be costlier than the elevated alignment by about Rs. 742 crores because of the following reasons:

I. An additional land acquisition of 5 m wide strip along NH-44 for a length of about 11.44 km (57210 sqm) and 9000sqm for three at-grade stations results to an additional cost of Rs. 968 crores.
II. Construction of 15 grade separators (Underpass) for road and rail crossings results into an additional cost of about Rs. 200 crores.
III. Construction of compound / security fencing on both sides of the Metro line results into an additional cost of about Rs. 41 crores.

91. In addition to the above the Metro Line At-grade along the road splits the city into two and number of underpasses / over bridges will have to be constructed for movement of people and vehicles from one side to other side of the metro corridor. There will be an additional security issues due to external interferences in spite of providing compound / security fencing.

92. 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

93. 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

94. 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:

95. 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 2B 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

96. 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

97. 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

98. 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

99. 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)

100. The Government of India has formulated these rules under the Environment (Protection) Act, 2016. 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 transhipment 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)

101. 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 thereunder 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

102. 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

103. 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)

104. 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

105. 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 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)

106. 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

107. 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

108. 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

109. 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

110. 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

111. The GOI enacted the Building and Other Constructions 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 the.

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

112. 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

113. 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:

114. 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:

115. The Asian Development Bank (AD 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 classify 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.

116. The project will follow state, national, as well as international best practices and standards related to environment, health and safety including IFC Environmental, Health, and Safety (EHS) General Guidelines (30 April 2007) in the preparation, implementation, and operation.

W. Clearances required for the Metro project

117. 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 Tree Act, 1976 & Forest Conservation Act, 1980	State Forest Department	Before Construction	BMRCL	Exact number and location of trees
2	Elevated Metro Corridor Crossing Indian railway lines		South Western Railways, Indian Railways	Before Construction	BMRCL	
3	No Objection Certificate (NOC) for Construction camp and 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 Environment (Protection) Act, 1986	KSPCB, Karnataka	During Construction	Contractor	If bituminous is used for rehabilitation of roads or any other hazardous wastes

Sl. No.	Subject	Relevant Act	Authority Granting Clearance/ In charge	When required	Responsibility	Remarks
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

Environmental Impact Assessment (Draft) Vol. 2 of 6

June 2020

India: Bengaluru Metro Rail Project

Phase 2B (Airport Metro Line)
KR Puram to Kempegowda International Airport

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

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.

IV. DESCRIPTION OF ENVIRONMENT

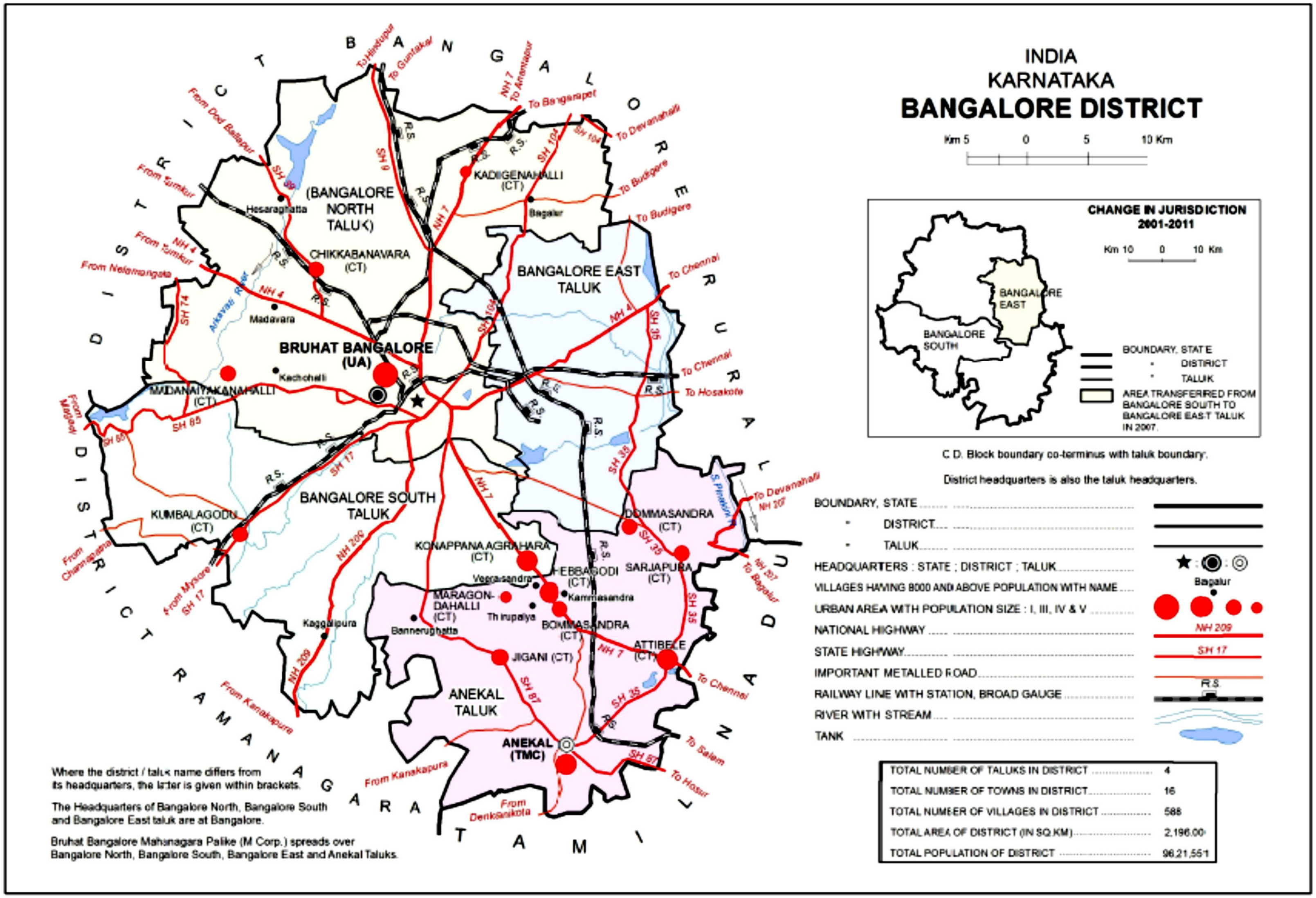
118. Assessment of the impacts of the proposed Phase 2B Airport Metro Line was done through actual the site visits, review of secondary data and information on the environment including biophysical attributes and other relevant aspects, and obtaining baseline data on the environmental condition of the study area with respect to physical and biological environment along the proposed alignment. Discussion on the environmental attributes considers the proposed alignment of Airport Line metro project located within the limits of Bengaluru city and broadly within Bengaluru Urban District. The larger part of alignment is located within the limits of Bengaluru Urban district except for a few hundred meters where the alignment deviates from NH 44 to KIA, bordering Bengaluru Urban and Rural Districts. Hence, the baseline aspects of environment in the report are restricted to Bengaluru Urban District only.

A. Location

119. Phase 2B project starts at KR Puram and follows the ORR for about 11.00 km till the Hebbal Junction and then follows NH 44 (Airport road) till airport toll plaza and takes another deviation towards the airport and ends at KIA terminals.

120. 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 12^0 39' to 13^0 14' N Latitude and 77^0 19' to 77^0 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 2-6 already illustrated the proposed Phase 2B Airport metro alignment along the ORR towards KIA.

Figure 4- 1: Administrative map of Bengaluru Urban District



Source: District Census Handbook, Bengaluru, 2011

B. Physiography

121. 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

122. 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.

123. 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 159.7 mm recorded on 1 October 1997. November 2015 (290.4 mm) 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.

124. 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.

125. 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.

126. 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: Month wise rainfall and Annual total rainfall data for Bengaluru urban district

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Rainfall (in mm)
1985	2.96	0.09	18.42	14.41	86.58	77.57	69.11	51.41	94.86	77.87	106.82	4.58	604.69
1986	16.72	12.42	0.26	13.45	90.12	121.30	58.53	72.59	295.45	110.34	98.76	16.81	906.76
1987	0.20	0.00	22.42	60.15	95.83	79.41	49.26	110.25	66.28	153.86	40.91	50.75	729.31
1988	0.00	1.54	0.43	84.22	202.75	32.38	206.16	169.13	261.10	15.69	39.93	28.42	1041.76
1989	0.06	0.00	5.49	9.87	95.21	108.34	180.46	45.99	173.79	229.16	12.12	4.15	864.63
1990	0.98	0.19	4.55	32.72	191.15	55.36	38.32	78.44	68.04	183.54	35.81	9.38	698.49
1991	0.03	0.02	0.26	47.80	204.38	191.57	69.05	86.44	85.20	285.12	26.57	0.32	996.75
1992	0.07	0.00	0.00	10.61	108.71	159.07	149.41	80.33	100.15	159.65	50.40	1.04	819.44
1993	0.00	0.02	24.73	40.83	122.39	127.30	85.22	92.28	152.13	180.65	34.26	73.32	933.13
1994	0.43	1.41	4.87	18.34	92.14	43.56	98.22	49.76	51.71	199.81	35.93	6.67	602.85
1995	16.37	0.10	15.62	36.34	170.96	90.00	96.59	162.77	158.10	174.22	19.97	0.25	941.28
1996	0.03	0.04	0.70	101.24	126.53	206.44	51.53	203.06	171.74	184.89	13.34	21.87	1081.41
1997	4.44	0.00	22.58	73.29	83.37	76.10	33.48	114.25	161.38	314.38	180.44	27.50	1091.20
1998	0.03	0.18	0.19	95.81	125.06	59.41	214.57	256.60	144.88	219.25	57.15	45.44	1218.56
1999	0.04	10.57	0.56	77.58	226.05	73.12	99.26	68.21	100.09	194.14	67.57	5.65	922.83
2000	0.04	11.83	0.07	80.11	73.29	89.69	99.86	193.46	132.48	291.84	13.41	14.70	1000.77
2001	0.46	0.12	3.65	102.72	71.60	35.69	97.21	64.21	150.75	165.14	32.04	8.25	731.83
2002	0.61	0.12	0.71	10.39	218.10	160.31	33.81	40.27	60.21	183.97	35.17	4.54	748.19
2004	5.40	1.20	5.50	47.50	205.30	75.70	210.40	65.20	186.90	197.30	25.70	0.00	1026.10
2005	1.60	4.40	13.40	75.10	115.70	127.90	136.40	194.00	173.50	446.00	56.50	6.30	1350.80
2006	0.30	0.00	62.70	25.20	133.90	190.50	53.60	44.20	31.50	48.90	48.00	0.30	639.10
2007	0.00	0.20	0.00	104.90	79.50	57.20	154.00	146.50	223.70	163.00	21.10	34.50	984.60
2008	0.10	9.90	115.40	30.40	87.10	59.20	182.50	247.40	105.60	210.90	47.60	0.30	1096.40
2009	0.10	0.00	15.20	63.90	123.80	125.40	30.20	162.20	335.30	35.20	66.80	17.50	975.60
2010	5.40	0.00	17.40	97.50	123.90	67.30	112.30	121.10	149.90	95.80	166.80	2.70	960.10

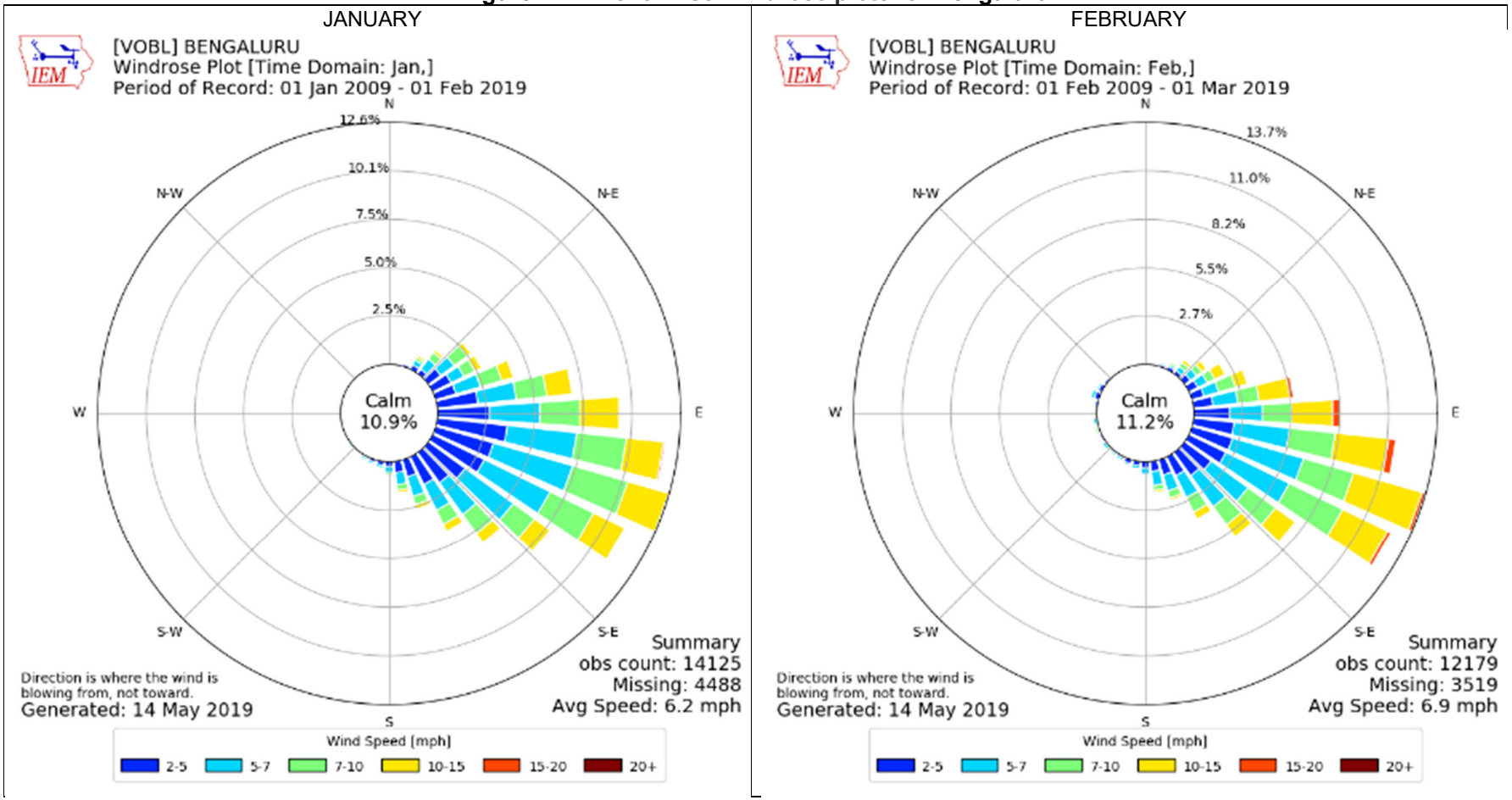
Source: http://www.indiawaterportal.org/met_data/

Table 4- 2: Month wise annual average temperature data for Bengaluru urban district

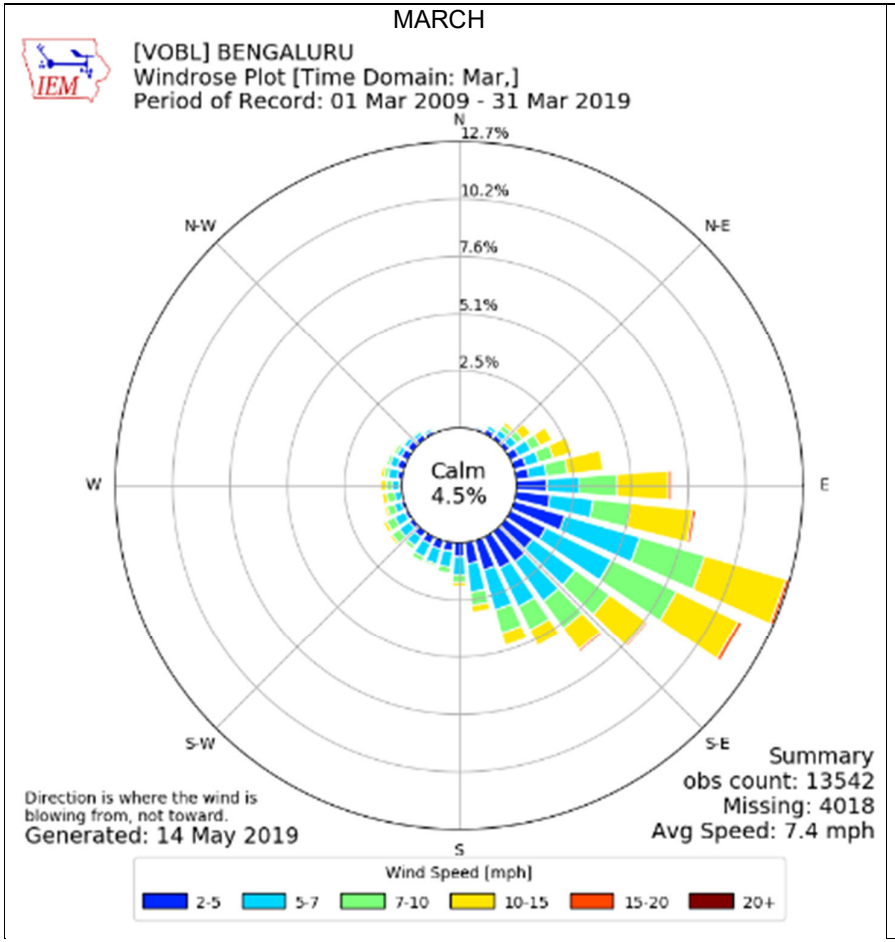
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average Temperature (^{0} Celsius)
1985	23.02	25.07	27.18	28.32	27.62	24.26	23.76	24.28	25.06	23.88	22.58	22.72	24.81
1986	21.99	24.02	26.91	28.74	27.71	24.82	24.58	24.05	24.73	24.76	23.24	22.71	24.85
1987	22.34	23.54	25.96	28.18	27.53	25.28	25.17	24.51	25.74	24.76	23.75	22.42	24.93
1988	22.21	25.39	27.60	27.55	27.38	25.49	24.02	24.01	24.16	24.74	23.29	22.09	24.83
1989	22.25	24.09	26.02	28.09	27.40	24.72	23.81	23.96	24.51	24.77	23.20	22.31	24.59
1990	22.40	24.70	27.15	28.71	26.14	24.60	23.99	23.85	25.06	24.33	23.35	22.20	24.71
1991	23.50	24.78	27.64	27.91	27.73	24.66	23.58	23.62	25.02	24.29	22.66	21.87	24.77
1992	21.39	24.74	26.48	28.10	26.87	24.81	24.26	24.09	24.63	24.39	23.54	21.44	24.56
1993	22.22	24.16	26.69	28.20	27.82	25.30	24.28	24.46	24.13	24.20	23.14	21.67	24.69
1994	22.50	24.59	26.98	27.74	27.69	25.07	23.75	24.59	24.82	24.27	22.47	21.25	24.64
1995	22.37	24.98	26.47	28.07	26.25	25.95	24.17	24.61	24.73	24.52	24.48	22.23	24.90
1996	22.98	24.35	27.08	27.69	28.27	25.05	24.58	24.17	24.44	24.14	23.75	21.86	24.86
1997	22.61	24.66	26.58	26.85	27.60	26.43	24.84	24.52	25.21	24.90	24.35	23.12	25.14
1998	23.53	25.72	27.92	28.91	28.08	26.26	24.55	24.76	24.59	24.51	23.91	22.48	25.43
1999	22.71	24.47	27.49	27.89	25.82	24.77	24.24	24.56	25.22	24.70	23.53	22.09	24.79
2000	23.17	25.03	26.54	28.09	26.86	24.39	24.06	24.07	24.91	24.34	23.75	21.90	24.76
2001	23.20	26.06	27.43	28.13	27.40	25.16	24.73	24.16	25.32	24.21	23.77	22.21	25.15
2002	23.35	24.13	27.28	28.56	27.50	25.29	24.93	24.72	25.87	25.09	23.67	22.78	25.26

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

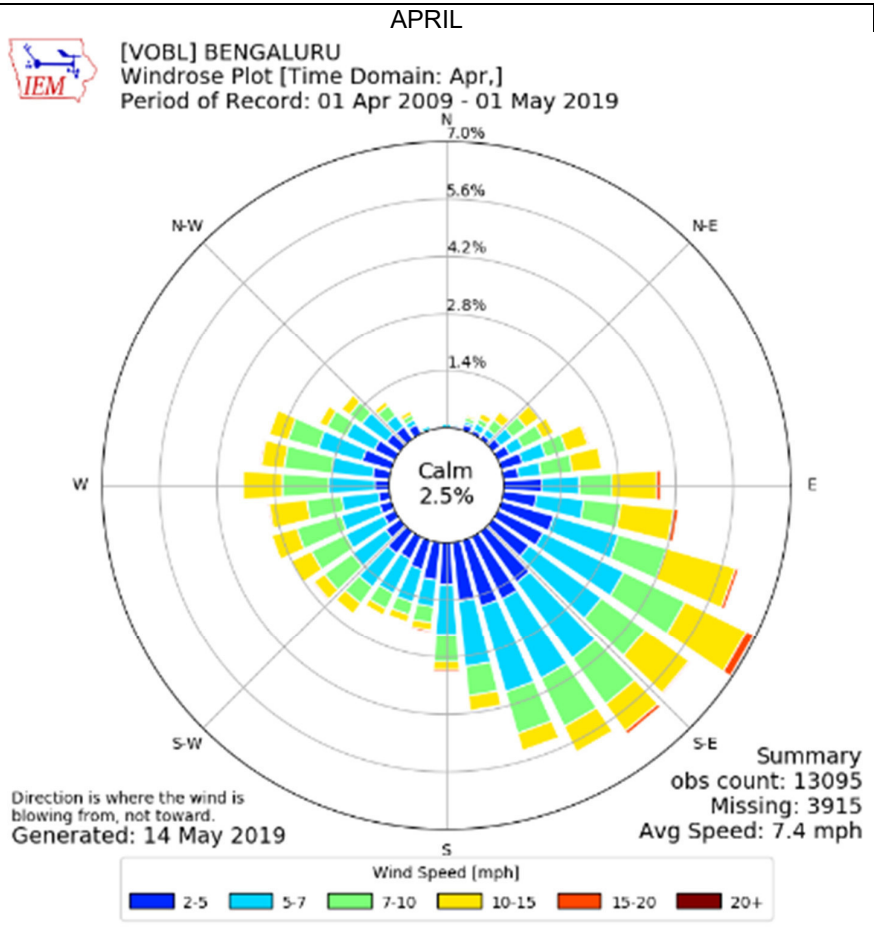
Figure 4- 2: Monthwise Windrose plots for Bengaluru



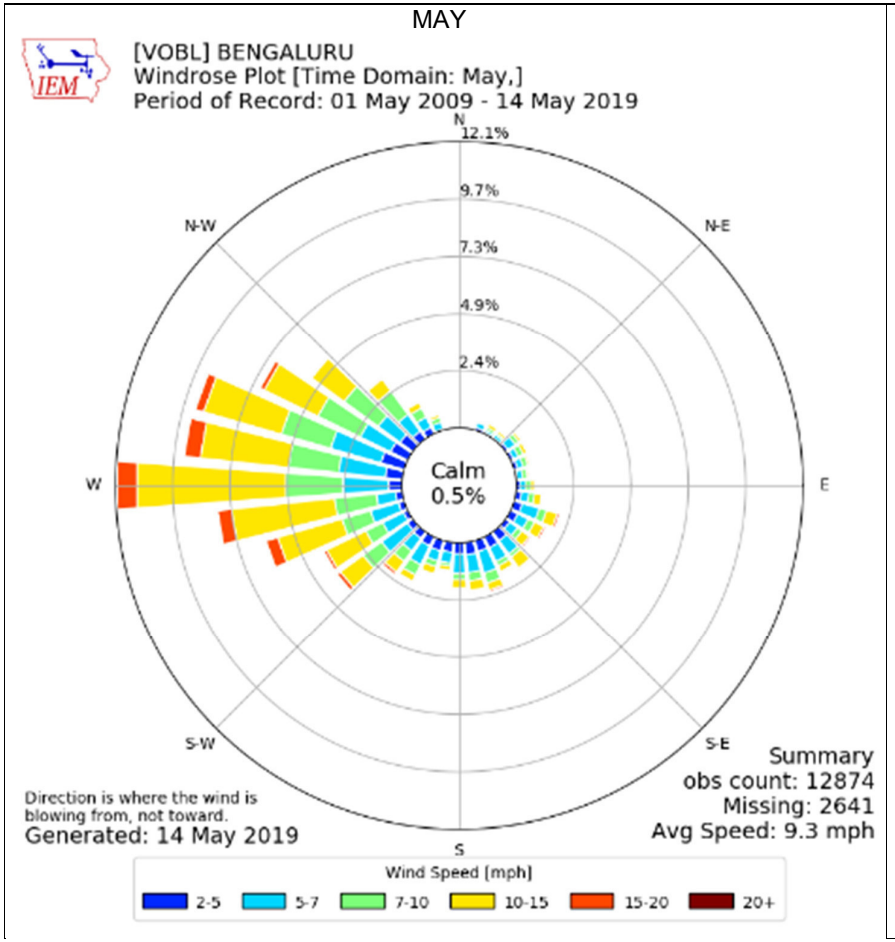
MARCH


[VOBL] BENGALURU
Windrose Plot [Time Domain: Mar,]
Period of Record: 01 Mar 2009 - 31 Mar 2019
N
N-E
E
S-E
S
S-W
W
N-W
12.7%
10.2%
7.6%
5.1%
2.5%
Calm
4.5%
Summary
obs count: 13542
Missing: 4018
Avg Speed: 7.4 mph
Direction is where the wind is blowing from, not toward.
Generated: 14 May 2019
Wind Speed [mph]
2-5
5-7
7-10
10-15
15-20
20+

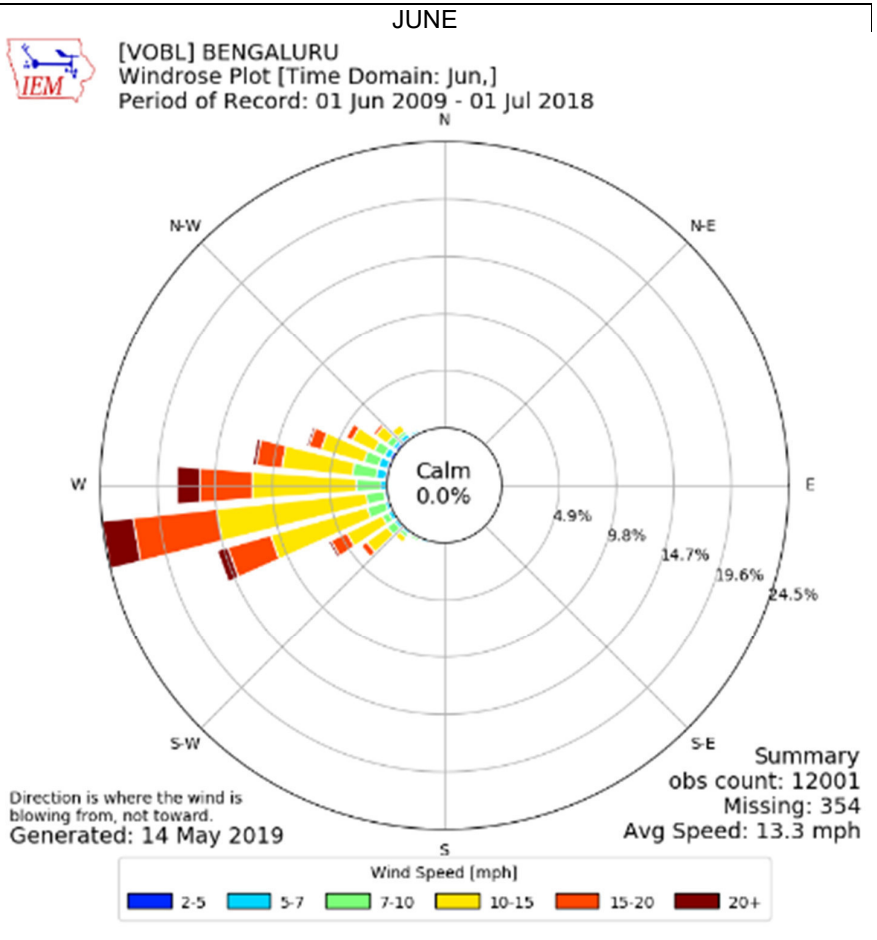
APRIL


[VOBL] BENGALURU
Windrose Plot [Time Domain: Apr,]
Period of Record: 01 Apr 2009 - 01 May 2019
N
N-E
E
S-E
S
S-W
W
N-W
7.0%
5.6%
4.2%
2.8%
1.4%
Calm
2.5%
Summary
obs count: 13095
Missing: 3915
Avg Speed: 7.4 mph
Direction is where the wind is blowing from, not toward.
Generated: 14 May 2019
Wind Speed [mph]
2-5
5-7
7-10
10-15
15-20
20+

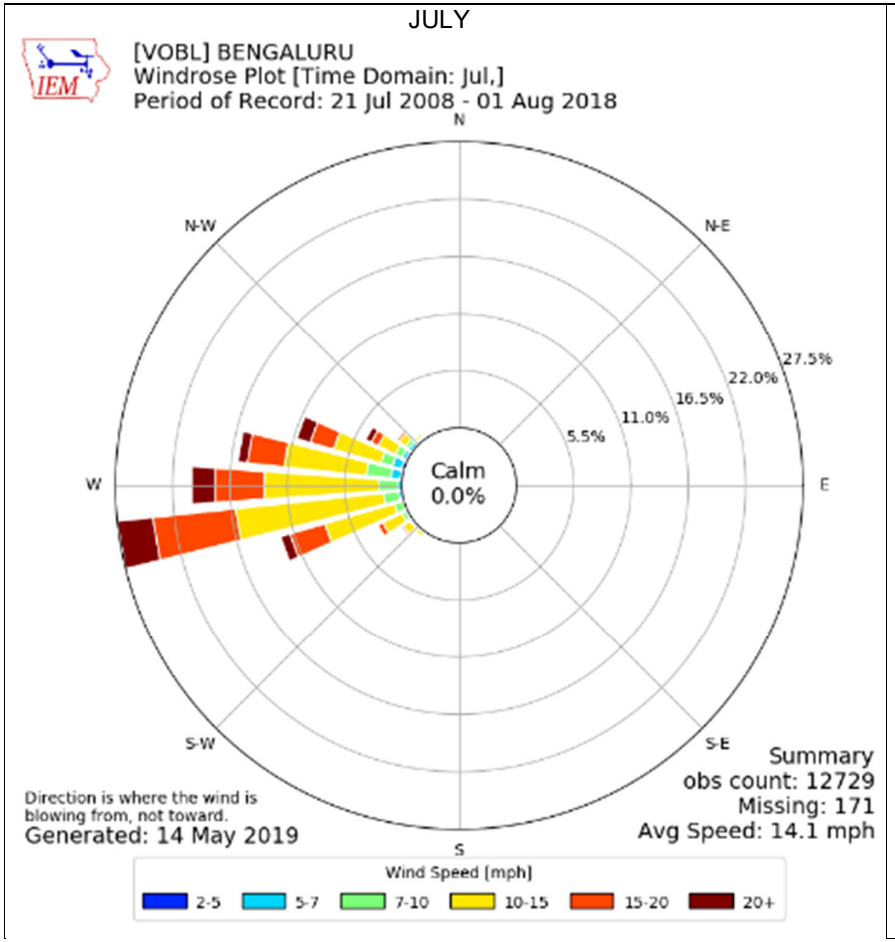
MAY


[VOBL] BENGALURU
Windrose Plot [Time Domain: May,]
Period of Record: 01 May 2009 - 14 May 2019
N
N-E
E
S-E
S
S-W
W
N-W
12.1%
9.7%
7.3%
4.9%
2.4%
Calm
0.5%
Summary
obs count: 12874
Missing: 2641
Avg Speed: 9.3 mph
Direction is where the wind is blowing from, not toward.
Generated: 14 May 2019
Wind Speed [mph]
2-5
5-7
7-10
10-15
15-20
20+

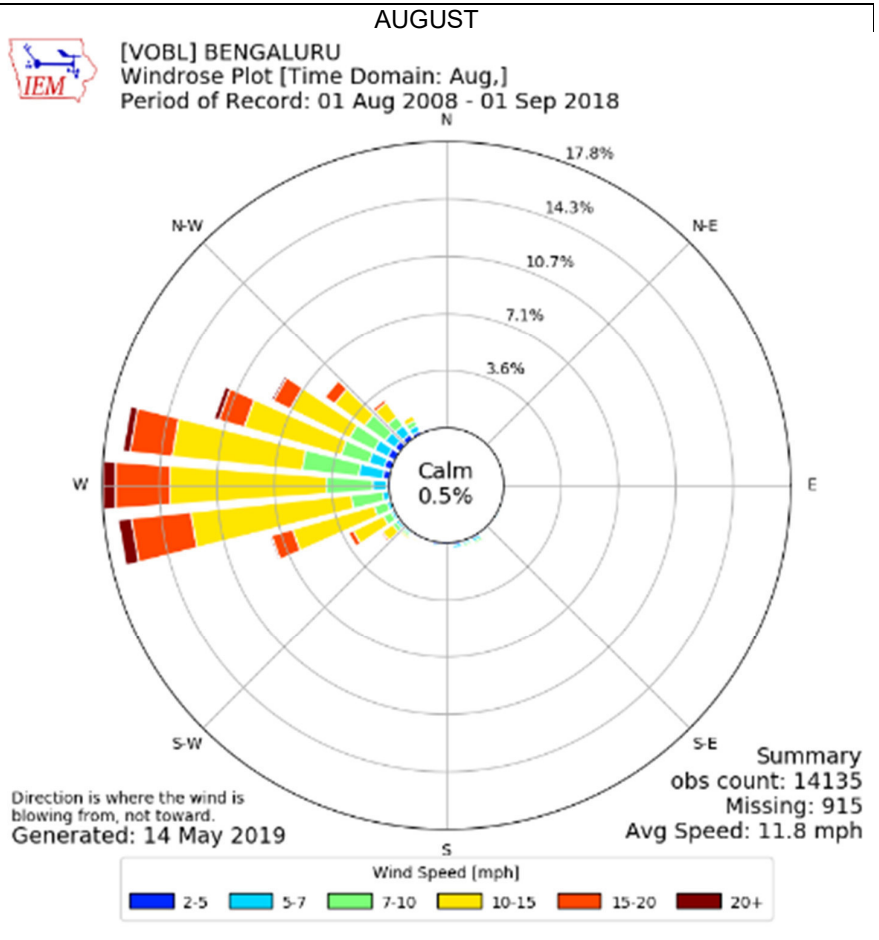
JUNE


[VOBL] BENGALURU
Windrose Plot [Time Domain: Jun,]
Period of Record: 01 Jun 2009 - 01 Jul 2018
N
N-E
E
S-E
S
S-W
W
N-W
4.9%
9.8%
14.7%
19.6%
24.5%
Calm
0.0%
Summary
obs count: 12001
Missing: 354
Avg Speed: 13.3 mph
Direction is where the wind is blowing from, not toward.
Generated: 14 May 2019
Wind Speed [mph]
2-5
5-7
7-10
10-15
15-20
20+

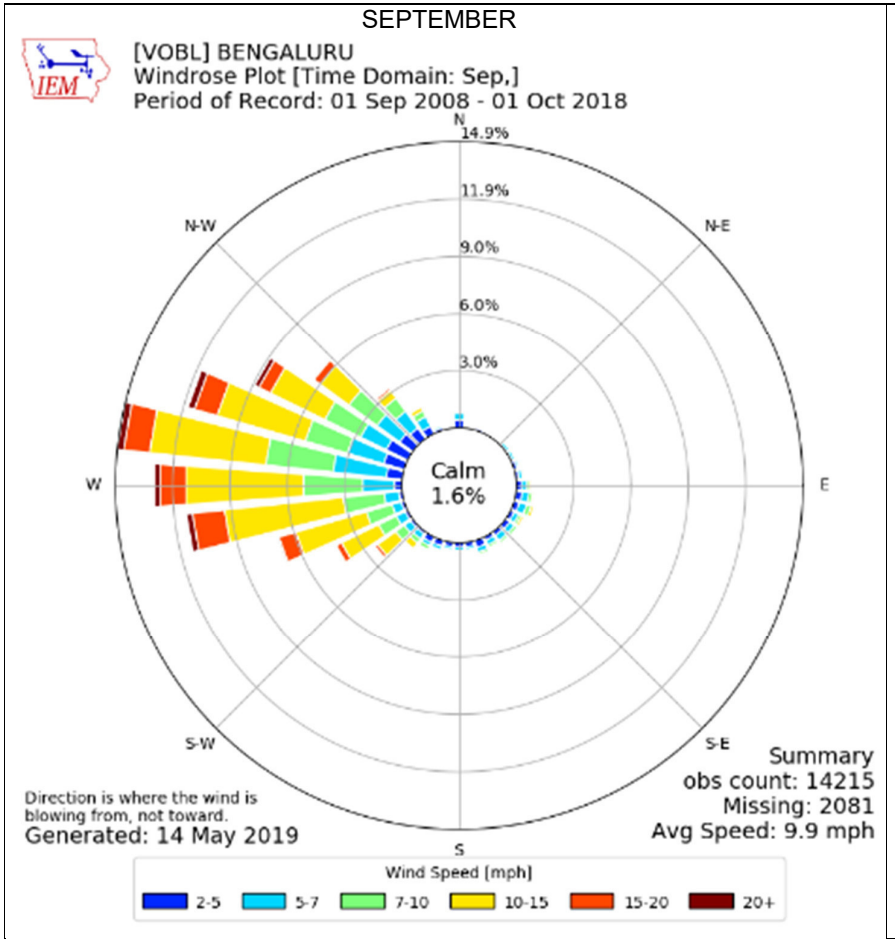
JULY


[VOBL] BENGALURU
Windrose Plot [Time Domain: Jul,]
Period of Record: 21 Jul 2008 - 01 Aug 2018
N
N-E
E
S-E
S
S-W
W
N-W
5.5%
11.0%
16.5%
22.0%
27.5%
Calm
0.0%
Summary
obs count: 12729
Missing: 171
Avg Speed: 14.1 mph
Direction is where the wind is blowing from, not toward.
Generated: 14 May 2019
Wind Speed [mph]
2-5
5-7
7-10
10-15
15-20
20+

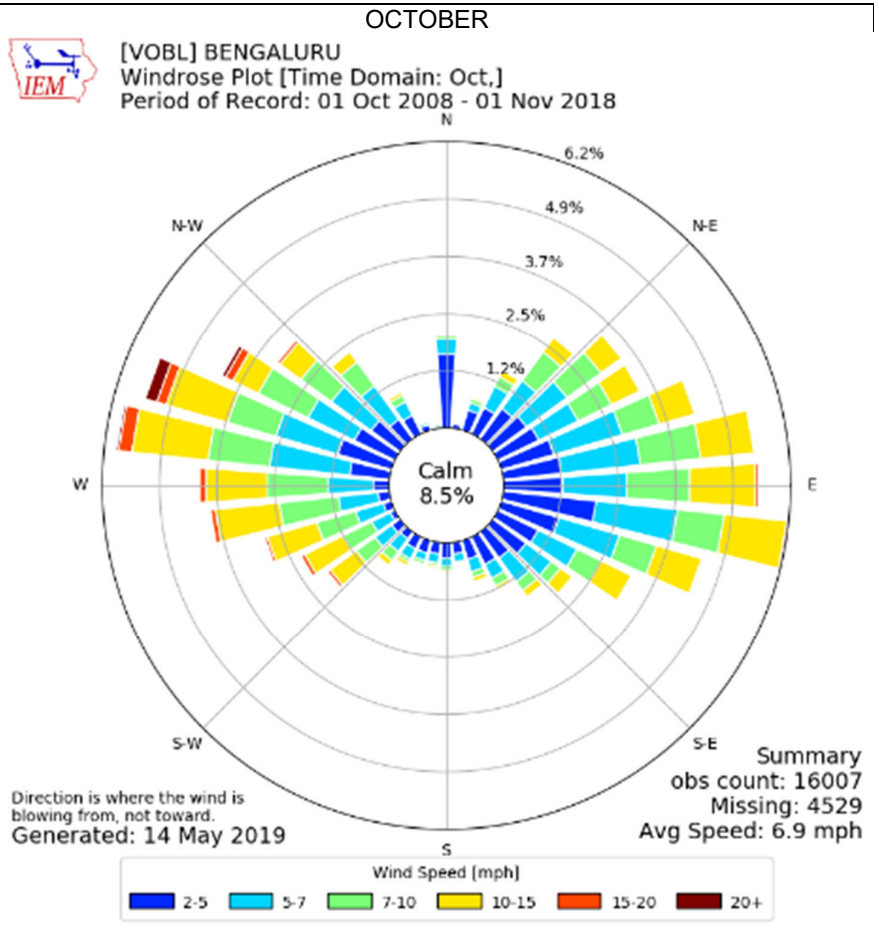
AUGUST


[VOBL] BENGALURU
Windrose Plot [Time Domain: Aug,]
Period of Record: 01 Aug 2008 - 01 Sep 2018
N
N-E
E
S-E
S
S-W
W
N-W
3.6%
7.1%
10.7%
14.3%
17.8%
Calm
0.5%
Summary
obs count: 14135
Missing: 915
Avg Speed: 11.8 mph
Direction is where the wind is blowing from, not toward.
Generated: 14 May 2019
Wind Speed [mph]
2-5
5-7
7-10
10-15
15-20
20+

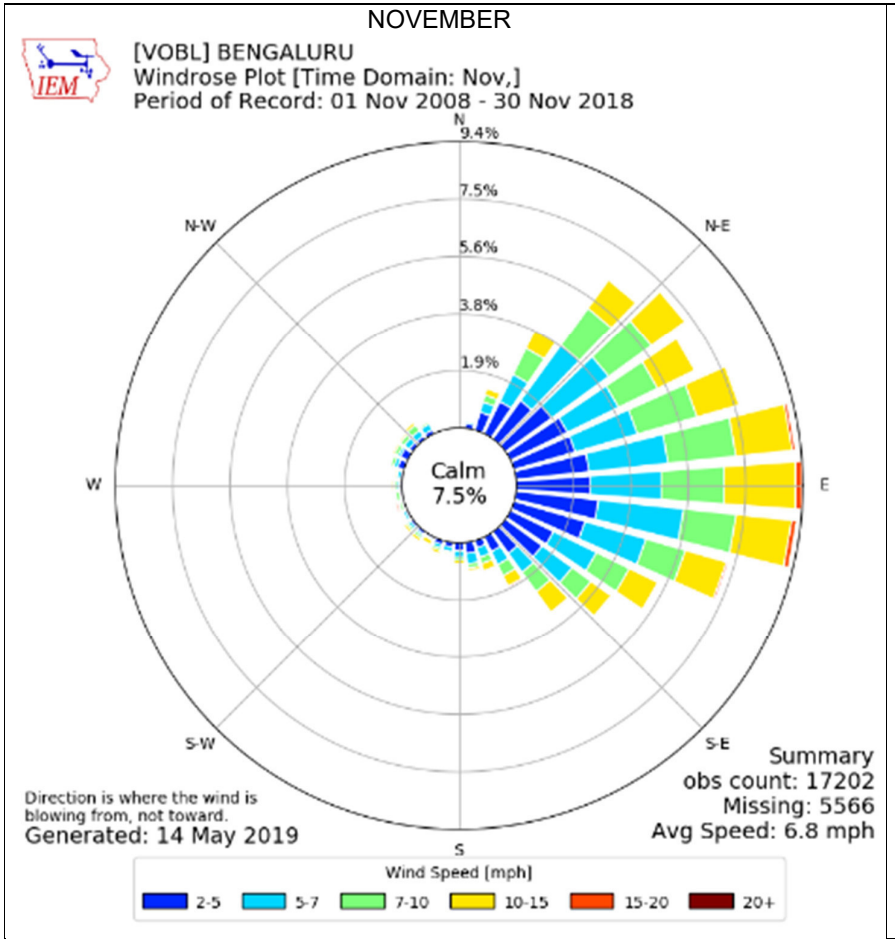
SEPTEMBER



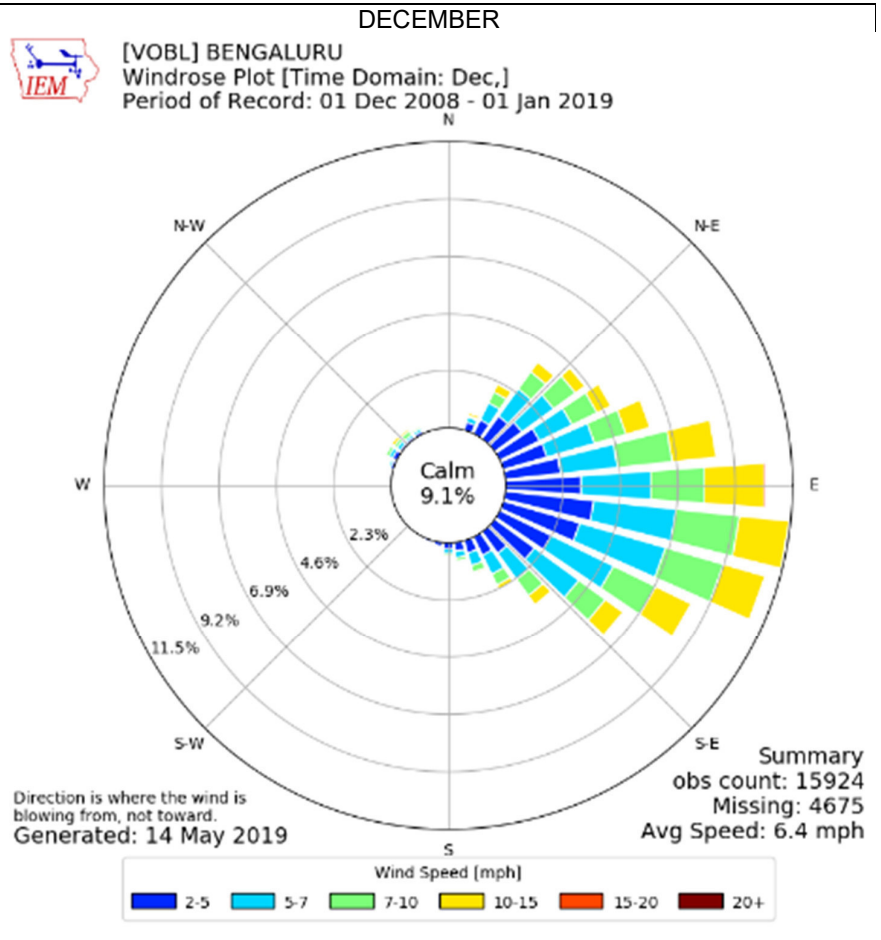
OCTOBER



NOVEMBER



DECEMBER



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

D. Ambient Air Quality

127. 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, PM2.5, 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

Sl. No.	Name of the Monitoring Stations	Month of Monitoring	Monthly average values of Pollutants in µg/m3					Index Value	Category
			PM10	PM2.5	SO2	NO2	NH3		
1	Export Promotion Industrial Park, ITPL, White Field Road.	Jan	*	*	*	*	*	*	*
		Feb	137	51	2	37	27	125	M
		Mar	98	43	2	35	31	98	S
		Apr	109	46	2	31	31	106	M
		May	95	37	2	31	30	95	S
		Jun	91	30	2	29	31	91	S
		Jul	66	27	2	25	26	66	S
		Aug	73	21	2	26	23	73	S
		Sep	73	26	2	21	17	73	S
		Oct	82	23	2	21	22	82	S
		Nov	99	28	2	20	18	99	S
		Dec	89	31	2	20	17	89	S
2	AMCO Batteries, Mysore Road	Jan	107	50	2	35	25	105	M
		Feb	92	40	2	37	39	92	S
		Mar	113	46	2	36	29	109	M
		Apr	99	42	2	33	29	99	S
		May	97	38	2	30	31	97	S
		Jun	89	32	2	29	31	89	S
		Jul	73	22	2	26	27	73	S
		Aug	68	29	2	26	25	68	S
		Sep	69	27	2	22	15	69	S
		Oct	83	26	2	23	21	83	S
		Nov	105	49	2	25	19	103	M
		Dec	89	30	2	22	23	89	S
3	Rail Wheel Factory, Yelahanka	Jan	170	*	2	32	25	147	M
		Feb	81	*	2	35	27	81	S
		Mar	117	*	2	37	28	111	M
		Apr	*	*	*	*	*	*	*
		May	123	41	2	33	29	115	M
		Jun	82	24	2	27	30	82	S
		Jul	56	26	2	23	26	56	S
		Aug	77	*	2	25	24	77	S
		Sep	78	*	2	19	20	78	S
		Oct	93	31	2	21	20	93	S
		Nov	67	29	2	18	18	67	S
		Dec	72	22	2	18	24	72	S
4	Swan Silk Pvt. Ltd.,	Jan	109	*	2	35	25	106	M
		Feb	125	*	2	36	26	117	M

Sl. No.	Name of the Monitoring Stations	Month of Monitoring	Monthly average values of Pollutants in µg/m3					Index Value	Category
			PM10	PM2.5	SO2	NO2	NH3		
	Peenya Industrial Area	Mar	147	*	2	37	22	131	M
		Apr	114	51	2	33	29	109	M
		May	89	*	2	31	29	89	S
		Jun	56	*	2	24	29	56	S
		Jul	*	*	*	*	*	*	*
		Aug	*	*	*	*	*	*	*
		Sep	*	*	*	*	*	*	*
		Oct	68	*	2	29	23	68	S
		Nov	106	40	2	21	16	104	M
		Dec	67	21	2	20	23	67	S
5	Victoria Hospital, K. R. Market	Jan	30	*	2	36	25	45	G
		Feb	46	23	2	32	25	46	G
		Mar	71	32	2	34	28	71	S
		Apr	59	28	2	33	27	59	S
		May	66	25	2	30	28	66	S
		Jun	65	28	2	25	28	65	S
		Jul	48	19	2	23	25	48	G
		Aug	55	18	2	21	26	55	S
		Sep	54	*	2	17	19	54	S
		Oct	55	17	2	21	18	55	S
		Nov	51	21	2	20	17	51	G
		Dec	65	20	2	16	23	65	S
6	Yeswanthapura Police Station, Yeswanthapura.	Jan	110	56	2	35	25	107	M
		Feb	108	53	2	35	26	105	M
		Mar	97	43	2	35	29	97	S
		Apr	93	41	2	34	27	93	S
		May	85	43	2	31	28	85	S
		Jun	71	23	2	29	29	71	S
		Jul	67	27	2	24	27	67	S
		Aug	62	23	2	24	25	62	S
		Sep	*	*	*	*	*	*	*
		Oct	57	24	2	23	20	57	S
		Nov	68	29	2	22	18	68	S
		Dec	68	20	2	22	21	68	S
7	TERRI Office Premises, Domlur.	Jan	91	45	2	35	25	91	S
		Feb	92	43	2	36	26	92	S
		Mar	66	*	2	35	34	66	S
		Apr	80	35	2	33	30	80	S
		May	66	31	2	33	29	66	S
		Jun	87	*	2	25	30	87	S
		Jul	61	20	2	23	26	61	S
		Aug	89	21	2	23	26	89	S
		Sep	79	20	2	22	20	79	S
		Oct	89	27	2	20	17	89	S
		Nov	114	34	2	24	16	109	M
		Dec	121	38	2	21	25	114	M
8	Central Silk Board, Hosur Road,	Jan	144	66	2	35	24	129	M
		Feb	156	56	2	35	25	137	M
		Mar	152	67	2	34	26	135	M
		Apr	122	44	2	35	28	115	M
		May	109	43	2	30	30	106	M
		Jun	91	31	2	28	27	91	S
		Jul	66	20	2	22	24	66	S
		Aug	80	18	2	24	24	80	S
		Sep	61	*	2	19	16	61	S
		Oct	95	31	2	25	18	95	S
		Nov	100	40	2	23	19	100	S

Sl. No.	Name of the Monitoring Stations	Month of Monitoring	Monthly average values of Pollutants in µg/m3					Index Value	Category
			PM10	PM2.5	SO2	NO2	NH3		
		Dec	99	35	2	21	22	99	S
9	Mr. Madhachari's House, Kazisonnenihalli.	Jan	91	*	2	36	25	91	S
		Feb	98	*	2	35	26	98	S
		Mar	119	53	2	34	28	113	M
		Apr	98	40	2	31	24	98	S
		May	98	38	2	32	29	98	S
		Jun	79	27	2	24	26	79	S
		Jul	65	20	2	20	22	65	S
		Aug	66	15	2	20	23	66	S
		Sep	56	19	2	18	18	56	S
		Oct	64	20	2	23	21	64	S
		Nov	91	35	2	21	16	91	S
		Dec	75	32	2	20	14	75	S
10	Urban Eco Park, KSPCB Office Premises, Peenya.	Jan	*	*	*	*	*	*	*
		Feb	*	*	*	*	*	*	*
		Mar	*	*	*	*	*	*	*
		Apr	92	45	2	32	26	92	S
		May	121	63	2	33	31	114	M
		Jun	109	42	2	29	27	106	M
		Jul	59	12	2	22	25	59	S
		Aug	92	32	2	25	25	92	S
		Sep	108	34	2	20	19	105	M
		Oct	115	40	2	25	22	110	M
		Nov	78	30	2	22	18	78	S
		Dec	82	25	2	18	22	82	S
11	Indira Gandhi Children Health Care Centre	Jan	65	*	2	35	25	65	S
		Feb	50	*	2	35	26	50	G
		Mar	72	37	2	35	29	72	S
		Apr	68	32	2	31	25	68	S
		May	63	30	2	29	28	63	S
		Jun	53	24	2	25	25	53	S
		Jul	52	17	2	21	23	52	S
		Aug	57	17	2	23	24	57	S
		Sep	55	17	2	19	13	55	S
		Oct	50	22	2	22	20	50	G
		Nov	57	*	2	21	18	60	S
		Dec	65	22	2	17	23	65	S
12	Banasawadi Police Station, Banasawadi	Jan	57	*	2	29	23	57	S
		Feb	45	*	2	16	23	45	G
		Mar	49	*	2	23	24	49	G
		Apr	*	*	*	*	*	*	*
		May	*	*	*	*	*	*	*
		Jun	*	*	*	*	*	*	*
		Jul	*	*	*	*	*	*	*
		Aug	68	*	2	22	24	68	S
		Sep	83	*	2	18	15	83	S
		Oct	73	*	2	21	20	73	S
		Nov	110	*	2	19	17	107	M
		Dec	105	*	2	20	21	103	M
13	S.K.R Silver Jublee Building, K. R. Circle.	Jan	39	*	2	29	24	39	G
		Feb	47	*	2	31	22	47	G
		Mar	42	*	2	22	22	42	G
		Apr	38	*	2	24	29	38	G
		May	64	*	2	25	25	64	S
		Jun	41	*	2	25	24	41	G
		Jul	57	13	2	21	21	57	S
		Aug	78	*	2	23	22	78	S

Sl. No.	Name of the Monitoring Stations	Month of Monitoring	Monthly average values of Pollutants in µg/m3					Index Value	Category
			PM10	PM2.5	SO2	NO2	NH3		
		Sep	117	*	2	20	18	111	M
		Oct	57	26	2	21	20	57	S
		Nov	111	*	2	21	16	107	M
		Dec	106	*	2	21	22	104	M

***-** Monitoring was not done

Sl. No.	Range	Category
1	0-50	G – Good
2	51-100	S – Satisfactory
3	101-200	M – Moderate
4	201-300	P – Poor
5	301-400	V - Very Poor
6	> 401	Se – Severe

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

128. Air quality monitoring by KSPCB using continuous ambient air quality monitoring (CAAQM), cannot be compared with to 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.

129. Baseline data on ambient air quality along the project alignment was collected from 8 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 the 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 8 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 4-6.The monitored values of air quality should also comply with IFC 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-8	Near Steel Authority of India, Outer Ring Road, Govindapura, Dooravani nagar, Bengaluru	Industrial
AAQ-9	Near Kalyannagar BMTC Depot, (near Kalyan nagar Metro Station) Outer Ring Road, Bengaluru	Hospital & School
6AQ-10	Near Manyata Embassy Business Park (Near proposed Verannana palya Metro Station) Outer Ring Road Bengaluru	Mixed use
AAQ-11	Near Aster CMI Hospital, Hebbala, Airport Road Bengaluru	Hospital & School
AAQ-12	Near University of Agricultural Sciences Library, Airport Road, Bengaluru	Hospital & Library
AAQ-13	Near Kogilu Cross along Airport Road (near proposed Kogilu Cross Metro Station)	Mixed use
AAQ-14	Near Airforce Station Kendriya Vidyalaya, Airport Road	Schools
AAQ-15	Near ITC Factory, Airport Road (Trumphet Junction)	Industrial

130. 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 tetra-chloro-mercurate solution. - The absorbance of the intensely colored para-rosaniline methyl sulphonic acid was measured and the amount of SO2 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 NOx 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- 3: Air and Noise Sampling Locations

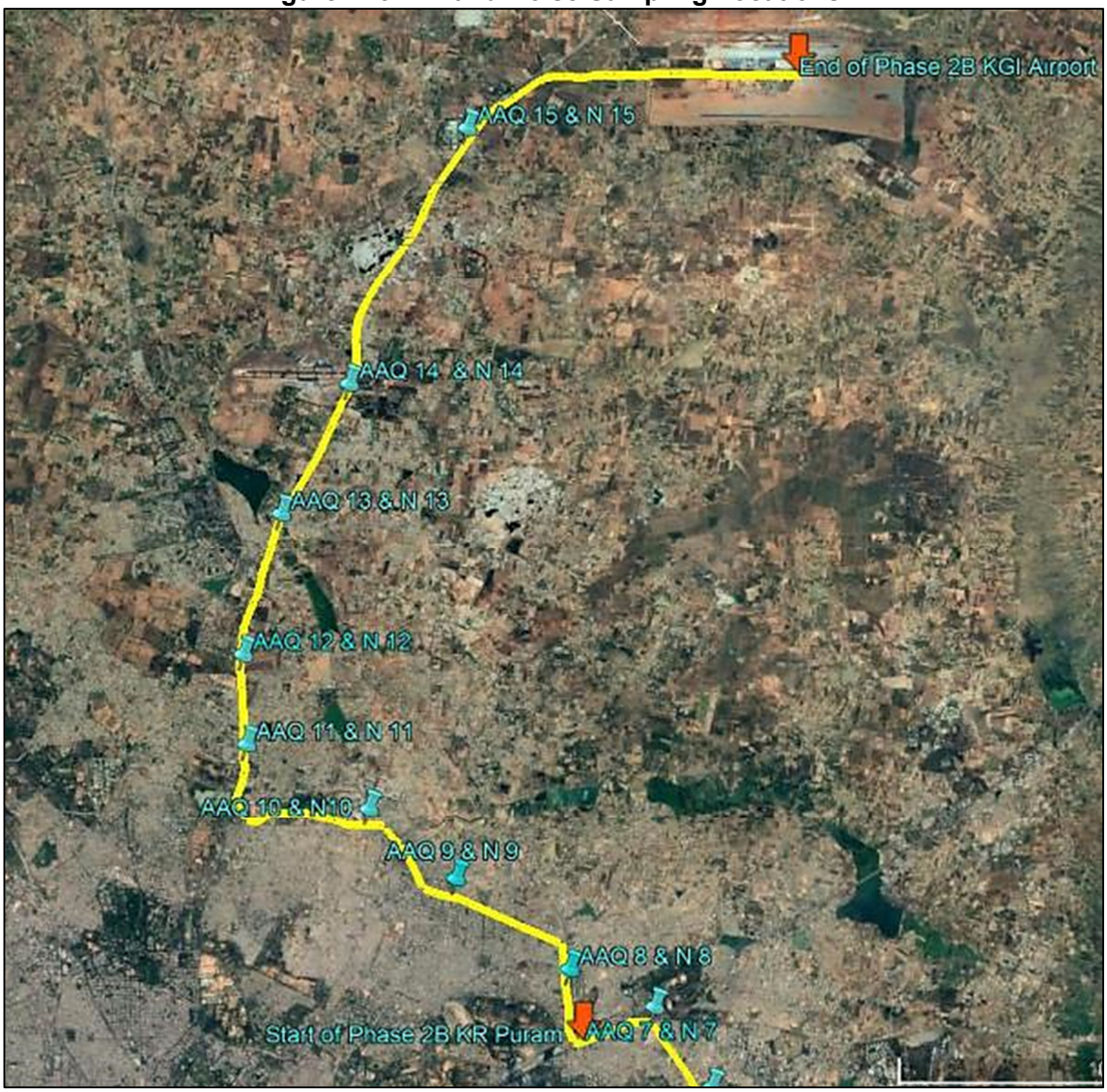


Table 4- 6: Ambient Air Quality along proposed Airport Metro Line

Parameters	Sample	AAQ8	AAQ9	AAQ10	AAQ11	AAQ12	AAQ13	AAQ14	AAQ15
PM10 24 Hourly (in µg/m³)	NAAQS	100	100	100	100	100	100	100	100
	WHO	50	50	50	50	50	50	50	50
	Sample I	77.4	89.1	81.8	76	97.2	82.2	62.5	90.6
	Sample II	70.3	92	84.4	79.3	99.1	88.5	59.5	80.2
	Average	73.85	90.55	83.1	77.65	98.15	85.35	61	85.4
PM 2.5 24 Hourly (in µg/m³)	NAAQS	60	60	60	60	60	60	60	60
	WHO	25	25	25	25	25	25	25	25
	Sample I	28.3	42.5	36	32.8	38.7	34.2	28.5	32.1
	Sample II	31	33.9	36.3	33.5	41.3	28.7	26.3	25.8
	Average	29.65	38.2	36.15	33.15	40	31.45	27.4	28.95

Parameters	Sample	AAQ8	AAQ9	AAQ10	AAQ11	AAQ12	AAQ13	AAQ14	AAQ15
SO2 24 Hourly (in µg/m³)	NAAQS	80	80	80	80	80	80	80	80
	WHO	20	20	20	20	20	20	20	20
	Sample I	8.11	9.04	10.81	9.82	8.89	8.47	8.16	8.52
	Sample II	7.4	10.39	9.27	8.21	9.78	9.17	7.9	8.97
	Average	7.755	9.715	10.04	9.015	9.335	8.82	8.03	8.745
NOX 24 Hourly (in µg/m³)	NAAQS	80	80	80	80	80	80	80	80
	WHO	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Sample I	29.73	25.43	31.35	27.29	27.07	21.15	27.92	28.94
	Sample II	24.86	28.14	25.83	25.28	29.24	24.52	22.32	26.27
	Average	27.295	26.785	28.59	26.285	28.155	22.835	25.12	27.605
CO 8 Hourly (in mg/m³)	NAAQS	4	4	4	4	4	4	4	4
	WHO	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Sample I	0.79	0.85	1.73	1.23	1.36	1.09	0.82	1.12
	Sample II	0.98	1.76	1.29	1.09	1.58	1.37	0.78	1.2
	Average	0.885	0.9225	1.51	1.16	1.47	1.23	0.8	1.16
Pb, µg/ m3	NAAQS	1	1	1	1	1	1	1	1
	WHO	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Sample I	0.045	0.035	0.021	0.019	0.025	0.044	0.028	0.014
	Sample II	0.049	0.034	0.031	0.054	0.057	0.031	1	0.006
	Average	0.047	0.0345	0.026	0.0365	0.041	0.0375	0.514	0.01

NAAQS: National Ambient Air Quality Standards
WHO: World Health Organization Air Quality Guidelines, Global Update, 2005

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

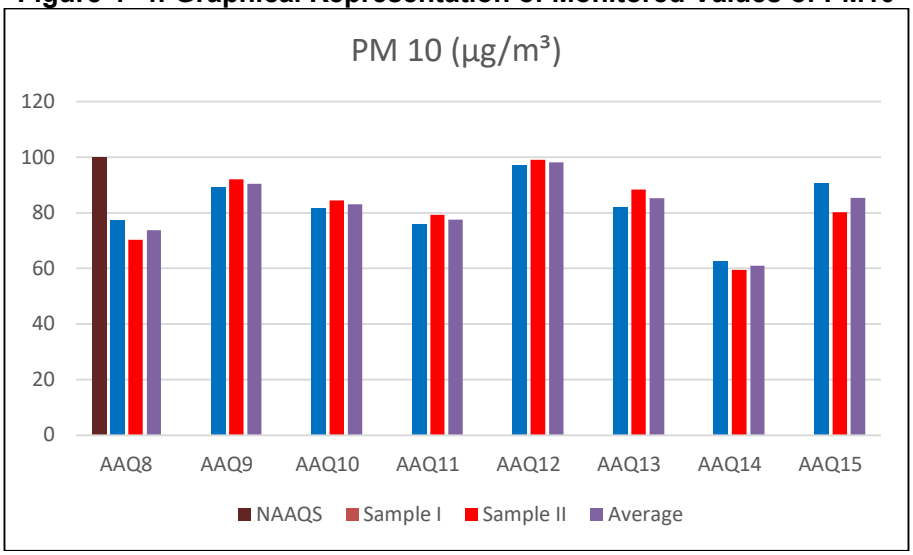


Figure 4- 5: Graphical Representation of Monitored Values of PM2.5

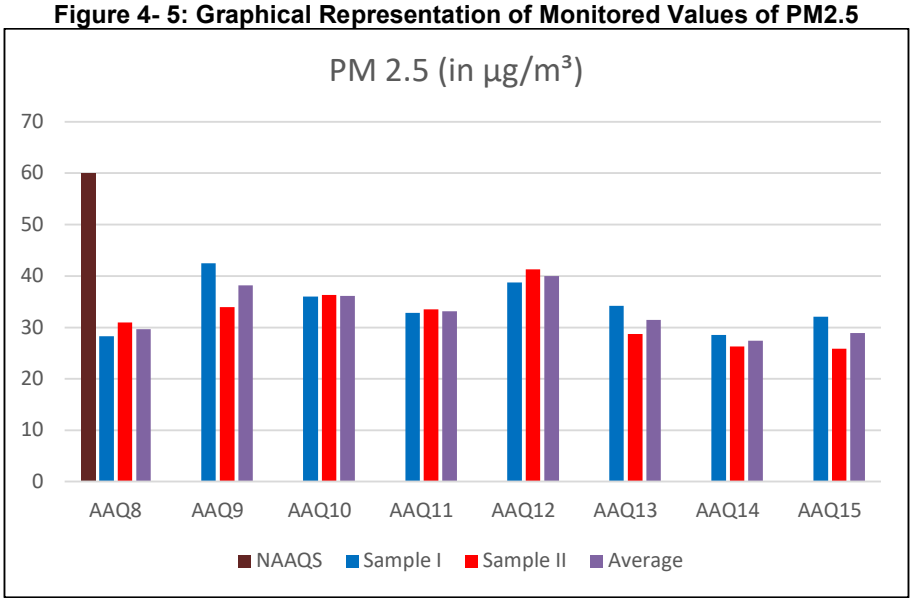


Figure 4- 6: Graphical Representation of Monitored Values of SO2

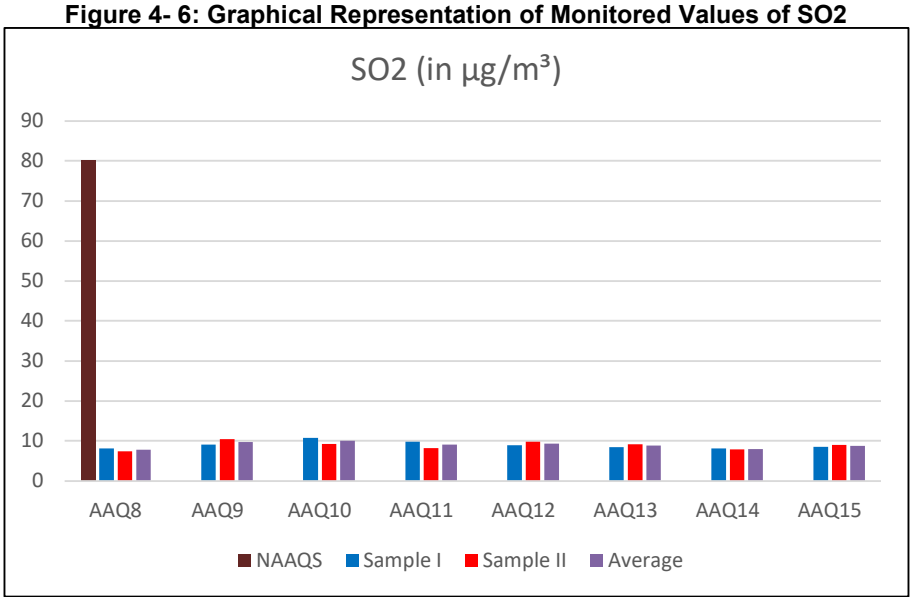


Figure 4- 7: Graphical Representation of Monitored Values of NOx

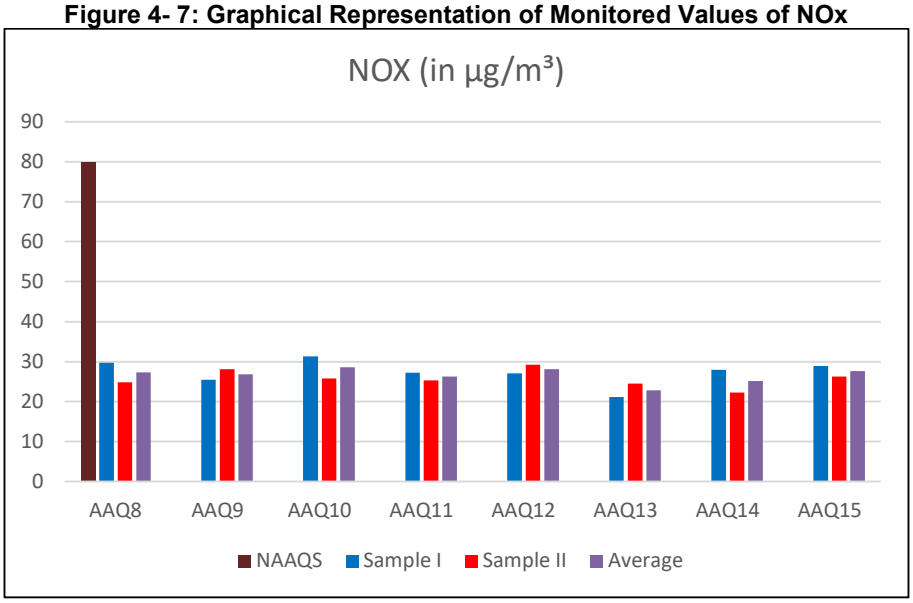


Figure 4- 8: Graphical Representation of Monitored Values of CO

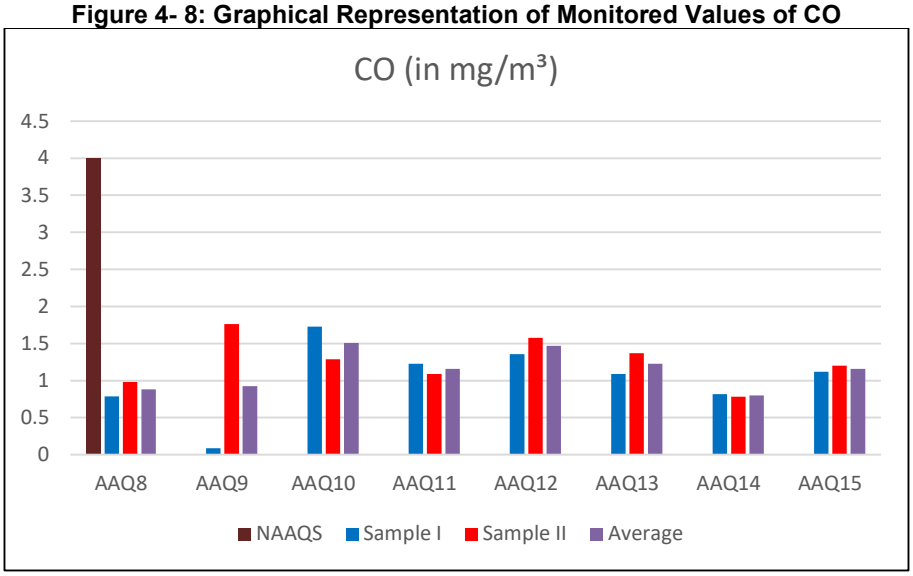
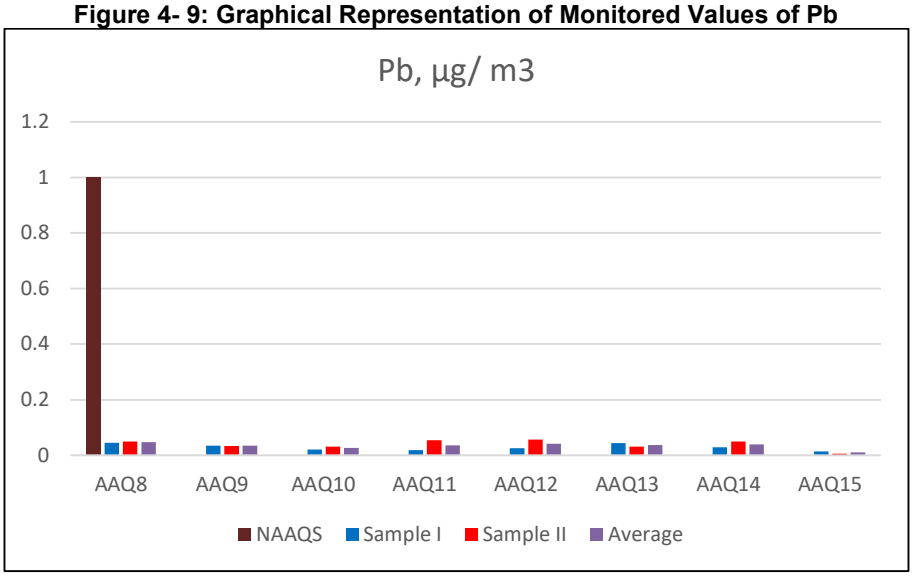


Figure 4- 9: Graphical Representation of Monitored Values of Pb



i. Inference on the monitored Ambient Air Quality Results

131. **Particulate Matter (PM_{10})**: The average concentrations for PM10 recorded were within the prescribed CPCB limits of 100µg/m^3 but exceeded the WHO guideline value of 50 µg/m^3 at all the eight monitored locations. The minimum value for PM10 was recorded as 61.0 at Airforce Station Kendriya Vidyalaya, Airport Roadand the maximum value was recorded as 98.15 µg/m3 at University of Agricultural Sciences Library, Airport Road.

132. **Particulate Matter ($PM_{2.5}$)**:The average concentrations for PM2.5 recorded were within the prescribed CPCB limits of 60µg/m3 but exceeded the WHO guideline value of 25 µg/m^3at all the sampling locations. The minimum value for PM2.5 was recorded as 27.4at Airforce Station Kendriya Vidyalaya, Airport Roadand the maximum value was recorded as 40.0 µg/m3 at University of Agricultural Sciences Library, Airport Road.

133. Sulphur Dioxide (SO_2): The average concentrations for SO_2 recorded were within the prescribed CPCB limits of 80 µg/$m^3$and the WHO guideline value of 20 µg/m^3at all the sampling locations. The maximum value of SO_2 was recorded as 10.04 µg/m3 at Manyata Embassy Business Park Outer Ring Road and minimum value of 7.76 µg/m3 was recorded at Steel Authority of India, Outer Ring Road.

134. Oxides of Nitrogen (NOx): The average concentrations for NO_X recorded were within the prescribed CPCB limits of 80 µg/m3 at all the sampling locations. The maximum NOx concentration was observed to be 28.59 µg/m3 at Manyata Embassy Business Park, Outer Ring Road and minimum value of 22.84 µg/m3 was recorded at Kogilu Cross along Airport Road.

135. Carbon Monoxide(CO): The average concentrations for CO recorded were within the prescribed CPCB limits of 4 mg/m3 at all the sampling locations. The maximum CO concentration was observed to be 1.51 mg/m3 at Manyata Embassy Business Park, Outer Ring Road and minimum value of 0.80 mg/m3 recorded at Airforce Station Kendriya Vidyalaya, Airport Road.

136. Lead (Pb): The average concentrations for Pb recorded were within the prescribed CPCB limits of 1 µg/m3 at all the sampling locations. The maximum Pb concentration was observed to be 0.047 µg/m3 at Steel Authority of India, Outer Ring Road and minimum value of 0.01 µg/m3 was recorded at ITC Factory, Airport Road.

Figure 4- 10:: Photographs of Ambient Air Quality Monitoring

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>AAQ 8 –Near Steel Authority of India, Outer Ring Road</td><td>AAQ 9–Near Kalyan nagar BMTC Depot, Outer Ring Road</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>AAQ 10–Near Manyata Embassy Business Park Outer Ring Road</td><td>AAQ 11–Near Aster CMI Hospital, Hebbala, Airport Road</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>AAQ 12–Near University of Agricultural Sciences Library, Airport Road</td><td>AAQ 13–Near Kogilu Cross along Airport Road</td></tr>
</table>

	
AAQ 14 – Near Airforce Station Kendriya Vidyalaya, Airport Road	AAQ 15 – Near ITC Factory, Airport Road / Trumpet Junction

E. Noise Environment

137. Noise levels were monitored continuously for 24 hours at eight (8) 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

Location Code	Ambient Noise Sampling Locations	Land use Category
N-8	Near Steel Authority of India, Outer Ring Road, Govindapura, Dooravani nagar, Bengaluru	Residential& Industrial
N-9	Near Kalyan nagar BMTC Depot, (near Kalyan nagar Metro Station) Outer Ring Road, Bengaluru	Hospital & School
N-10	Near Manyata Embassy Business Park (Near proposed Verannana palya Metro Station) Outer Ring Road Bengaluru	Mixed use
N-11	Near Aster CMI Hospital, Hebbala, Airport Road Bengaluru	Hospital & School
N-12	Near University of Agricultural Sciences Library, Airport Road, Bengaluru	Hospital & Library
N-13	Near Kogilu Cross along Airport Road (near proposed Kogilu Cross Metro Station)	Mixed use
N-14	Near Airforce Station Kendriya Vidyalaya, Airport Road	Schools
N-15	Near ITC Factory, Airport Road	Industrial

138. The results of the ambient noise level monitoring along with CPCB noise limits for day time and night time are presented in table 4-8 below.

Table 4- 8: Noise Levels along the proposed project alignment

Station Id.	Sample Location	Time Frequency	Parameters in dB(A)			CPCB Standards for Residential Zone
			Max.	Min.	Leq	
N8	Steel Authority of India, Outer Ring Road	6:01am to 10:00pm	91.6	32.8	94.15	55 dB(A) Day
		10:01pm to 6:00am	92.3	33.5	69.11	45 dB(A) Night
N9	Kalyan nagar BMTC Depot, Outer Ring Road	6:01am to 10:00pm	99.5	51.0	90.94	65 dB(A) Day
		10:01pm to 6:00am	89.3	48.2	61.71	55 dB(A) Night

N10	Manyata Embassy Business Park Outer Ring Road	6:01am to 10:00pm	91.1	32.8	100.30	65 dB(A) Day
		10:01pm to 6:00am	85.8	32.0	48.64	55 dB(A) Night
N11	Aster CMI Hospital, Hebbala, Airport Road	6:01am to 10:00pm	88.5	52.3	69.65	50 dB(A) Day
		10:01pm to 6:00am	72.2	50.1	61.14	40 dB(A) Night
N12	University of Agricultural Sciences Library, Airport Road	6:01am to 10:00pm	84.8	50.0	63.85	50 dB(A) Day
		10:01pm to 6:00am	81.0	40.0	55.60	40 dB(A) Night
N13	Kogilu Cross along Airport Road	6:01am to 10:00pm	99.6	63.2	76.37	65 dB(A) Day
		10:01pm to 6:00am	84.0	63.2	74.23	55 dB(A) Night
N14	Airforce Station Kendriya Vidyalaya, Airport Road	6:01am to 10:00pm	85.0	34.0	89.65	50 dB(A) Day
		10:01pm to 6:00am	72.9	33.2	47.03	40 dB(A) Night
N15	ITC Factory, Airport Road	6:01am to 10:00pm	86.7	51.3	67.32	75 dB(A) Day
		10:01pm to 6:00am	78.4	47.3	61.54	70 dB(A) Night

Figure 4- 11: Graphical Representation of Noise Levels at N8

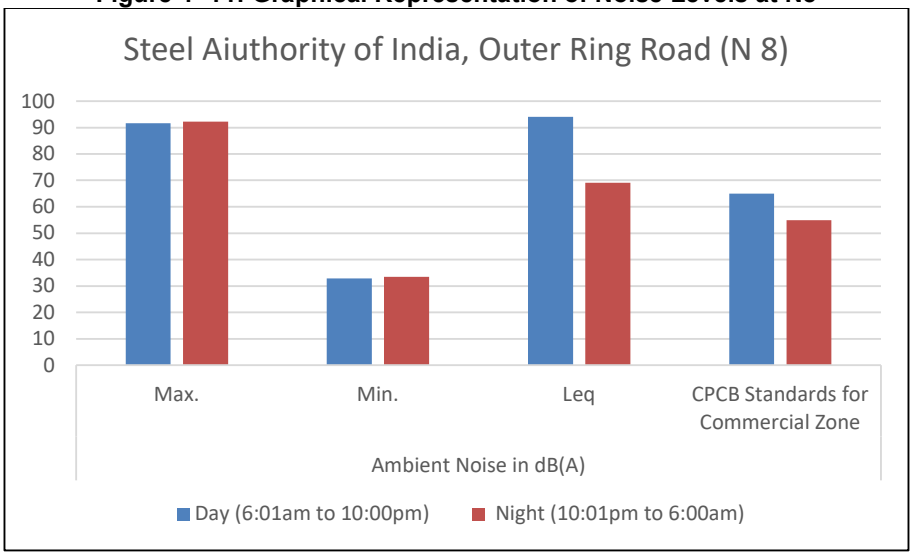


Figure 4- 12: Graphical Representation of Noise Levels at N9

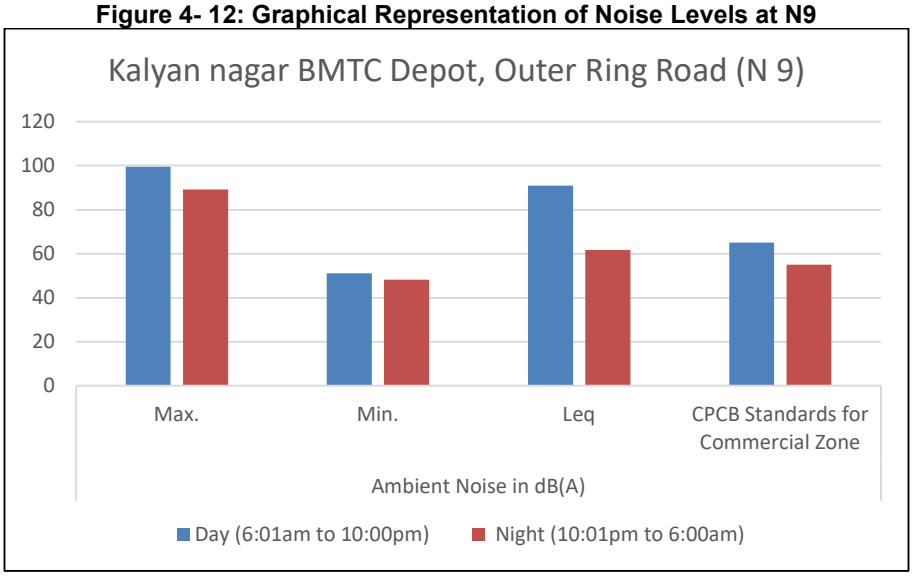


Figure 4- 13: Graphical Representation of Noise Levels at N10

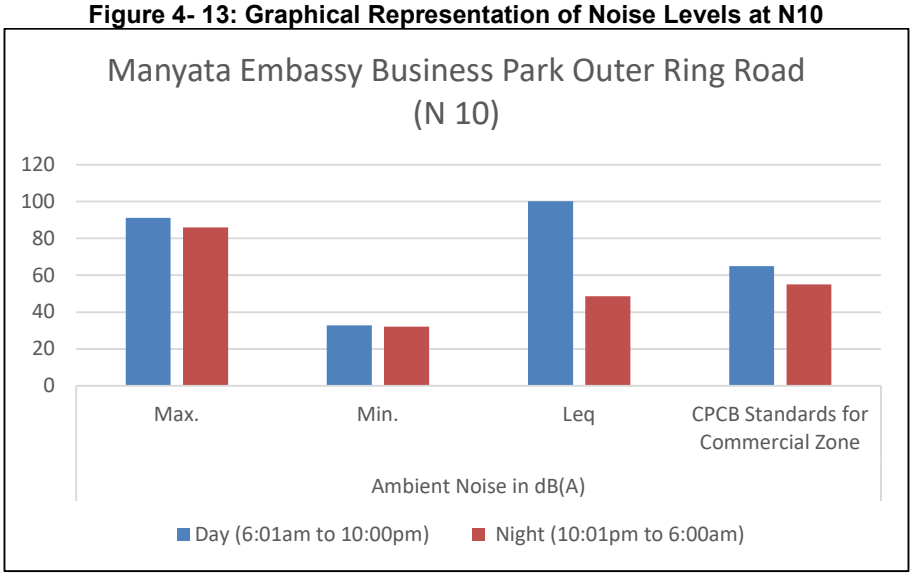


Figure 4- 14: Graphical Representation of Noise Levels at N11

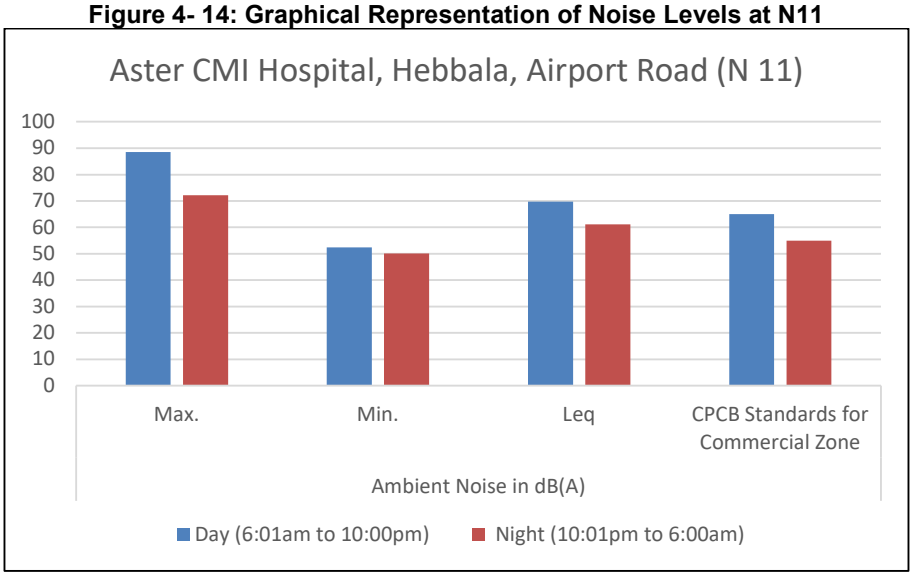


Figure 4- 15: Graphical Representation of Noise Levels at N12

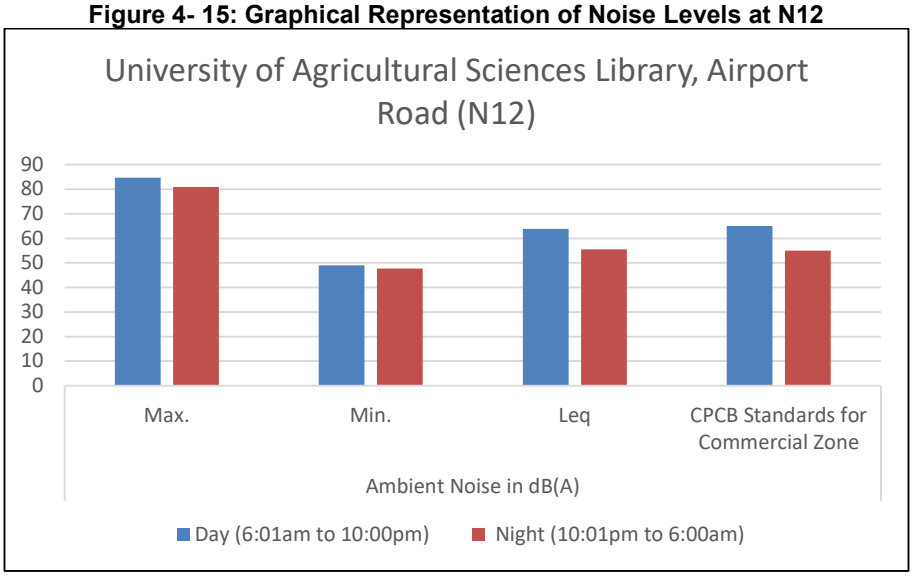


Figure 4- 16: Graphical Representation of Noise Levels at N13

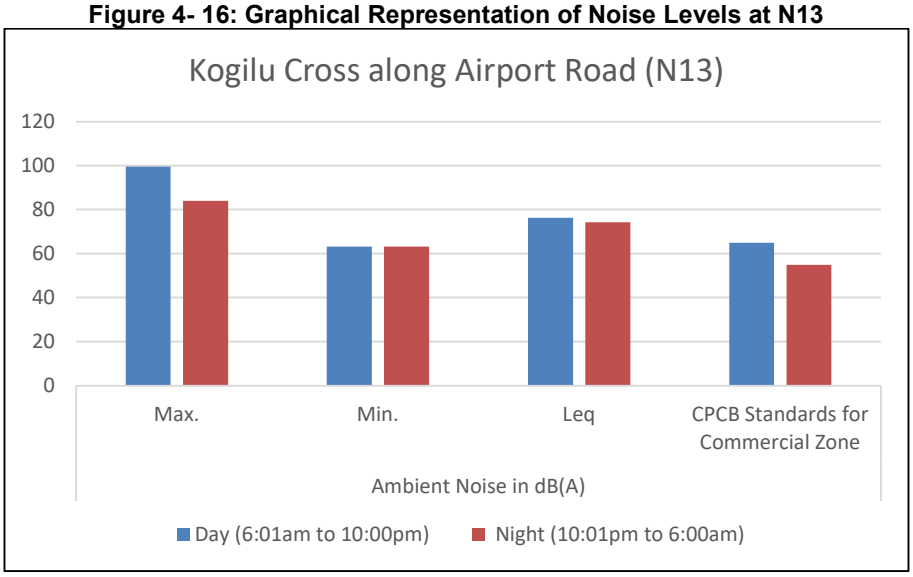


Figure 4- 17: Graphical Representation of Noise Levels at N14

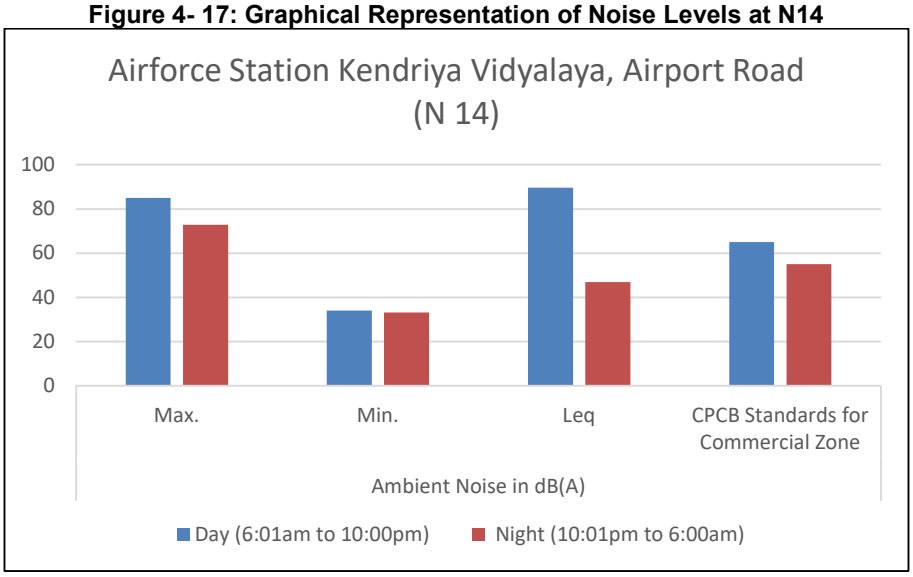


Figure 4- 18: Graphical Representation of Noise Levels at N15

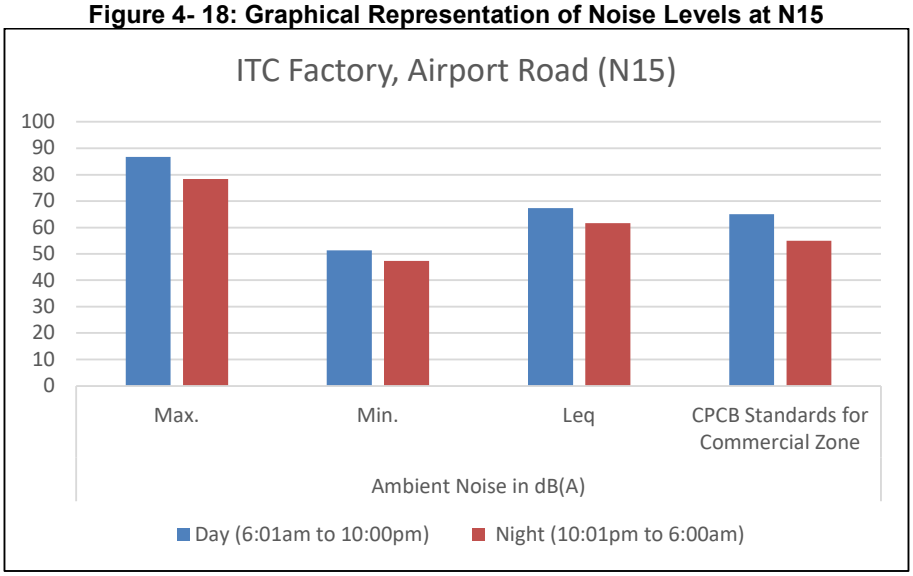


Figure 4- 19:: Photographs of Ambient Noise Monitoring

N8 - Steel Authority of India, Outer Ring Road

N9 - Kalyan nagar BMTC Depot, Outer Ring Road

N10 - Manyata Embassy Business Park Outer Ring Road

N11 - Aster CMI Hospital, Hebbala, Airport Road

	
N12 - University of Agricultural Sciences Library, Airport Road	N13 -Kogilu Cross along Airport Road
	
N14 – Airforce Station Kendriya Vidyalaya, Airport Road	N15 – ITC Factory, Airport Road

i. Inference on the monitored Noise levels

139. Noise levels were monitored at 8 different locations along the project alignment.

140. **Steel Authority of India, Outer Ring Road (N8):** The Leq values of noise were 94.15 dB(A) and 69.11 dB(A) for day and night respectively and noise for both day and night exceeded CPCB prescribed norms for Residential Zones.

141. **Kalyan nagar BMTC Depot, Outer Ring Road (N9):**The Leq values of noise were 90.94 dB(A) and 61.71 dB(A) for day and night respectively and noise for both day and night exceeded CPCB prescribed norms for Commercial Zones.

142. **Manyata Embassy Business Park Outer Ring Road (N10):** The Leq values of noise were 100.30dB(A) and 48.64 dB(A) for day and night respectively and noise for day exceeded CPCB prescribed norms for commercial areas and noise for night was found to be within the prescribed norms.

143. **Aster CMI Hospital, Hebbala, Airport Road (N11):** The Leq values of noise were 69.65dB(A) and 61.14 dB(A) for day and night respectively and noise for both day and night exceeded CPCB prescribed norms for Silence zones.

144. **University of Agricultural Sciences Library, Airport Road (N12):** The Leq values of noise were 63.85dB(A) and 55.60 dB(A) for day and night respectively and noise for day and night exceeded CPCB prescribed norms for Silence zones.

145. **Kogilu Cross along Airport Road (N13):** The Leq values of noise were 76.37 dB(A) and 74.23 dB(A) for day and night respectively and noise for both day and night exceeded CPCB prescribed norms for Commercial Zones.

146. **Airforce Station Kendriya Vidyalaya, Airport Road (N14):** The Leq values of noise were 89.65 dB(A) and 47.03 dB(A) for day and night respectively and noise both for day and night exceeded CPCB prescribed norms for Silence Zones.

147. ITC Factory, Airport Road (N15): The Leq values of noise were 67.32 dB(A) and 61.54 dB(A) for day and night respectively and noise for both day and night are within CPCB prescribed norms for Industrial areas.

F. Vibration Monitoring

148. The common sources of vibration during construction of an elevated metro project is pile driving. 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 vibrations 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 4.9 and are shown in Figure 4.21.

149. 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 will be annexed with this report.

Table 4- 9: Details of Vibrationmonitoring locations

Sl. No.	Station Code	Locations of Vibration Monitoring Stations	Chainage (km)	LHS/ RHS	Distance from Center Line (m)
1	VM6	Motherhood Hospital	3+700	LHS	30.00
2	VM7	Manyata Tech Park	9+200	RHS	25.00
3	VM8	Columbia Asia Hospital Hebbal	12+100	RHS	44.70
4	VM9	Cytecare Cancer Hospital,	19+900	LHS	90.00
5	VM10	Chikkajala Fort	26+900	RHS	33.00

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June 2020

India: Bengaluru Metro Rail Project

Phase 2B (Airport Metro Line)
KR Puram to Kempegowda International Airport

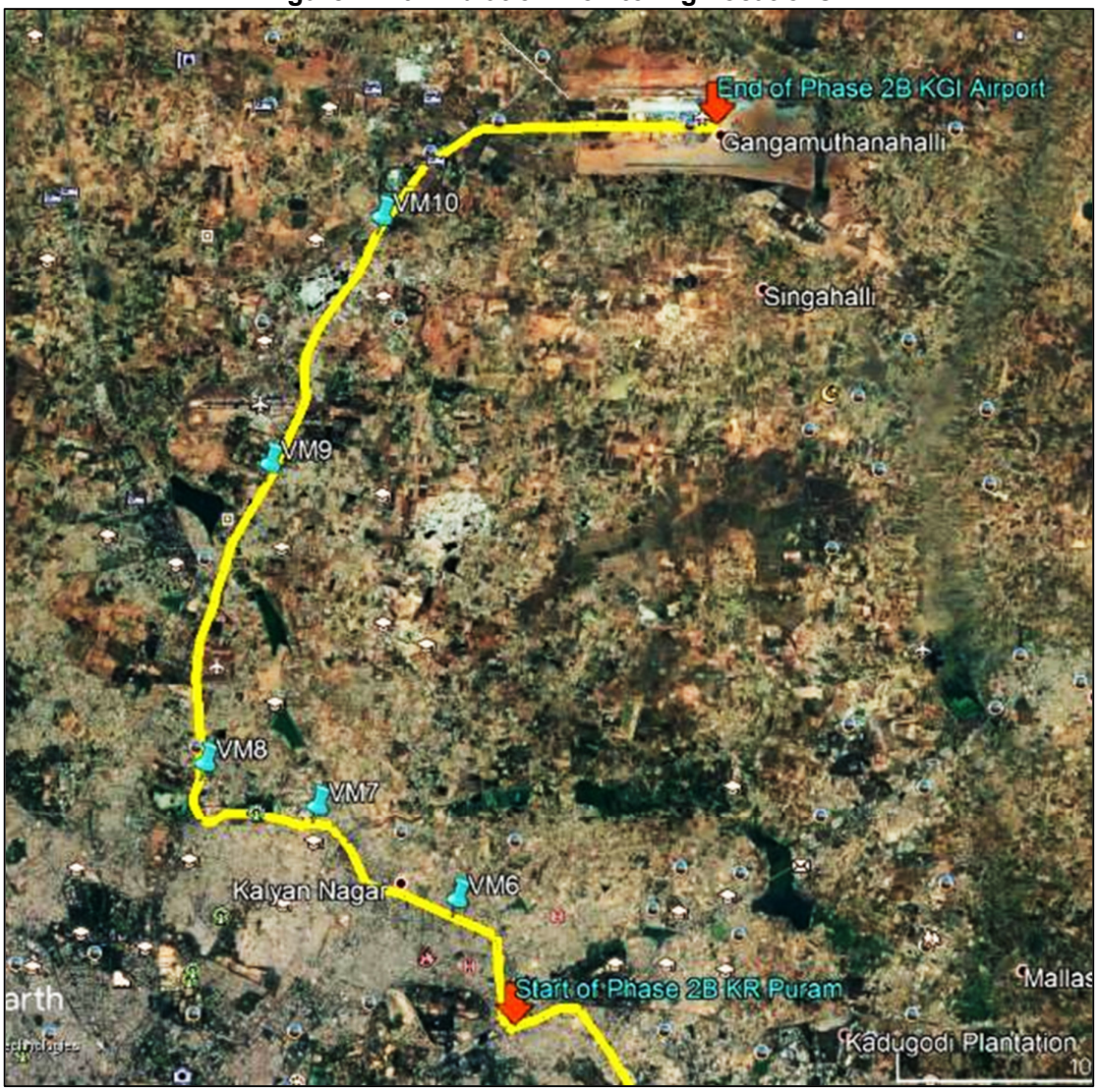
Prepared by Bangalore Metro Rail Corporation Ltd. (BMRCL), India for the Asian Development Bank.

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.

Figure 4- 20: Vibration Monitoring Locations



150. 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. 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 Table4-10 below. The operating traffic such as buses and trucks on the Outer Ring Road and Airport road were the predominant source of vibration.

Table 4- 10: Results of Vibration Monitoring

Sl. No.	Station Code	Location	Maximum Value (mm/s)
1.	VM6	Motherhood Hospital	3.32 mm/s
2.	VM7	Manyata Tech Park	< 0.5
3.	VM8	Columbia Asia Hospital Hebbal	1.82 mm/s
4.	VM9	Cytecare Cancer Hospital,	< 0.5
5.	VM10	Chikkajala Fort	1.71 mm/s

Figure 4- 21: Photographs of Vibration Monitoring Locations

VM6–Near Motherhood Hospital

VM7–NearManyata Tech Park

VM 8 –NearColumbia Asia Hospital Hebbal

VM 9–Near Cytecare Cancer Hospital

VM 10 – Near Chikkajala Fort

151. 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 VM06,VM08 and VM10 recorded maximum value of 3.32, 1.82 and 1.71 milli meter/second, respectively. The predominant source of vibrations is due to passing commuter traffic which includes buses, trucks and commercial delivery vehicles. Among all the monitored locations VM 10 Chikkajala Fort is the most sensitive to vibrations, as structure is ancient uncemented structure which needs proper protection from vibrations generated from project construction activities and metro trains operation.

G. Water Environment

152. 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.

153. 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, Nekkundhi Lake (Mahadevapura Lake), B Naranyanpura Lake, and Benneganahalli Lake. Groundwater occurs in silty to sandy layers of alluvial sediments and jointed quartzite. Presently, none of the lakes within Bengaluru serve as 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.

154. 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 is 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 4-11and the details of water bodies located adjacent to the metro alignment is given in Table 4-12 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

Sl. No.	Name of the Range / Unit	Number of Tanks	Extent In Ha
2	Banashankari unit	17	170.45
3	Rajajinagar unit	16	117.77
4	Tree unit	7	51.78
5	Kaggali pura range	7	54.97
6	K.R.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	Beninganahalli Lake	0+000 to 0+800	RHS	30
2	Chalkere Lake	4+500 to 4+750	RHS	170
3	Pond	7+000 to 7+200	LHS	30
4	Nagavara Lake	9+000 to 10+100	RHS	50
5	Drain	10+300	both sides	25
6	Hebbal Lake	11+500 to 11+700	LHS	140
7	Pond	16+500 to 16+750	LHS	100
8	Hunasemaranahalli Lake	22+300 to 22+800	LHS	65
9	Pond	25+200 to 25+400	LHS	80
10	Lake near Chikkajala	26+600 to 26+700	LHS	70

155. 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.

156. Challakere: Challakere lake is located 175 m away from Phase 2B metro corridor on right hand side. Thelake is spread over an area of 38 acres. Challakere is part of the Yellamallappa Chetty lake series within Hebbal Valley, overflowing into the downstream Ramapura Lake and eventually Yellamallappa Chetty Lake. There is no sewage treatment plant (STP) within the lake premises but there exists a wetland on the northeast corner of the lake which somewhat performs the STP function. Wastewater flows through two inlets into this wetland from the northeast direction which then enters into the lake through a culvert. KSPCB water analysis report on the lake water finds it to be below ‘E’ Class which is fit for irrigation, industrial cooling after disinfection and the controlled waste disposal only. Untreated sewage disposal into the lake is said to be the reason for this.

157. Nagavara: Nagavara lake is situated in the ORR and is spread across an area of 56 hectares. Lumbini Gardens park is recently developed adjacent to the lake adding to its natural beauty. One side (east) of the lake attracts children and visitors but the other half of the lake (west) is covered with water hyacinth and polluted with sewage inflow. There was a proposal in Comprehensive Development Plan to develop park and open space and turn this water body into a tourist spot. The portion of the lake is being maintained under public private partnership model. Efforts have been made by Lake Development Authority to stop sewage from entering the lake and growth of weeds. The part which is accessible for public is maintained well but the rest is neglected and eutrophic in nature.

158. Hebbal Lake: Hebbal Lake is located on NH 7 where the proposed metro corridor passes. The Lake is spread over 192 acres and has a single water inlet channel. Upstream are the HMT layout, Tata Nagar and Vidyaranyapura and downstream is Nagavara Lake and Manyata Tech Park. The Lake is putrefied and covered with water hyacinth. With the help of funds and efforts from local residents and the Forest Department, the water quality has been revived to some extent. This was achieved by building diversion canal for sewage downstream to bypass the lake. Wetland system was also created within the Hebbal Lake. This helps in the biological purification of lakes by hydrophytic plants which absorb dissolved pollutants and toxins. Islands were created using silt and planting fruit bearing trees. This island attracts birds such as purple moorhens, cormorants, Brahminy kites, kingfishers, weaver bids, purple herons, grey herons, pond herons, etc.

159. Hunasemaranahalli Lake and Lake near Chikkajala: These lakes are comparatively small lakes and away from the influences and impacts from the city developments. Hunasemaranahalli Lake is located adjacent to Yelahanka Airforce base near Bharath Nagar on left had side of the proposed metro alignment. The lake has poor water quality and gets filled for four to six months during monsoon and post monsoon only.

160. 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 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 Benniganahalli Lake, Nagavara Lake, Hebbal 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 4-23.

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

Benniganahalli Lake

Chalkere Lake

Nagawara Lake

Hebbala Lake

Hunasemaranahalli Lake

Lake near Chikkajaala

i. Hydrogeology

161. 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 Ground water 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. Groundwater 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 4-24. The surface drainage network, water bodies and water shed boundaries for Bengaluru urban district is shown in figure 4-25.

162. 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 freshwater with EC ranging from 250 to 2000 micro mhos/cm at 25° C.

163. 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. Groundwater 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 ground water 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 reveals some 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 abstraction rate is more than the recharge rate to the aquifer.

164. In the urban area of Bengaluru district, main problems affecting ground water are sewage pollution, industrial pollution, high nitrate concentration and overexploitation of ground water resources.[4] This is attributed to factors like rapid urbanization in the last three decades paving the way for commercial buildings, new residential layouts and industries. 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. Even if such systems have been provided, they are mostly not functional or connected to trunk sewers of 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 ground water levels on account of poor permeability with more and more silt, clay deposits, trash and toxic waste accumulation in the lakes year after year.

165. A solution is building up of groundwater resource through artificial recharge and rainwater harvesting.

[4]Central Ground Water Board Ground Water Information Booklet, Bangalore Urban District, 2012.

Figure 4- 23: Hydrogeology of Bengaluru Urban district

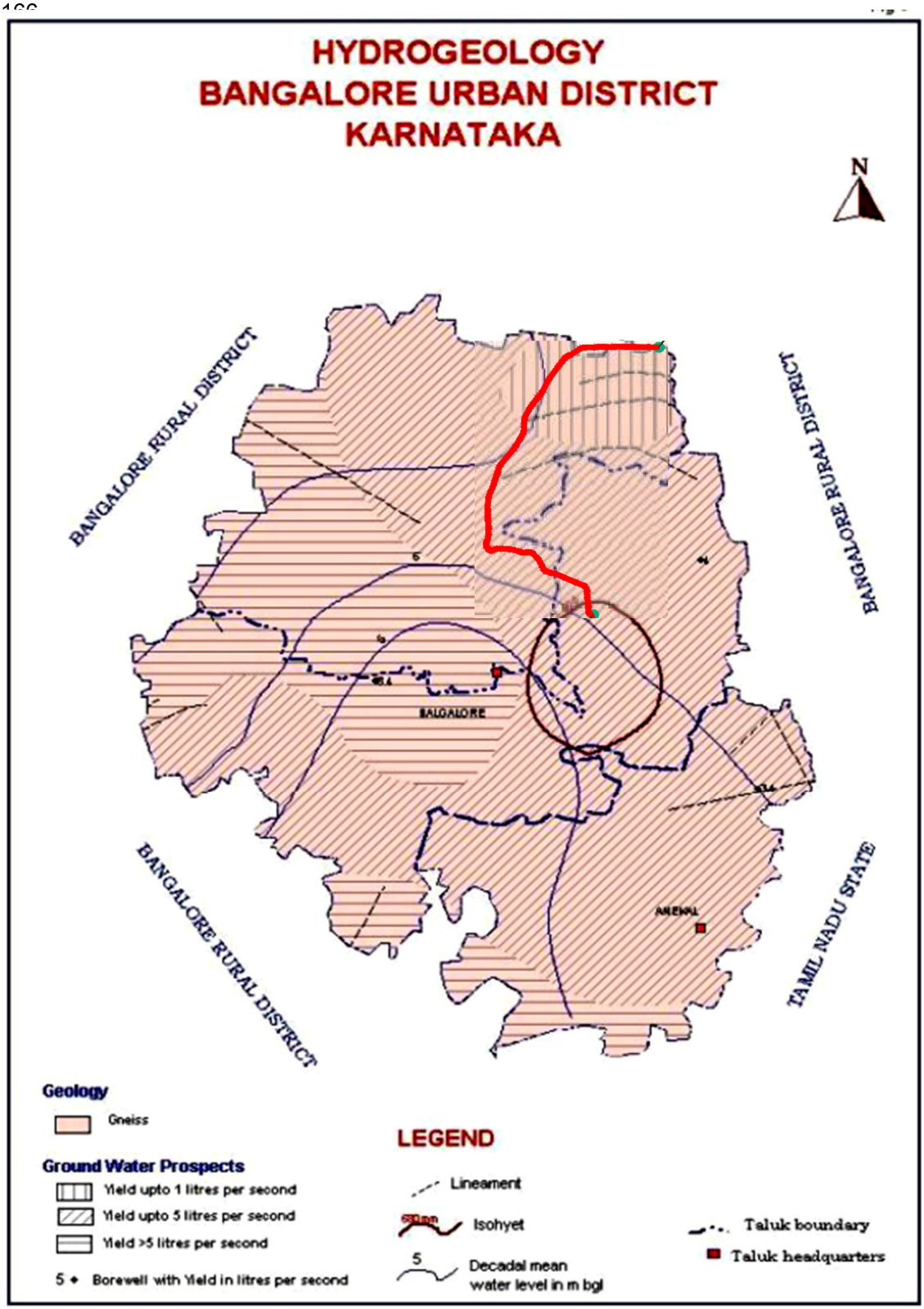
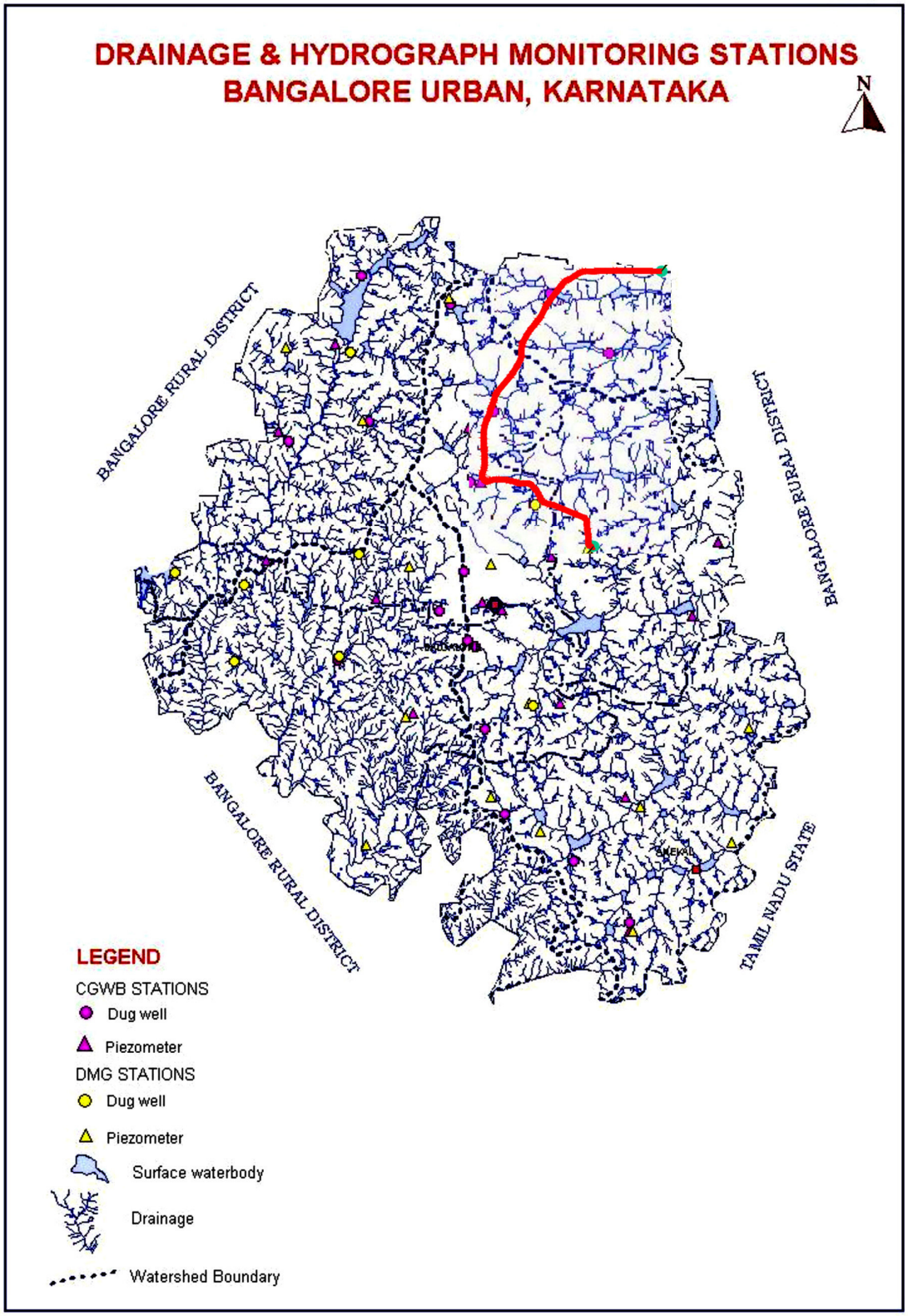


Figure 4- 24: Drainage map of Bengaluru Urban district

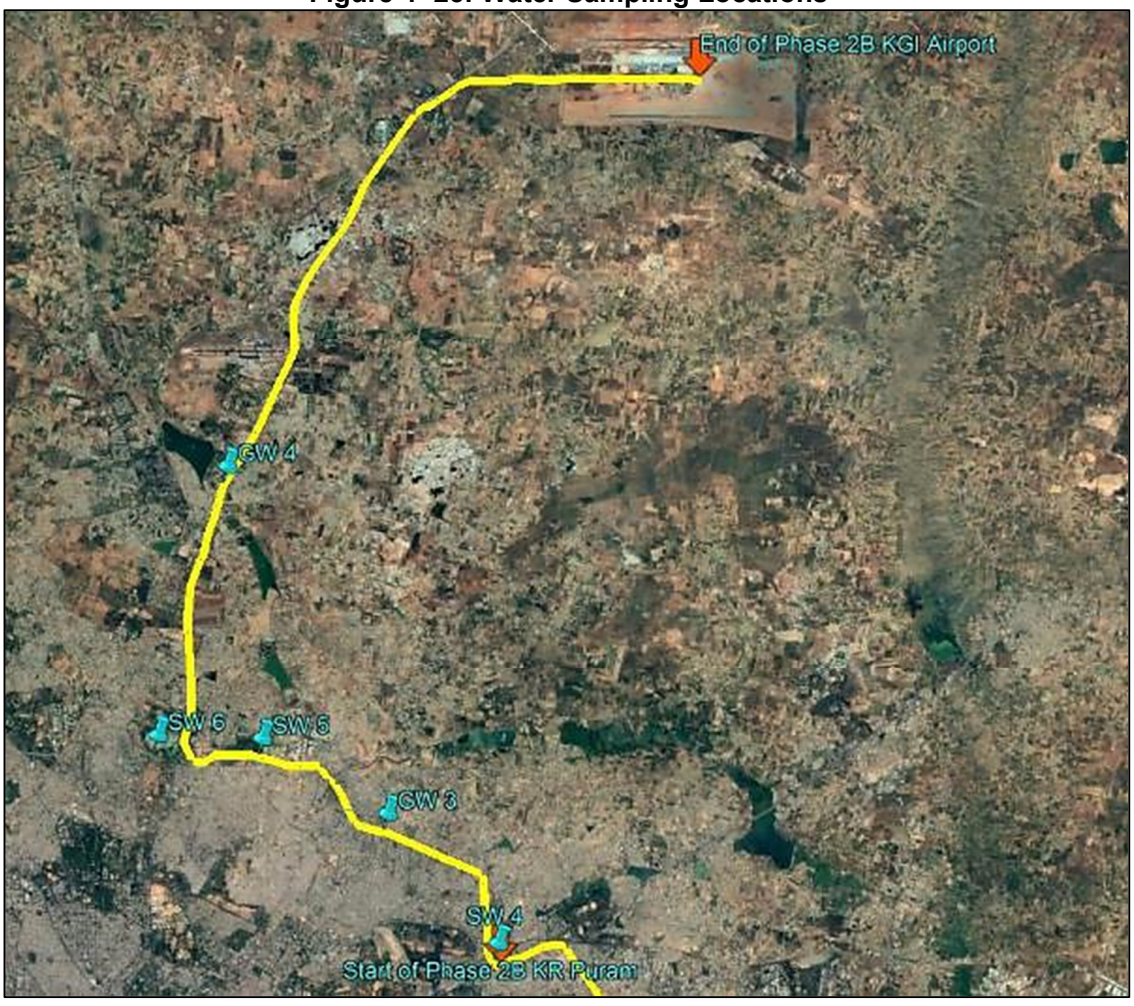


167. Three surface water samples and two ground water samples were collected from the study area (Table 4-13) for analysis of water quality. Samples from lakes and ponds were collected for surface water analysis while borewell water samples were collected to analyse the groundwater quality. The results of the analysis of surface water and ground water are given in Tables 4-14 and 4-15 respectively. Google earth images showing water sampling locations and the photos of water sampling along the proposed metro corridor is shown in figures 4-26 and 4-27.

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-4	Benniganahalli Lake (RHS)
2	SW-5	Nagawara Lake (RHS)
3	SW-6	Hebbal Lake (LHS)
4	GW-3	Bore Well near Kalyan nagar along Outer Ring Road
5	GW-4	Bore Well near Yelahanka along Airport Road

Figure 4- 25: Water Sampling Locations



168. 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					SW4	SW5	SW6
			A	B	C	D	E			
1.	pH	-	6.5-8.5					7.62	7.63	7.79
2.	Colour	Hazen	10	300	300	-	-	<1	<1	<1
3.	Odour	--	-	-	-	-	-	Disagreeable	Disagreeable	Disagreeable
4.	Turbidity	NTU	-	-	-	-	-	1.40	4.71	1.03
5.	Electrical Conductivity	µs /cm	-	-	-	1000	2250	363	713	581
6.	Total Dissolved Solids	mg/L	500	-	1500	-	2100	262	489	402
7.	Total Hardness as $CaCO_3$	mg/L	-	-	-	-	-	88.0	80.0	100.0
8.	Calcium as Ca	mg/L	-	-	-	-	-	24.0	17.6	24.0
9.	Magnesium as Mg	mg/L	-	-	-	-	-	6.80	8.74	9.72
10.	Chloride as Cl	mg/L	250	-	600	-	600	35.22	109.58	86.10
11.	Sulphate as SO_4	mg/L	400	-	400	-	1000	32.21	62.21	35.53
12.	Dissolved Oxygen	mg/L	6	5	4	4	-	**4.6**	**4.7**	**4.6**
13.	BOD (3 Days@27°C)	Mg/L	2	3	3	-	-	**15.0**	**14.0**	**12.0**
14.	Chemical Oxygen Demand	Mg/L	-	-	-	-	-	56.0	48.0	56.0
15.	Fluoride as F	mg/L	1.5	1.5	1.5	-	-	0.38	0.54	1.02
16.	Total Alkalinity as $CaCO_3$	mg/L	-	-	-	-	-	104	100	104
17.	Nitrate as NO_3	mg/L	20	-	50	-	-	5.19	9.30	5.51
18.	Phosphate as PO_4	mg/L	-	-	-	-	-	0.13	0.34	0.19
19.	Sodium as Na	mg/L	-	-	-	-	-	23.12	82.23	57.80
20.	Potassium as K	mg/L	-	-	-	-	-	10.32	18.0	11.97
21.	Iron as Fe	mg/L	0.3	-	50	-	-	0.19	0.13	0.23
22.	Manganese as Mn	mg/L	-	-	-	-	-	0.090	0.052	0.208
23.	Copper as Cu	mg/L	1.5	-	1.5	-	-	BDL	BDL	BDL
24.	Zinc as Zn	mg/L	15	-	15	-	-	0.011	0.008	0.014
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**	**2800**	**1700**
28.	*E-coli*	MPN Index /100ml	-	-	-	-	-	**94**	**110**	**58**

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NOTES

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

Table 4- 15: Results of Ground Water Analysis

Sl. No.	Parameters	Std. IS 10500:2012 (Second Revision		Unit	GW3	GW4
		AL	PL			
1.	pH	6.5-8.5		-	7.32	7.62
2.	Colour	5	15	Hazen	<1	<1
3.	Odour	Agreeable		--	Agreeable	Agreeable
4.	Turbidity	1	5	NTU	0.12	0.34
5.	Electrical Conductivity	Not specified			980	1797
6.	Total Dissolved Solids	500	2000	mg/L	668	1217
7.	Total Hardness as $CaCO_3$	200	600	mg/L	232	476
8.	Calcium as Ca	75	200	mg/L	72.0	136.0
9.	Magnesium as Mg	30	100	mg/L	12.63	33.04
10.	Chloride as Cl	250	1000	mg/L	84.14	260.25
11.	Sulphate as SO_4	200	400	mg/L	61.11	84.71
12.	Dissolved Oxygen	Not Specified		mg/L	5.0	4.9
13.	BOD (3 Days @ 27°C)	Not Specified			BDL	BDL
14.	Chemical Oxygen Demand	Not Specified			6.4	3.2
15.	Fluoride as F	1	1.5	mg/L	1.13	0.91
16.	Total Alkalinity as $CaCO_3$	200	600	mg/L	256	348
17.	Nitrate as NO_3	45		mg/L	25.07	11.33
18.	Phosphate as PO_4	Not Specified		mg/L	BDL	0.52
19.	Sodium as Na	Not Specified		mg/L	79.33	112.83
20.	Potassium as K	Not Specified		mg/L	5.0	1.68
21.	Iron as Fe	0.3		mg/L	BDL	BDL
22.	Manganese as Mn	0.1	0.3	mg/L	BDL	0.022
23.	Copper as Cu	0.05	1.5	mg/L	0.006	0.006
24.	Zinc as Zn	5	15	mg/L	0.010	0.008
25.	Mercury as Hg	0.001		mg/L	BDL	BDL
26.	Total Chromium as Cr	0.05		mg/L	BDL	BDL
27.	*E-coli*	Not specified		MPN Index/100ml	<1.8	<1.8
28.	Total Coliform	Not specified			<1.8	32

169. 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 desire 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 4-16.

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

Designated-Best-Use	Class of water	Criteria
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
		Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	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

SW4 – Benniganahalli Lake

SW5 – Nagawara Lake

SW6 – Hebbal Lake

GW3 - Bore Well near Kalyan nagar, Outer Ring Road

GW24-Bore Well near Yelahanka, Airport Road

ii. Inference on the water quality analysis

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

171. **SW-1 – Benniganahalli Lake:** Based on the measured values for the water quality parameters with respect to dissolved oxygen, biological oxygen demand (3 days @27^0C), total coliform and E-coli, water sample from Benniganahalli lake is likely to conform to Class 'Dfit for propagation of wildlife and fisheries.

172. **SW-2 – Nagavara Lake:** Based on the measured values for the water quality parameters with respect to total dissolved solids, dissolved oxygen, biological oxygen demand (3 days @27^0C), total coliform and E-coli, water sample from Nagavara lake is likely to conform to Class 'D'fit for propagation of wildlife and fisheries.

173. **SW-3 - Hebbal Lake:** Based on the measured values for the water quality parameters with respect to dissolved oxygen, biological oxygen demand (3 days @27^0C), total coliform and E-coli, water sample from Hebbal lake is likely to conform to Class 'D'fit for propagation of wildlife and fisheries.

174. **GW-1 - Bore Well near Kalyan nagar, Outer Ring Road:** The measured values for total dissolved solids, total hardness, fluoride and total alkalinity exceed the acceptable limits of IS 10500:2012 (second revision) standards. MPN value for E-coli was less than 1.8.

175. **GW-2 - Bore Well near Yelahanka, Airport Road:** The measured values for total dissolved solids, total hardness, Calcium as Ca, Magnesium as Mg, Chloride as Cl and Total alkalinity exceed the acceptable limits of IS 10500:2012 (second revision) standards. Presence of e-coli renders water not suitable for drinking water without prior proper treatment.

H. Land Environment

176. 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.

177. 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.

178. 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.

179. 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 4-17 and 4-18.

Table 4- 17: Details of Soil Sampling Locations

Sl. No.	Location Code	Soil Sampling Locations	Chainage (km)
1	S-6	Kasthuri Nagar Park (LHS)	0+600
2	S-7	BDA Park (LHS)	6+600
3	S-8	Lumbini Gardens Park (RHS)	9+600
4	S-9	Jakkur Plantation (RHS)	16+000
5	S-10	Agricultural Land near proposed Doddajala metro Station (RHS)	28+800

Table 4- 18: Results of Soil Quality Analysis

Sl. No	Parameters	Unit	S6	S7	S8	S9	S10
1	pH	-	7.87	7.73	7.43	6.86	8.01
2	Electrical Conductivity	µs/cm	171.4	371	268	116.4	105.9
3	Organic Carbon	Percent	0.28	0.23	0.17	0.28	0.34
4	Sand	Percent	62.96	54.96	60.96	52.96	57.04
5	Silt	Percent	27.28	35.28	27.28	37.28	29.2
6	Clay	Percent	9.76	9.76	11.76	9.76	13.76
7	Porosity	Percent	62.96	44.48	45.14	54.37	43.89
8	Texture	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
9	Available Nitrogen as N	kg/ha	160.87	189.47	424.30	161.06	189.66
10	Available Potassium as K	kg/ha	632.46	210.11	720.60	337.00	382.92
11	Available Phosphorus as P_2O_5	kg/ha	172.26	164.49	392.45	120.45	244.79
12	Calcium as Ca	meq/L	7.3	6.1	7.7	4.0	5.0
13	Magnesium as Mg	meq/L	0.3	1.2	1.0	1.0	0.4
14	Sodium as Na	mg/100gm	6.30	16.84	3.90	9.14	16.04
15	Boron as B	mg/100gm	BDL	BDL	BDL	BDL	BDL
16	Iron as Fe	Ppm	112.17	42.282	111.518	53.264	35.74
17	Zinc as Zn	mg/kg	13.1	8.3	24.1	5.5	3.5
18	Manganese as Mn	mg/kg	215.8	82.6	285.4	120.6	47.7
19	Molybdenum as Mo	mg/kg	BDL	BDL	BDL	BDL	BDL
20	Copper as Cu	mg/kg	9.1	5.2	15.3	5.5	12.7
21	Aluminum as Al	mg/kg	4463.9	2010.6	3699.8	2035.2	1028.6

BDL: Below Detectable Limit.

Figure 4- 27: Photographs of Soil Sampling

S6 - Kasthuri Nagar Park

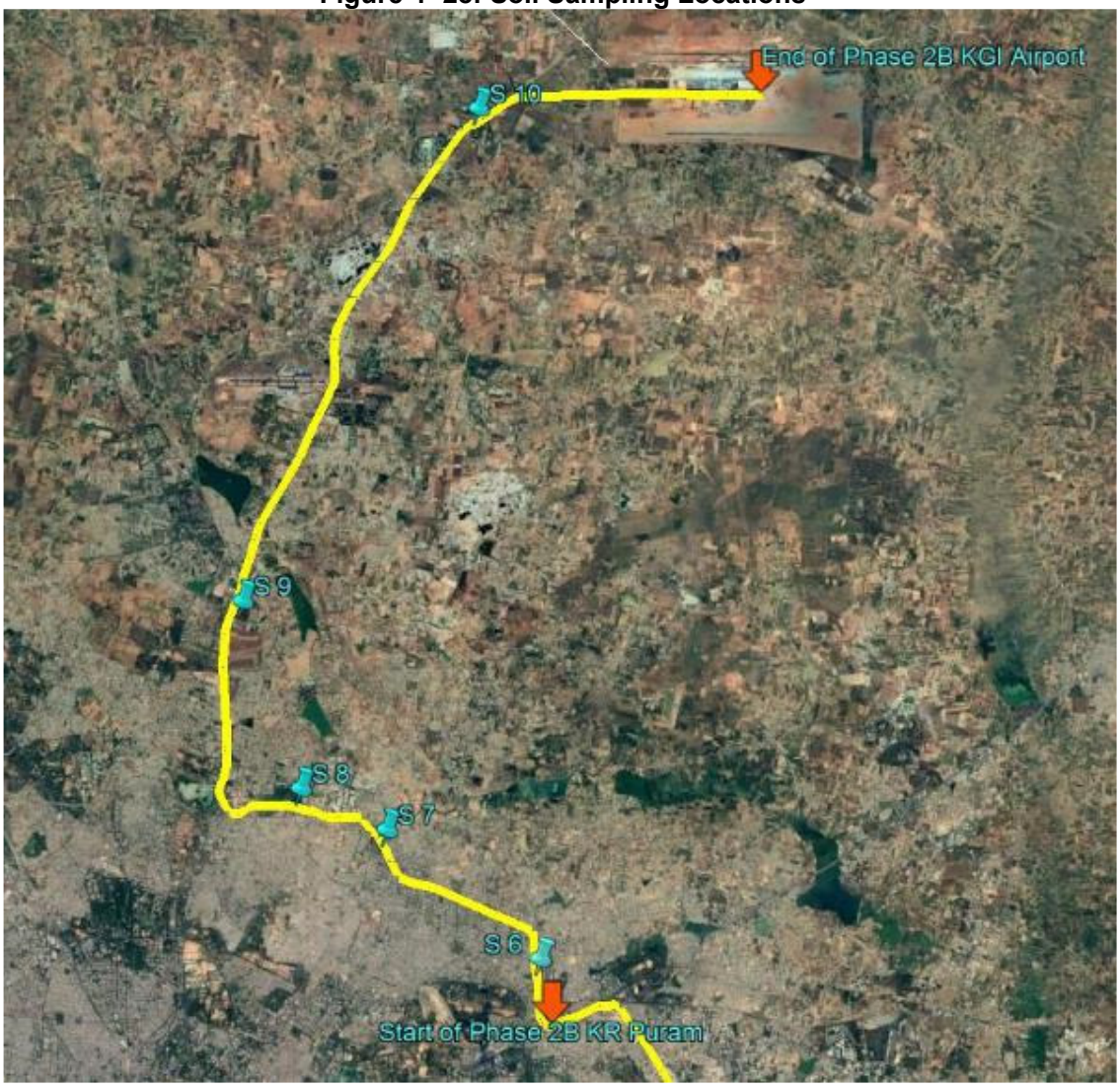
S7 - BDA Park

S8 - Lumbini Gardens Park

S9 - Jakkur Plantation Area

S10 - Agriculture Land Near Proposed Doddajala Metro Station

Figure 4- 28: Soil Sampling Locations



i. Land use pattern

180. Bengaluru city is being heavily flooded with public investment in industry and infrastructure which is leading to significant changes in the land use patterns.

181. 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 over-crowding, 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 4-19.

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

Land use Class	Urban		Vegetation		Water		Others	
Year	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

182. The changes in land use over 40 years is represented in the form of bar chart in Figure 4-30 and the land use changes in Bengaluru city is given in Figure 4-31.

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

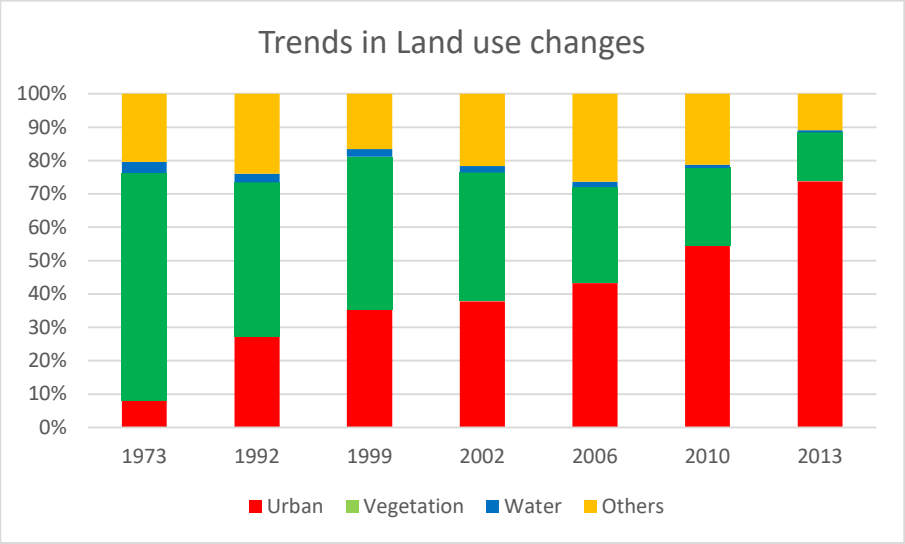
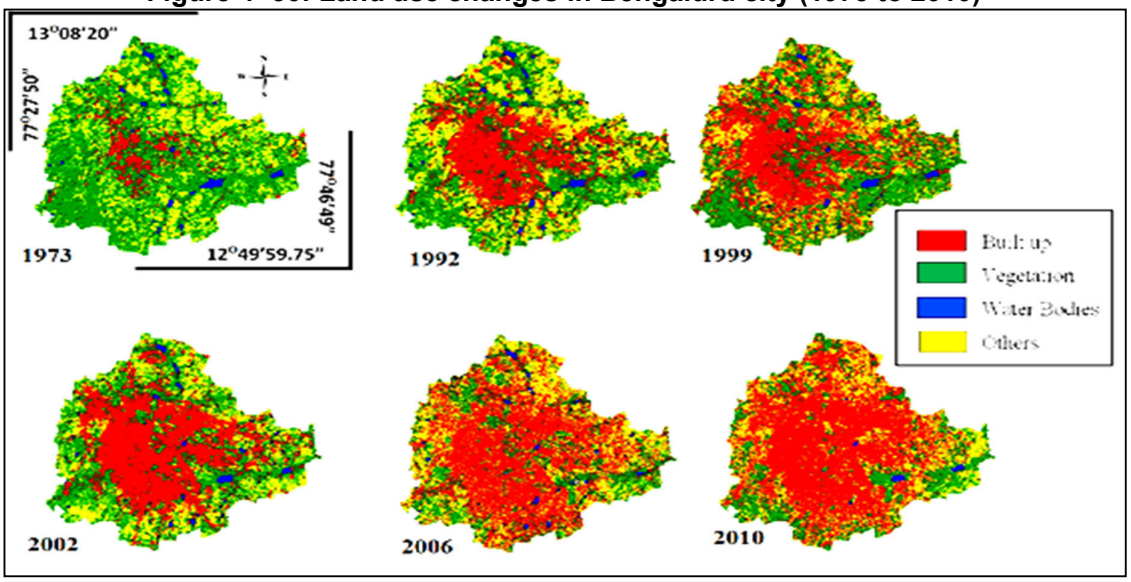


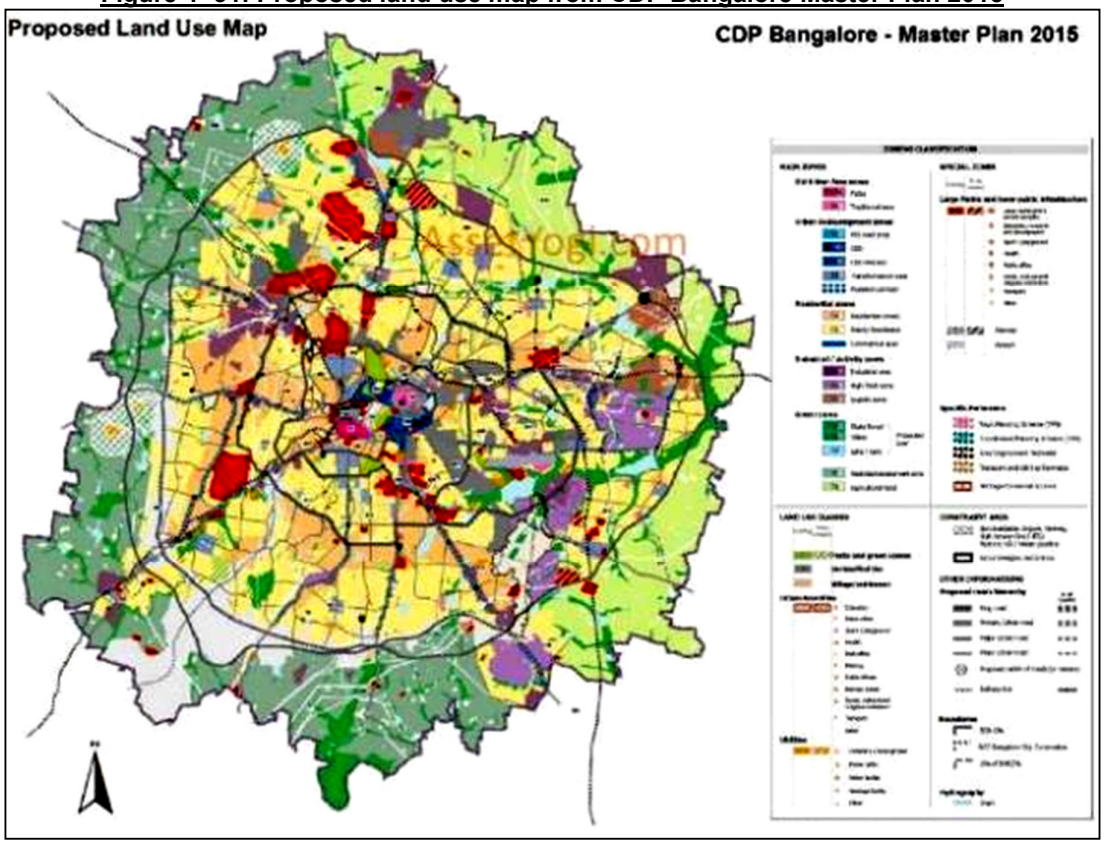
Figure 4- 30: Land use changes in Bengaluru city (1973 to 2010)[5]



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

183. The proposed land use map from CDP Bangalore Master Plan, 2015 is given in Figure 4-32.

Figure 4- 31: Proposed land use map from CDP Bangalore Master Plan 2015

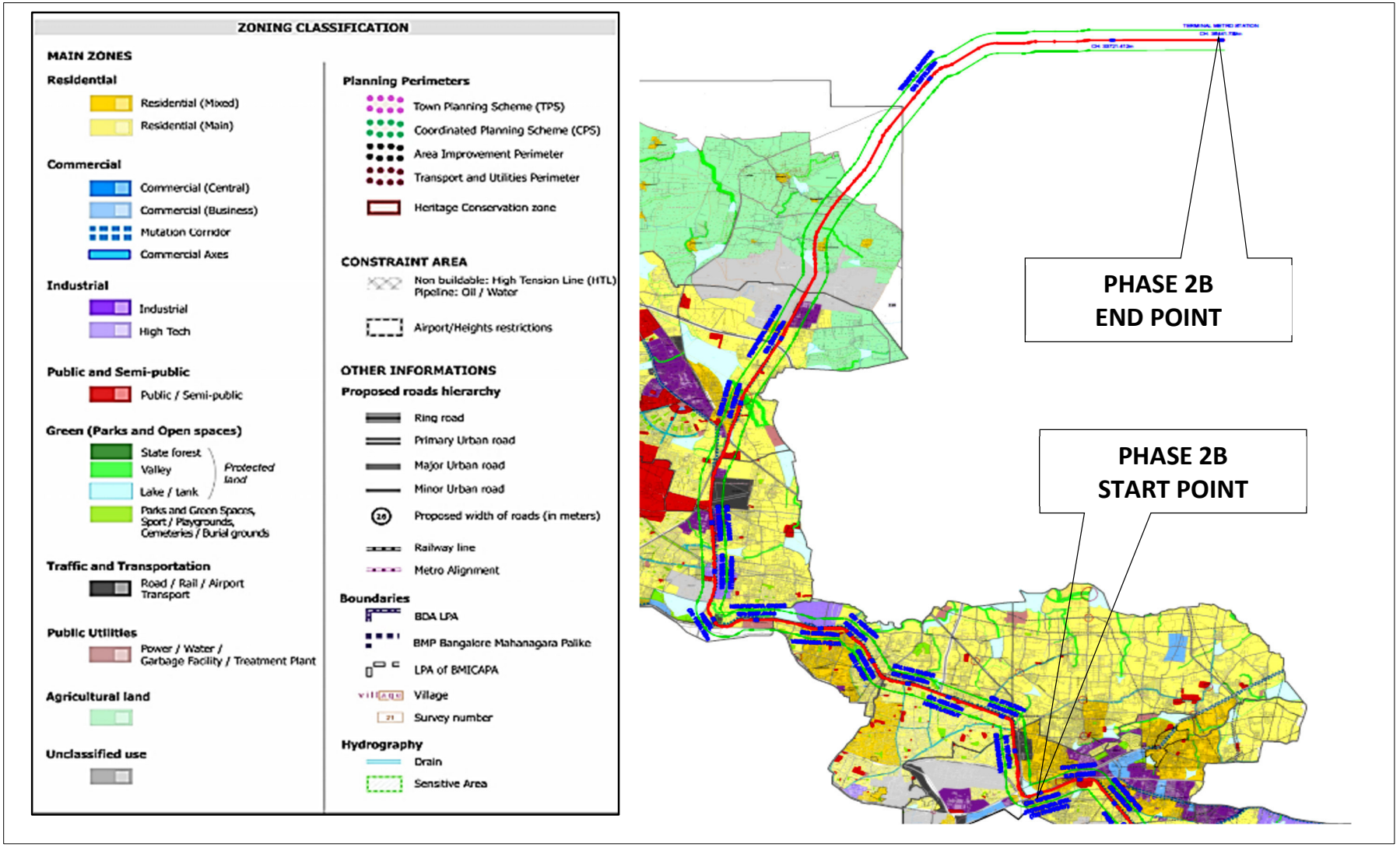


184. The land use map along the proposed Phase 2B metro alignment and presented in Figure 4-33 and the details of land use classes are given in Table 4-20.

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	1170	**4.10**
2	Commercial	15380	13950	**43.39**
3	Industrial	0	850	**1.26**
4	Public & Semi Public	1800	1150	**4.36**
5	Green (Parks & Open Spaces) Lake / Tank (Pond)	1530	2150	**5.44**
6	Traffic & Transportation	100	1850	**2.88**
7	Public Utilities	740	0	**1.09**
8	Agricultural Land	10000	10400	**30.18**
9	Unclassified Use	2650	2280	**7.29**
Total		**33800**	**33800**	**100.00**

Figure 4- 32: Landuse adjacent to proposed project corridor



I. Biological Environment

185. 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 6000 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, Schinus molle, Swietenia mahagoni, Tabebuia species, etc. Lalbagh, is a botanical garden and has been a treasure house of plants. The rich floral wealth of Lal Bagh 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.

186. In 1982 a Forest Division was created under the name Bangalore 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 Albizzia amara, Albizzia lebbek, Anogiessus latifolia, Acacia species, Shorea talura and Santalum album, etc.

187. 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, Albizzia, Wrightia tinctoria, Zizyphus, Pongamia, etc.

188. 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 4-21.

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	K.R. 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)

189. 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.

190. The government lands such as C and D class lands, Gomals, tanks, etc. which were originally under the control of Revenue Department are now under the control of Bangalore Urban Division, Forest Department. These transferred lands can be utilized for taking up compensatory plantation in lieu of trees being impacted by of the proposed metro project.

191. The following Table 4-22 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	Turahalli Gudda 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**	

192. Critical habitats. The nearest wildlife sanctuary which is adjacent to Bengaluru Urban District is Banneraghatta National Park. Bannerghatta National Park is declared National Park notified under the Wildlife (Protection) Act, 1972. It is located at distance of 15 km from the proposed metro 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. 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. 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.

193. The other key biodiversity areas found within 50 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 are not key biodiversity areas notified under Wildlife Protection Act, 1972 and are not impacted by the proposed project.

J. Social Economic Environment

194. 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.

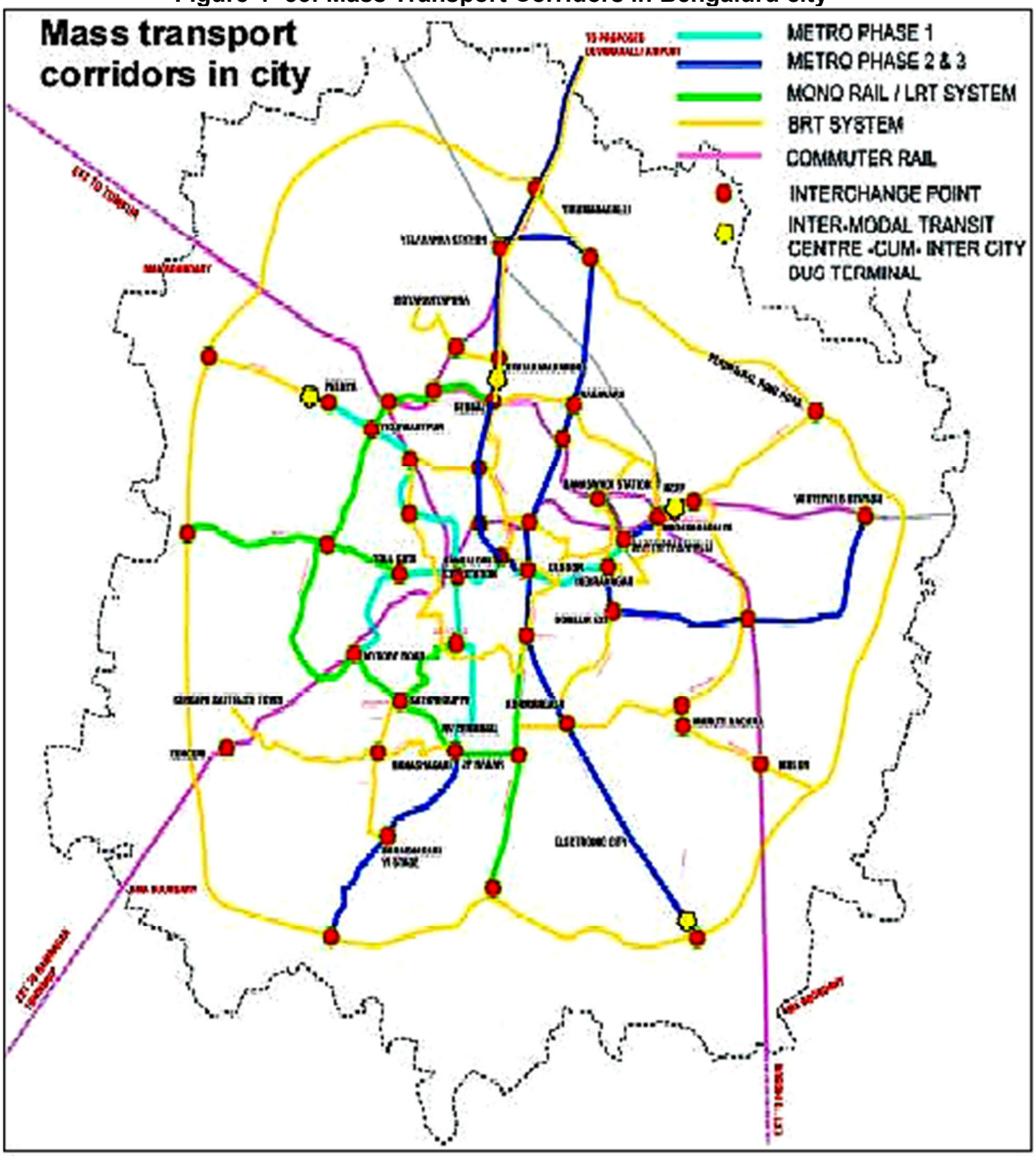
195. Average literacy rate of Bengaluru in 2011 were 87.67 compared to 82.96 of 2001. If things are looked out at gender wise, male and female literacy were 91.01 and 84.01 respectively. For 2001 census, same figures stood at 87.92 and 77.48 in Bengaluru District[6].

196. 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 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 in two Phases i.e., Phase I of 500 MLD capacity and Phase II of 275 MLD capacity.[7]Bengaluru Urban has 46 water tanks of various capacities serving the irrigation needs and has 52 reservoirs and 118 ground level reservoirs.

197. Bengaluru district has a total national highway length of 147 km. NH 4, NH 7 and NH 209 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 4-35).

[6]Source: http://www.census2011.co.in/census/district/242-bangalore.html
[7]https://www.bwssb.gov.in/com_content?page=3&info_for=4

Figure 4- 33: Mass Transport Corridors in Bengaluru city



198. Economy - Bengaluru is the highest contributor of 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.[8]

199. 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

[8] http://www.investkarnataka.co.in/district-profiles-bangaloreurban

649 milk co-operatives that annually produce 119 Million liters of milk, 34.7 million Eggs, and 5,880 tonnes of meat.

200. 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.

201. 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 & DRDO, and many internationally renowned institutions like HAL, DRDO, ISRO, ADA, NAL, IISC, and Antrix Corporation. Also, 4 out of 9 R&D Centres of HAL and DRDO's 5 Aeronautic Centres are in Bengaluru.

202. 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.

K. Sites of Tourist and Archaeological Interest

203. Chikkajala Fort: Chikkajala fort consists of a circular walled compound with a large pond or kalyani in the centre. On the eastern side of the pond is a small Hanuman temple with stucco decorations in the 19th century Mysore style. The prime property of 2 acre 8 gunta belongs to government according to Chikkajala Revenue Department. NHAI acquired the front portion of the fort for road widening by depositing a compensation of Rs 84 lakh to the Taluk office, Yelahanka. National Highway Authority of India (NHAI) pulled down the compound wall of the monument in the year 2011after obtaining No Objection Certificate from the Tahsildar but the temple, mantapam, kalyani (pond), etc. stands unattended with no protection provided to the structures inside.

204. Dr S. K. Aruni, Deputy Director of the Indian Council for Historical Research (ICHR), said there was a sculpture of Gandaberunda (a two-headed mythological bird) in the fort to prove that that the builder followed the architectural style that existed during the reign of Mysore kings. He said, "the structure located next to NH-4 in Chikkajala cannot be termed a fort. It's nothing but a private fort (called Wada) constructed by a rich business family and for the same reason, it has a house and private garden. There was a practice of building such structures by a community called Guttedars during the Nizam period."

205. A senior official with Archaeological Survey of India said that the monument does not come under their purview. Deputy Director of the State Department of Archaeology H. M. Siddanagoudar said the structure at Chikkajala fell under the category of unprotected monuments and it doesn't come under the purview of the State Department of Archaeology.[9]

[9]https://www.deccanherald.com/content/252946/six-months-chikkajala-monument-yet.html

Figure 4- 34: Photots of Chikkajala Fort

206. Bengaluru Palace: Constructed by Chamaraja Wodeyar in 1887, the palace carves a niche for its architecture. Besides, the Gothic windows and fortified towers of this palace are worth viewing. Bengaluru Palace is a minor replica of the Windsor Castle in England.

207. HAL Aerospace Museum: Located 11 km from the city, it is the first aerospace museum in India. The museum is home to equipment for navigation and communication, and many model aircraft.

208. 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.

209. 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.

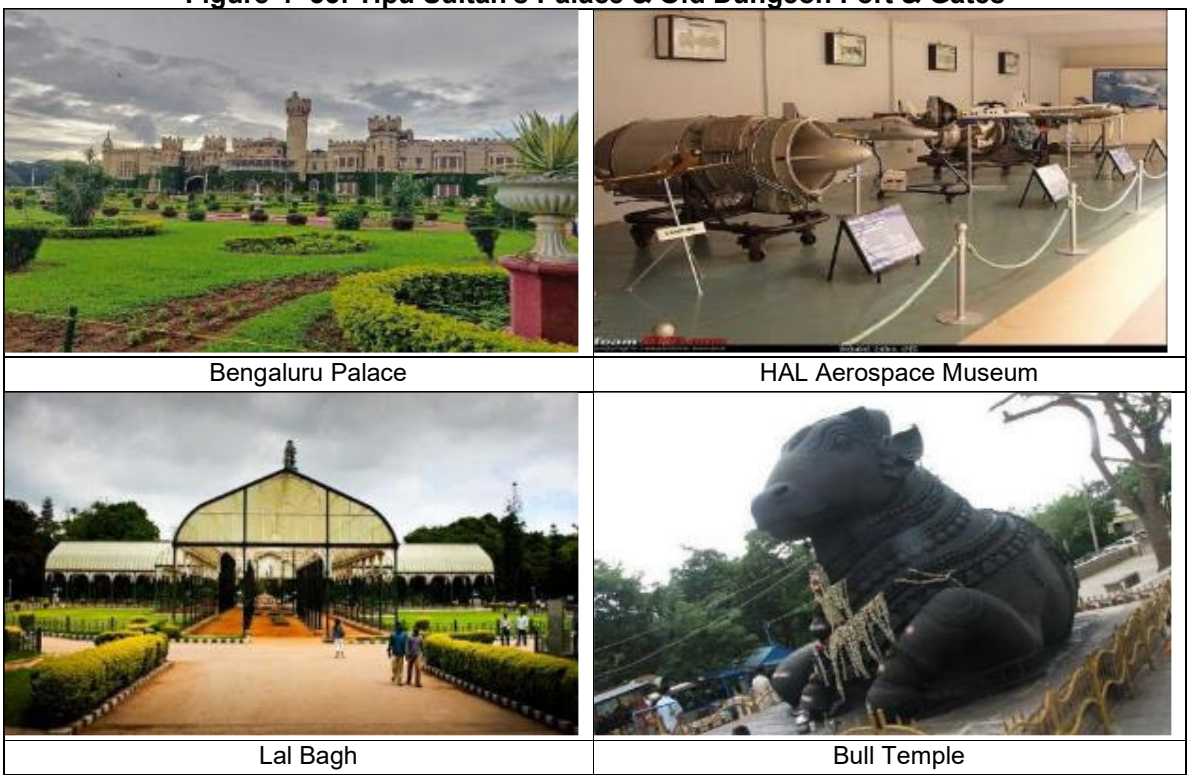
210. Bannerghatta National Park: Located 22 km from Bengaluru, this national park is famous for its picturesque natural beauty. Besides, the park is also home to Indian tigers, lions, and crocodiles. Bannerghatta National Part is a rich natural zoological reserve which also hosts first butterfly park of India.

211. Bull Temple: is a magnificent pilgrimage of Nandi which is 15 ft tall and over 20 ft long.

212. Tipu Sultan's Palace: Formerly one of the summer retirements of Tipu Sultan, today the palace has been transformed into a museum. The palace is a beautiful two storied ornate wooden structure with exquisitely carved pillars arches and balconies built in 1791 and were Tipu Sultan’s summer retreat. This is a splendid structure now present within the old fort. It has a large open courtyard in the front with a fountain and small, ornamental garden.

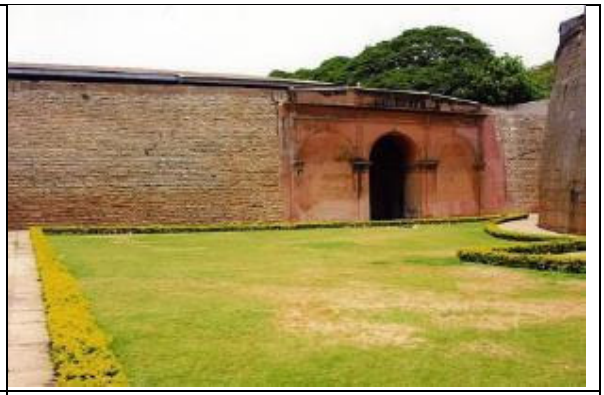
213. Old Dungeon Fort & Gates: Old Dungeon Fort & Gates or Bengaluru Fort began in 1537 as a mud fort by Sri Kempe Gowda I, a vassal of the Vijaynagar Empire and the founder of Bengaluru. Haider Ali in 1761 replaced the mud fort with a stone fort. The army of the British East India Company led by Lord Cornwallis on 21 March 1791 captured the fort in the siege of Bengaluru during the Third Mysore War (1790–1792). Today, the fort's Delhi gate, on Krishna Rajendra Road and two bastions are the primary remains of the fort in figure 4-36.

Figure 4- 35: Tipu Sultan's Palace & Old Dungeon Fort & Gates



Bengaluru Palace	HAL Aerospace Museum
Lal Bagh	Bull Temple

Tipu Sultan's Summer Palace

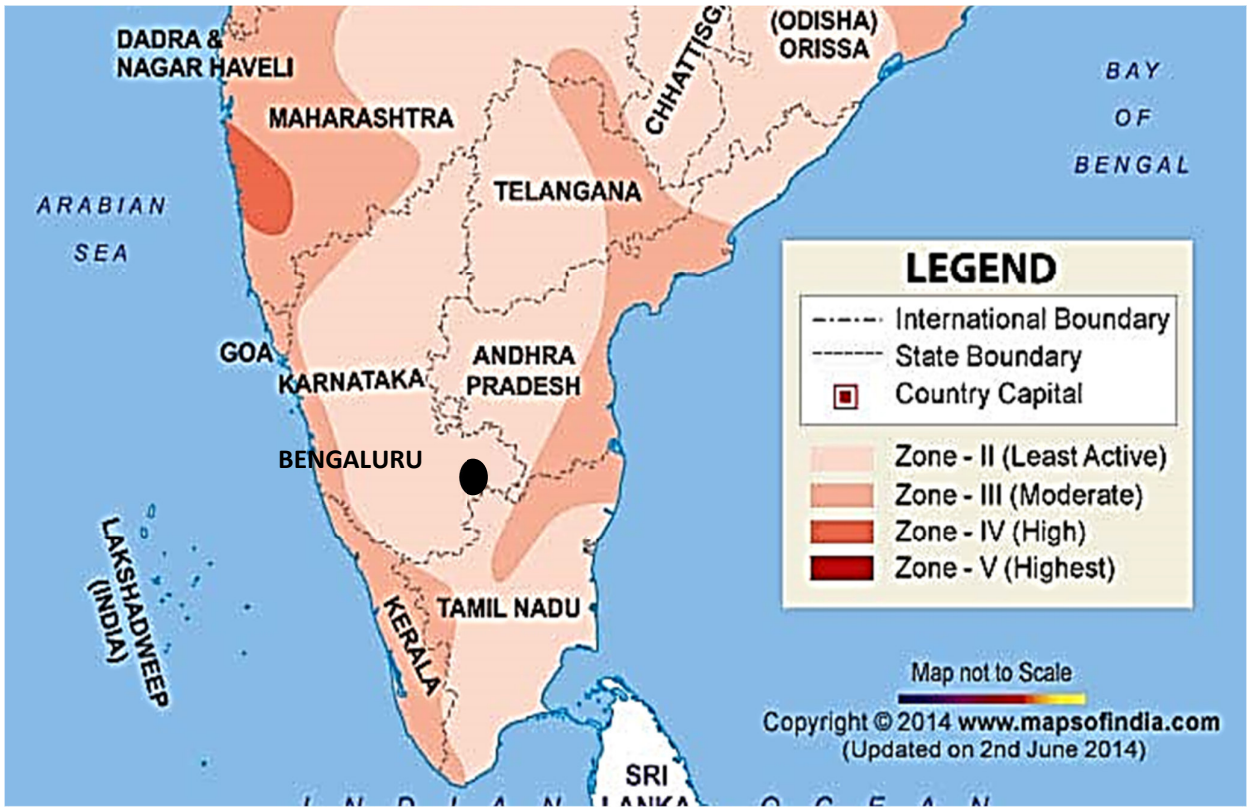


Old Dungeon Fort & Gates, Inside view

L. Seismicity

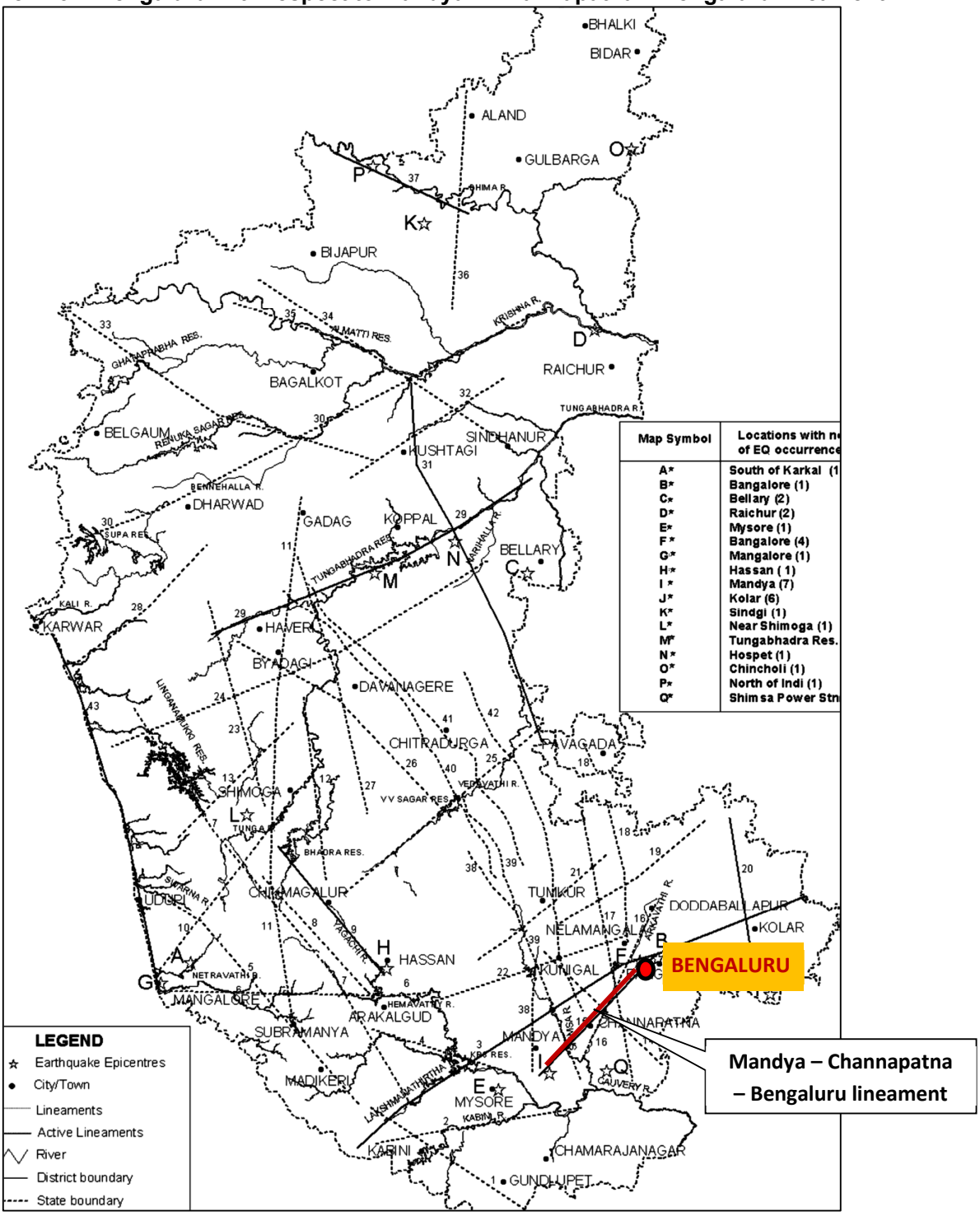
214. Bengaluru Urban district lies in a seismically stable region, Zone II (Figure 4-37). Bengaluru has been untouched by major seismic events with only mild tremors recorded in the past. The Indian Peninsular region which was once considered to be seismically stable is experiencing many earthquakes 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 4-38) with an earthquake moment magnitude of 5.1.

Figure 4- 36: Bengaluru with respect to Seismic Zones of India



Source: www.mapsofindia.com

Figure 4- 37: Bengaluru with respect to Mandya – Channapatna – Bengaluru lineament



Environmental Impact Assessment (Draft) Vol. 5 of 6

June 2020

India: Bengaluru Metro Rail Project

Phase 2B (Airport Metro Line)
KR Puram to Kempegowda International Airport

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

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.

V. ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

A. Methodology

215. 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

216. 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

217. 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

218. 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

219. 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.

220. (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).

221. 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

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 coliform.
1.6 Ground water quantity	High	Bengaluru is facing major water shortages.
1.7 Land degradation and pollution	Medium	The project alignment is following the median of the Outer Ring Road which passes mainly through residential and industrial areas or is located next to Highway 44 passing agricultural land. Generation of muck due to underground section.
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 15 km from the proposed project alignment with extensive urban development in between. The alignment passes a number of fresh water bodies, however none of these serve as ecological habitat for avian and/or aquatic fauna. Approx 3541 trees have to be removed from the project alignment and the stations and depot areas
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 264 families will be affected, approx. 208,000 m^2 of private land needs to be acquired.
3.2 Public property/ infrastructure/ utility structures	High	A major gas pipeline has to be shifted from the median of the Outer Ring Road in order to provide space for the metro line.
3.3 Noise	High	The ambient noise levels exceed CPCB limits during daytime as well as night time
3.4 Vibration	High	There are several structures located near the alignment. Regular traffic such as buses and trucks on the Outer Ring Road and NH 44 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 ORR and the highway
3.6 Public health and safety	Medium	
3.7 Physical cultural resources (PCR)	Medium	There are several religious places located near the alignment

222. (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.

223. (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.

224. (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.

225. 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

226. 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.

227. 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 (high sensitivity)	None	D				Neutral
	Increased water scarcity due to utilization for construction	C	Temporary	Limited	Low	Moderate -ve

VEC/Sensitivity	Impact/Activity	Stage	Duration	Area	Severity	Significance
	Increased water demand from public water supply	O	Permanent	Limited	Medium	Moderate -ve
1.7 Land degradation/ pollution (medium sensitivity)	Pollution due to poor waste management practices	D	Permanent	Limited	Low	Minor -ve
	Change in topography, excavation, soil erosion, muck and debris generation and disposal, removal of trees, removal of bituminous pavement	C	Temporary	Local	Low	Moderate -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 river beds	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
	Increased accessibility	O	Permanent	Local	High	+ve

VEC/Sensitivity	Impact/Activity	Stage	Duration	Area	Severity	Significance
3.2 Public property/infrastructure/ utility structures (high sensitivity)	Alignment passes major utility services that have to be shifted	D	Permanent	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	Limited	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
	None as long as SHE features are incorporated in the design	O				Neutral
3.6 Public health and safety (medium sensitivity)	Large scale movement of people	D	Permanent	Local	High	Moderate -ve
	Nuisance due to large scale construction activities in urban area	C	Temporary	Limited	High	Moderate -ve
	None	O				Neutral
3.7 Physical cultural resources (PCR)	Damage to religious and cultural sites next to the alignment	D	Permanent	Local	High	Moderate -ve

VEC/Sensitivity	Impact/Activity	Stage	Duration	Area	Severity	Significance
(medium sensitivity)	Possible chance find 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 during Pre-Construction (Design) Phase

i. Change of Land use:

228. The proposed metro project requires acquiring residential, commercial, government and defence lands. The proposed alignment follows one of the busiest traffic corridors in Bengaluru city and finalization of the alignment is much influenced by traffic induced obligatory factors and the connectivity it offers in the region. However, attempts have been made to take the alignment along the median of the outer ring road to minimise the land acquisition and the consequent impact. Major share of land acquisition is required for proposed metro stations. 313,519 Sqm (Government land – 105,500 Sqm and Private land – 208,019 Sqm) of land is acquired for the Phase 2B project. The type of land acquired involves private, government and defence lands. Acquisition of land leads to insignificant change in the land use. The change in land use is insignificant as the proposed metro alignment is following the median of ORR and the available space between main highway and service road along Airport Road. In addition, most of the metro stations are proposed on the vacant land without much impact on the existing structures. Land is also required, for establishing construction camps, casting yards, material storage and labour camps during construction phase.

229. Transfer of land and involuntary resettlement will cause adverse social, economic and cultural impacts on families and communities who are dependent on them. The details of land requirement for different components of the project of Phase 2B metro line is given in table 5-4.

Table 5- 4: Land acquired Phase 2B project

Sl. No.	Land required for	Land acquired in (Sqm)				
		Private	State Government	Central Government	Defence	Total
1	Depot	91,532	-	-	-	91,532
2	Stations and viaduct	116,487	-	105,500	-	221,987
	Total	208,019		105,500		**313,519**

Source: BMRCL Dec 2019

230. From the data, it could be concluded that out of total permanent land requirement about 66.35 % land to be acquired is from private and 33.65 % from Central Government.

a. Mitigation measures:

- The land acquisition has been avoided and minimized to reduce the impact on owners owning the adjacent properties and lands. Alternative engineering designs have been attempted to avoid or minimize land acquisition. Where land acquisition is unavoidable, resettlement of Project Affected Persons (PAPs) shall be implemented as an integral part of the project.
- All temporary land required for construction establishments and labour camps acquisition will be preferably Government lands and away from Bengaluru city to reduce the impact of these construction establishments. The conditions for locating and management of these establishments and camps are given in EMP.
- The temporarily lands for construction camps, labour camps, batching plants shall be transferred back to the owner after suitable rehabilitation before the completion of construction works.
- Contractor has to conduct baseline monitoring of ambient air, ambient noise, surface and ground water quality from nearby water resources and soil before establishing the construction camps.

C. Impacts during Construction Phase

i. Impact on Land Environment

231. The impact on the topography is limited as most of the alignment is elevated and follows median of existing outer ring road and the space between main highway and service road on airport road that has been allocated for high speed public rail. The impact on topography is limited to metro station locations and the 800 m underground section including ramps near Yelahanka air force station. In addition, there will be significant change in topography at the locations of construction camps, labour camps, material storage yards, gravel & sand quarries.

232. The project may not have significant impact on soil erosion, however, minor impact on soil erosion due to runoff from unprotected excavated areas which may result in soil erosion, especially where the erodibility of soil is high. During monsoon, 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.

233. The soil/debris will be generated during foundation excavations for pile construction which needs to be carefully and safely disposed of. Lot of waste slurry is also generated during pile foundation construction which causes soil pollution if it is not disposed properly. However, soil contamination is not considered to be a significant concern in this project as the alignment is following the median of outer ring road which has a median width of 1 to 2 metre and the rest is paved surface. Problems could arise from dumping of construction soils (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 construction machinery at construction camps may lead to soil pollution.

234. Proposed project involves construction of as many as 1120 pile foundations which requires soil to be excavated and disposed of at the pre-identified and approved disposal sites safely. The estimated total earth work excavation from pile drilling, pile cap, cut-and-cover and open foundation activities is about 273,586 Cum and the concrete debris of about 14,096 Cum is generated from Phase 2B project. The details are given in table 5-2.

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

Package No.	Source of debris (At viaduct and station)	Qty (Cum)
I	A. Earth work excavation	
	a. Pile drilling muck	46911
	b. Pile cap and open foundations	18677
	B. Concrete Debris	4691
II	A. Earth work excavation	
	a. Pile drilling muck	54290
	b. Pile cap and open foundations	33024
	c. Yelahanka underground section	39691
	B. Concrete Debris	5432
III	Earth work excavation	
	a. Pile drilling muck	39711
	b. Pile cap and open foundations	41281
	B. Concrete Debris	3973
Total earth work excavation		**273586**

Package No.	Source of debris (At viaduct and station)	Qty (Cum)
Total concrete Debris		**14096**

235. The run off from unprotected excavated areas during construction results in excessive soil erosion. Periods of prolonged rainfall or heavy downpours during construction phase may increase the risk of erosion and subsequent sedimentation of local storm water drains. Similarly, periods of dry and windy weather may increase the potential for soil erosion in the project area.

236. 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 impact on the soil is not of importance as the land use pattern in project area is urban and uncultivable. However, 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. Alteration of storm water drainage near the project construction site may lead to soil erosion. The elevated structure of viaduct will have the runoff during monsoon and if this runoff is not drained off properly, may lead to flooding and accelerated soil erosion on the at grade roads.

237. Removal of existing bituminous pavement at grade for preparatory works of pile foundation and indiscriminate disposal would cause soil pollution. These wastes could be managed well, by careful handling, storing and disposal.

a. Mitigation measures:

- Unplanned disposal of the soil from the pile foundation excavation from the proposed metro stations sites will cause the loss of productive top soil and erosion of soil. In such locations where soil is susceptible for erosion due to exposed surface area shall be limited to minimum and construction shall be scheduled immediately after completing 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 the existing roads should not be disposed nearby water bodies, open spaces and parks and wastes should not be left unmanaged on the road sides. Bituminous material should be examined for PAH to establish if it can be recycled. If not, the scarified bitumen shall be treated as hazardous and disposed of in clay lined bitumen disposal pits.
- 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 top soil 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.

- Refilling and servicing areas in construction camps shall be properly lined such that the oils and lubricants should not contaminate the soil. The washings from this area shall be provided with proper drainage with oil interceptors to prevent oil waste entering main drainage.
- 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.
- The unserviceable debris generated from project shall be disposed of in a scientific and sustainable manner in the listed BBMP approved locations located in and around Bengaluru city. All required permissions shall be obtained from the concerned authorities before disposing the debris.

ii. Impact on Air Quality

238. Dust generation and gaseous emissions from construction machinery are the main air quality issue associated with the construction of metro project. 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. Operation of heavy equipment & construction machinery; transporting vehicles, traffic diversion, etc. release 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 obnoxious gaseous pollutants like Carbon Monoxide, Oxides of Nitrogen, Sulphur Dioxide deteriorating quality of ambient air along the project corridor and at construction establishments.

239. 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).

240. In addition to dust, it is also expected that the project activities release air pollutants like SO_2, NO_x, CO, Lead, etc. Air pollutants adversely impact on human health, vegetation and materials. Human beings exposed to air pollutants will have higher incidence of cough, shortness of breath, bronchitis, chronic fibrosis, emphysema, bronchopneumonia, colds of long duration and fatigue. Pollutants such as SO2 and NO_x in the atmosphere are converted to acid, thereby making rain water acidic. Air pollution has damaging effect on vegetation depending upon their chemical nature, level of concentration and duration of exposure. Air pollutants cause physical and chemical change in materials and results in damage and their destruction. The most destructive air pollutants to materials are smoke, grit, dust and oxides of sulphur.

241. 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 54 ASRs considered to be affected by the air pollution and noise generated from construction activities of the project.

242. 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. Proper site selection, appropriate location of plant and regular maintenance and monitoring of DGs will minimize such impacts. However suitable mitigation measures such as using chimneys of required height will be ensured as

per the KSPCB norms. The details of air sensitive receptors along the metro alignment is given in table 5-3.

Table 5- 6: 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	Primary School, Benniganahalli	0+250	LHS	145
2	Shemrock Happy Hearts - Play school	0+850	LHS	90
3	Zamindar Microsurgical Centre - Eye Care Clinic	1+200	LHS	175
4	Presidency School	1+330	LHS	170
5	New Horizon College	1+400	LHS	180
6	Asha Nursing Home	2+210	LHS	210
7	Sri Sai Sathyanarayana PU College	2+250	LHS	145
8	EITA Training Academy – University	3+230	RHS	95
9	PB Academy – University	3+400	RHS	130
10	Cloud nine Hospital – HRBR	3+560	RHS	56
11	Motherhood Hospital	3+700	LHS	30
12	Banasawadi Medical Centre	3+770	LHS	30
13	Future Ray Play and Learn School	3+950	RHS	80
14	Leviosa Business School – University	4+120	RHS	60
15	Chethana Super Speciality Child Clinic	4+240	LHS	75
16	International School of Business	4+300	LHS	40
17	Parankushachar Institute of Vedic Studies - Research institute	4+590	RHS	75
18	Bangalore Nethralaya	4+620	RHS	90
19	Royal Concorde International School	4+850	RHS	75
20	VJR High School	4+990	RHS	100
21	Spandana Hospital & Diagnostic Centre	5+000	LHS	85
22	Bangalore City College – College	5+090	RHS	250
23	Susruta Nursing Home	5+200	RHS	99
24	The Princeton School	5+250	LHS	165
25	Sneha College of Nursing	5+480	RHS	85
26	Indo Asian Academy Group of Institutions	5+550	RHS	50
27	SERRA International Pre-School	5+750	LHS	110
28	Florence College of Nursing and Physiotherapy	5+900	LHS	30
29	Chris Super Specialty Hospital	6+000	RHS	65
30	New Life College	6+230	RHS	40
31	VBR PU College	6+725	RHS	100
32	Navashakthi Nethralaya	7+100	RHS	50
33	Government Kannada Model Primary School Nagavara	7+500	LHS	155
34	Art of Living Yoga & Meditation Center	7+580	RHS	45
35	JMJ Hospital	7+670	LHS	125
36	Little Glady's English High School	8+800	LHS	185
37	Columbia Asia Hospital Hebbal	12+100	RHS	35
38	Aster CMI Hospital, Hebbal & Sankara Nethralaya	12+100	RHS	40
39	North Side Hospital	12+460	LHS	190
40	Green Country Public School (B)	12+940	LHS	105
41	Government Primary School	13+010	RHS	90
42	Prolife Hospital	13+500	LHS	300
43	Cytecare Cancer Hospital,	13+650	RHS	25
44	Government Flying Training School - Flight school	13+870	RHS	30
45	University of Agricultural Sciences Library	14+900	RHS	30
46	Vidya Prakash high School	15+650	RHS	30
47	Vidyashilp Academy	15+700	RHS	130
48	Shree Nava Chaitanya Association for Special – School	16+250	RHS	165

Sl. No.	Name of Schools & Colleges	Chainage (Km)	LHS/ RHS	Distance from Center Line (M)
49	Bhuvan Group of Institution – College	17+100	RHS	200
50	Vinayaka Public School	19+070	RHS	30
51	Astra Zenica Pharmaceuticals	19+900	LHS	90
52	Kendriya Vidyalaya Airforce Station	20+200	RHS	110
53	ECHS Polyclinic Yelahanka	20+900	RHS	140
54	Academy of Aviation and Engineering	21+400	RHS	190

a. Mitigation measures:

243. 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 prevent dust. All construction sites, material haulage roads (unpaved) and the traffic diversion routes should be sprayed with water two to three times a day.
- The materials transported to and from the construction site will should 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 should be covered or sprayed with water on a regular basis, particularly during dry or windy conditions;
- All stockpiles should be located far from residences and businesses where possible, prevent placing dusty material storage piles near ASRs;
- 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 shall obtain the 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 adhered to conditions stipulated in the consent.
- Batching plants, Hot (asphalt) mix plants, crushers, etc. should be located at least 500 m down windward of human settlements. These establishments should be compulsorily fitted with dust suppression units including 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 implement required mitigation measures if any of the air pollutant exceeds the limit. If any of the air quality parameter exceeds the prescribed NAAQS standards, more stringent measures such as use of construction machineries complying to emission norms; timing of construction activities; stopping unnecessary idling of construction equipment; use of proper PPEs by construction labours; etc. shall be implemented.

iii. Traffic Diversions

244. During construction, complete or partial traffic diversions will be required. 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, increased noise levels to the inhabitants living adjacent to the proposed project corridor.

245. 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. Along airport road, the metro alignment follows the space between main highway and the service road. Hence, it is not necessary to completely block either the ORR or airport road. A clear passage shall be maintained on both sides of ORR road, for smooth operation of through traffic and local vehicular movements. The traffic along Airport road will not be significantly affected as the metro alignment is between the main highway and the service road. Local traffic using the service road will get impacted during construction. 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.

246. 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 are given in the table 5-4. where traffic control and diversion will be a challenging task.

Table 5- 7: Major Junctions along the proposed project

Sl. No.	Junction Name	Chainage (km)
1	TIN Factory Junction	0+000
2	Ramamurthy Nagar Main Road Crossing	2+200
3	Horamaavu Junction	3+300
4	Kalyan Nagar Junction	4+700
5	Kammanahalli main Road Junction	5+450
6	Hennur Junction	5+950
7	Nagawara Junction	7+600
8	Manyata Tech Park Junction	8+200
9	Veerannapalya Cross	8+850
10	Hebbala Junction	11+100
11	Kempapura Main Road Junction	11+900
12	Kodigehalli gate Junction	12+800
13	Sahakara Nagar Junction	13+400
14	Jakkur Main Road Junction	14+600
15	Yelahanka Junction	15+500
16	Kogilu Cross Junction	18+050
17	Bagalur Main Road Junction	20+350
18	Yelahanka Airforce Station Junction	21+500
19	Sadahalli Gate Junction	29+050

iv. Impact on Noise

247. 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 & 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. The values for noise and vibrations monitored along the

proposed alignment is being put to model to predict the impact of construction activities on the baseline noise will be annexed with this report and forms part of this report.

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

Table 5- 8: Average noise levels generated from equipment used in construction[10]

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

249. Increase of noise around 90 dB (A) creates fatigue of the hearing organs. Prolonged stay in an area with noise pollution gradually induces deafness. Increased noise may induce various types of temporary physiological changes, such as hypertension, change of the rate of heart-beat, high respiratory rates, excessive perspiration, vomiting tendency, vertigo, exhaustion and disturbs sleep. If the noise is intolerable, it can tend people to shift to far off places.

250. The impact of noise from the project activities are insignificant as the recorded noise levels in the project area monitored are more than the norms prescribed for the nature of commercial land use adjacent to project corridor. All the identified inhabited stretches are prone to increased noise. Further, noise sensitive receptors like schools, hostels, hospitals, libraries are largely impacted from project activities both during construction and operation phase. The noise sensitive receptors along the proposed metro corridor are tabulated in the table 5-6below.

Table 5- 9: Noise sensitive receptors along the proposed metro corridor

Sl. No.	Name of Schools & Colleges	Chainage (Km)	LHS/ RHS	Distance from Center Line (M)
1	Primary School, Bennigana Halli	0+250	LHS	145
2	Shemrock Happy Hearts - Play school	0+850	LHS	90
3	Zamindar Microsurgical Centre - Eye Care Clinic	1+200	LHS	175
4	Presidency School	1+330	LHS	170
5	New Horizon College	1+400	LHS	180
6	Asha Nursing Home	2+210	LHS	210
7	Sri Sai Sathyanarayana PU College	2+250	LHS	145
8	EITA Training Academy – University	3+230	RHS	95
9	PB Academy – University	3+400	RHS	130
10	Cloud nine Hospital – HRBR	3+560	RHS	56
11	Motherhood Hospital	3+700	LHS	30

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

Sl. No.	Name of Schools & Colleges	Chainage (Km)	LHS/ RHS	Distance from Center Line (M)
12	Banasawadi Medical Centre	3+770	LHS	30
13	Future Ray Play and Learn School	3+950	RHS	80
14	Leviosa Business School – University	4+120	RHS	60
15	Chethana Super Speciality Child Clinic	4+240	LHS	75
16	International School of Business	4+300	LHS	40
17	Parankushachar Institute of Vedic Studies - Research institute	4+590	RHS	75
18	Bangalore Nethralaya	4+620	RHS	90
19	Royal Concorde International School	4+850	RHS	75
20	VJR High School	4+990	RHS	100
21	Spandana Hospital & Diagnostic Centre	5+000	LHS	85
22	Bangalore City College – College	5+090	RHS	250
23	Susruta Nursing Home	5+200	RHS	99
24	The Princeton School	5+250	LHS	165
25	Sneha College of Nursing	5+480	RHS	85
26	Indo Asian Academy Group of Institutions	5+550	RHS	50
27	SERRA International Pre-School	5+750	LHS	110
28	Florence College of Nursing and Physiotherapy	5+900	LHS	30
29	Chris Super Specialty Hospital	6+000	RHS	65
30	New Life College	6+230	RHS	40
31	VBR PU College	6+725	RHS	100
32	Navashakthi Nethralaya	7+100	RHS	50
33	Government Kannada Model Primary School Nagavara	7+500	LHS	155
34	Art of Living Yoga & Meditation Center	7+580	RHS	45
35	JMJ Hospital	7+670	LHS	125
36	Little Glady's English High School	8+800	LHS	185
37	Columbia Asia Hospital Hebbal / Embassy Lake Terraces	12+100	RHS	35
38	Aster CMI Hospital, Hebbal & Sankara Nethralaya	12+100	RHS	40
39	North Side Hospital	12+460	LHS	190
40	Green Country Public School (B)	12+940	LHS	105
41	Government Primary School	13+010	RHS	90
42	Prolife Hospital	13+500	LHS	300
43	Cytecare Cancer Hospital,	13+650	RHS	25
44	Government Flying Training School - Flight school	13+870	RHS	30
45	University of Agricultural Sciences Library	14+900	RHS	30
46	Vidya Prakash high School	15+650	RHS	30
47	Vidyashilp Academy	15+700	RHS	130
48	Shree Nava Chaitanya Association for Special – School	16+250	RHS	165
49	Bhuvan Group of Institution – College	17+100	RHS	200
50	Vinayaka Public School	19+070	RHS	30
51	Astra Zenica Pharmaceuticals	19+900	LHS	90
52	Kendriya Vidyalaya Airforce Station	20+200	RHS	110
53	ECHS Polyclinic Yelahanka	20+900	RHS	140
54	Academy of Aviation and Engineering	21+400	RHS	190

251. 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.

a. Mitigation measures:

252. 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.

- Properly maintained equipment & machinery, designed with in-built silencers, mufflers and enclosures and shock absorbing pads shall be used in the construction. This would 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 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.
- Proposed project involves construction of as many as 800 pile foundations. Generally, piling is driven using an impact hammer which often produces excessive noise. This noise can be reduced by various dampening and shielding methods. Alternative method such as vibration or hydraulic insertion can be used. Drilled holes for cast in place piles are another alternative that may produce noise levels significantly lower than the traditional driving methods.
- 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.
- Noise levels may be regulated by stopping the noise generating construction works at night time near the inhabited localities. Noisier construction and demolition activities to be restricted around 6 AM and 10 PM to reduce construction noise impacts during night hours.
- 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.

- Dissemination of information to the public and adjacent property owners of upcoming noise generating construction activities in order to allow residents to plan their activities accordingly.
- Efforts shall be made to reduce truck trips by increasing load size, decreasing fill requirements, or combining trips would help to reduce noise levels.
- 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; use of proper PPEs by the receptors can be recommended.
- 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 speed limit shall be erected at all the noise sensitive receptors.

v. Impact from Vibrations

253. Vibrations are expected to be generated due to construction activities of proposed project and operation metro trains which has the potential to cause some damage to the building and properties. Therefore, various mitigation measures are to be adopted during design phase to prevent any such damage.

254. 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. Because of the limited workspace at the underground section near Yelahanka air force station and the depth of the construction some form of retaining wall has to be installed. Installing a temporary sheet pile wall may cause vibrations, when using in-situ techniques like diaphragm walls the possibility of impacts due to vibration is minnimalized.

255. Further, vibrations monitored along the proposed alignment is being put to model to predict the impact of construction activities on the baseline vibrations which will be annexed with this report and forms part of this report.

a. Mitigation measures:

- 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.
- 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.
- 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 & EMP.

- 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.
- 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.
- As per RDSO (Research Designs and Standards Organization) Guidelines 2015, baseline and vibration monitoring studies have to be conducted along the project corridors to determine the extent of impacts. If significant impacts are expected, mitigation measures have to be implemented and building condition survey have to be conducted before and during construction.

vi. Impact on Water Quality, Drainage and Hydrology

256. There are a few important water bodies along the proposed metro alignment which may be impacted from construction activities. Water bodies adjacent to the alignment are shown in table 5-7.

Table 5- 10: Details of water bodies adjacent to proposed metro corridor

Sl. No.	Water bodies / Lakes	Chainage (Km)	LHS / RHS	Distance from Metro alignment (m)
1	Beninganahalli Lake	0+000 to 0+800	RHS	30
2	Chalkere Lake	4+500 to 4+750	RHS	170
3	Pond	7+000 to 7+200	LHS	30
4	Nagavara Lake	9+000 to 10+100	RHS	50
5	Drain	10+300	both sides	25
6	Hebbal Lake	11+500 to 11+700	LHS	140
7	Pond	16+500 to 16+750	LHS	100
8	Hunasemaranahalli Lake	22+300 to 22+800	LHS	65
9	Pond	25+200 to 25+400	LHS	80
10	Lake near Chikkajala	26+600 to 26+700	LHS	70

257. There are a few major water bodies like Benniganahalli Lake, Chalkere Lake, Nagawara Lake, Hebbala Lake, Hunasemaranahalli Lake and Lake near Chikkajaala along the proposed metro corridor. These water bodies may get affected by the construction activities during construction phase, if proper precautions are not taken.

258. Construction of metro project requires water. 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.

259. 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, will lead to water pollution increasing the risk of outbreak of communicable diseases.

260. If disposed without proper treatment, the waste water from toilets of metro stations and washings and oil spills from metro depots will pollute the nearby waterbodies. Precaution shall be taken to treat and dispose the wastes in a proper manner to prevent and minimize the impact of oil spills from construction equipment.

261. Construction of metro project requires water. 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.

262. Construction of the project corridor and the associated activities may impact on the water bodies. 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 in these waterbodies.

263. There is no significant impact on either ground water or water table by the project activities. The metro alignment is proposed along the existing paved roads which are not making significant impact on the ground water percolation and ground water potential.

a. 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. If a new tube-well is to be bored, proper sanction and approval from local authorities and Central Ground Water Board should be obtained.
- 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, labour camps, stone crushing units should be located away from the water bodies. Domestic and sewage wastes from labour camps shall be treated to the standards specified by CPCB before disposal.
- The excavated earth, stones or any other construction material, shall be properly handled, stacked and disposed of so as not to choke the nearby drainage system and block the flow of water. All required precautions shall be taken up to ensure no silt, soil, construction material reaches and silt up the adjacent waterbodies by constructing suitable retaining barricades.
- The water used for curing structures shall be passed through desilting chambers 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.
- Proper treatment methods such as oil interceptors for oil wastes from depots and treatment plants to treat the toilet wastes shall be established to ensure proper treatment before disposing to sewer or surface 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 stored

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, vehicle service areas (Depots), to ensure oils and oil-based product do not pollute the soil or reach nearby waterbodies.
- Rain water harvesting and recharge pits shall be proposed all along the median. Rain water collected on the via duct 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.

vii. Impact on Biological Environment

a. Impact on wildlife

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 19 km which is the nearest wildlife sensitive protected area. The list of birds and reptiles commonly found around Bengaluru is given in annexure – 3. As brought out in baseline environment chapter, water bodies located adjacent to the proposed alignment do not have significant aquatic fauna because of sewage inflow from adjacent residential layouts and are not attracting the birds because of presence of high-rise buildings around these waterbodies. When it comes to green spaces (neighbourhood parks) like in Bengaluru city, are small green patches which vary in size and scattered in nature are mainly catering to the recreational purposes and do not support large number of birds. The trees which are impacted by the project are mainly on the median of ORR are small and are in the middle of busy road do not serve as shelter to avian community. Hence, there are no perceivable impacts on the wildlife by the proposed metro project.

b. Impact on Trees

265. Trees are major source of air purification in urban areas making cities environmentally more sustainable. Trees clean air by absorbing CO2 from atmosphere during photosynthesis and play an important role in climate amelioration. In addition, trees will help to control temperature and keeps the air cool, thus reducing the urban heat island effect. The impact on the trees is unavoidable as the alignment of the metro corridor is taken almost along the median of existing Outer Ring Road. 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.

266. Removal of trees will impact the quality of air. Total of 3541 trees located on the alignment, station and at depots locations which are getting affected along Phase 2B. The breakup of trees impacted along the alignment, stations and depot locations are given in table 5-8 below.

Table 5- 11: Details of trees impacted along the metro project corridor

Sl. No.	Type of Ownership	No. of trees impacted				Total
		Package 1	Package 2	Package 3	Depot	
1	Government	2091	503	52	170	2816
2	Private	45	105	575	-	725
	Total	2136	608	627	170	3541

Table 5- 12: Details of trees impacted along the metro project corridor

Phase No.	No. of trees to be transplanted				Total
	Package 1	Package 2	Package 3	Depot	
2B	1472	294	42	50	1853

Most of the trees which are being affected by the project are transplanted to a suitable location.

c. Mitigation measures:

- Trees cutting and felling shall be done only after the confirming that the tree comes in the way of construction. 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 Tree Committee or Forest Department. The saplings will be monitored for their survival for three years. Replantation shall be taken up every year with new saplings where sapling 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 base of 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. 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.
- Two rows of suitable ornamental plants shall be planted in medians of at grade roads all along the proposed metro alignment.

viii. Impact on Socio – economic environment

a. Structures Affected

267. During pre-construction stage, the proposed metro project requires land to be acquired and structures to be demolished. Total land required for Phase 2B project 3,14,212.516 Sqm (Government land – 11,976.180 Sqm and Private land – 1,94,444.336 Sqm).Survey covered major structures like residential, commercial and government.

268. The project affected families are limited in number (only 123 owners, 137 tenants and 4 non-title holders) as the land being acquired for construction of viaduct is very less and the land required for construction of proposed metro stations is minimum as12 metro stations out of 17 metro stations are located on the vacant government lands. Approximately 93 structures are affected by the proposed metro project, especially at the proposed metro station locations. The type of structures impacted includes both residential and commercial. 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- 13: Details of Structures Impacted and Open lands (Nos.)

Phase No.	Residential Structures	Commercial Structures	Religious Structures	Vacant lands
2B	10	32	01	15

269. There are no notified archaeological structures present along the proposed metro alignment. However, there is one ancient Chjikkajala fort at chainage 22+600 km on RHS of the alignment which is already in dilapidated condition during widening of National Highway 44. Construction of metro project near the Chikkajala fort does not require special clearance but care should be taken not to damage the existing structure.

b. Mitigation measures:

- 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.
- Construction of metro stations shall be planned in such a way that impact on the adjacent structures is minimized. Alternative engineering designs shall be attempted to avoid or minimize land acquisition.
- If valuable or invaluable articles such as fabrics, coins, artefacts, structures or other geographic or archaeological rarities are discovered, the excavation should be stopped and the archaeological department to be contacted.

ix. Impact on Livelihood, Public services, Health and Safety of Community and Laborer

270. There will be inconveniences and nuisance to the public temporarily during construction of the project. Inconveniences will be mainly due to utility shifting, excavations, unplanned stacking of excavated earth and traffic diversions in the vicinity of project corridor. The construction of proposed metro project may impact on utility services such as electricity, telephone, optical cables, storm water drains, UGD, water supply, etc. during the construction stage.

271. Movement of pedestrians though constricted space may cause potential health & safety issues especially during erecting elevated structures like viaduct components. Fine dust of cement / silt / sand could cause problem to respiratory system of pedestrians nearby. Use of cranes and launchers during construction of elevated structures are a major safety concern not only for the labours involved in construction but also to the pedestrians who are around construction site. The movement of trucks to and from construction areas will increase the traffic risk of the commuters.

272. Construction activities causes disturbance to traffic along the proposed alignment resulting congestion, traffic diversions, dust generation, emission of air pollutants, etc. The commercial activities along the proposed alignment will be affected incurring loss to the retailers and businessmen. Increase in noise along the corridor will impact inhabitants particularly old age people, school children and the patients. In addition to the above concerns, 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.

273. Encountering unexpected polluted soil 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 should be ready as a part of mitigation measures.

a. Mitigation measures:

- All the utilities shall be shifted to proper and pre-approved locations before the start of construction to avoid or reduce the impact on public.
- Contractor shall prepare traffic management plan to address the traffic issues in the project corridor alignment and get the approval of engineer concerned before start of construction.
- As much as possible semi-skilled and unskilled labourers would 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 labour camps within the city thus alleviating impacts associated with establishment of labour camps.
- All the labourers engaged in the construction works are provided with proper camp facilities including sanitation, drinking water supply, washing facilities, cooking facilities and primary health facilities as per the Building and other Construction Workers' (Regulation of Employment and Conditions of Service) Act, 1996.
- 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 labourers, educating and training the labourers and local community, and establishing labour camps far from the inhabited areas.
- 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, television& newspaper announcements regarding the construction activities and timeframe of projects and expected disruptions or access restrictions.
- 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.
- 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 work place, 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, the 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.

x. Impact on Economy

274. During metro construction phase, local people involving in construction activities earn their livelihood in the form of wages and salaries. Local retail shops get their business by construction workers, making everyday purchases. This is likely to give a short-lived stimulus to daily commercial activities till the completion of project. Broader, flow-on economic impacts will be experienced in other sectors of economy as a result of purchase of construction materials.

D. Impacts during Operation Phase

275. There are no significant adverse impacts on the physical and biological environment envisaged during operation phase. However, the project may cause the following negative impacts to the social environment during operation phase:

- Noise from operating metro trains and track structures is of concern, especially for noise sensitive receptors and residential areas. A separate noise and vibration study is being conducted to capture the baseline conditions along the proposed metro corridors to model and predict the impact on noise and vibrations both during construction and operation phase of the project. The details of the study will be a part of the final EIA report. Preliminary results show that 1 noise sensitive receptor, the Embassy Lake Terraces development located at chainage km 12+100, might be impacted by noise during operation phase of the metro. Detailed additional monitoring at this specific location will be carried out to determine the necessity and extent of mitigation measures. Construction of the metro will be in such a way that additional measures, such as transparent walls to be placed on top of the parapet walls, can be added when proven necessary.
- The cut-and-cover underground section near Yelahanka Airforce station potentially poses a risk of flooding during extreme rainfall. Proper water proofing on outer surface of the RCC box will be ensured to avoid any leakage of water into cut and cover section. Protection against the flood water entering into the cut and cover section will be provided by constructing parapet / curtain walls for sufficient height. There is a possibility of rain water entering into cut and cover from open ramps and same will be collected in sump on either end by providing side drains on either side of tracks. The leakage if any, within the cut and cover in spite of water proofing treatment will be directed towards the sump through side drains with proper gradient. Water collected in the sump at either end of the cut and cover will be dewatered by using suitable pumping system.
- 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.
- 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. The vibration shock absorbing pad will be provided. Impact of vibration to the passengers will be reduced by maintaining the distance between rail seat assembly and concrete plinth. Preliminary results of the vibration study show that minimal impacts are possibly to be expected when buildings are within 12.2 meters from the alignment at sections where metro is travelling with a speed of 60 km/h (Yelahanka Station to KIA Terminals).

- 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.
- Elevated structures of metro project would impact the light transmission below the structure thus reducing the visibility to drivers using at-grade roads. This may impact the safety of vehicle users, particularly during evenings in absence of proper lighting arrangement. However, looking at the location of elevated structure along the outer ring road which is wider enough and the built-up structures are away from the metro alignment, the impact is not significant.
- Elevated structures of metro after completion of construction will also affect the aesthetics of area by blocking the view. Aesthetics can be improved by taking up painting on the pier structures and landscaping beneath the elevated structures.
- Increase in the number of passengers and trains at the stations will require more water for drinking, toilet, cleaning and also for other purpose like AC, chiller and other purposes. The trash from station includes garbage, rubbish, and floor sweepings.
- First and last mile connectivity including poor access to stations; lack of parking facilities; and absence of dedicated space for buses, cabs and autorickshaws, etc. are apparently costing the Metro at least one lakh daily ridership. BMRCL has the dedicated team comprising of six to seven officials led by an executive director to explore ways to address connectivity issues.

i. Positive Impacts of Metro Project

276. Construction of 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 have been listed and discussed below.

- GHG emission reduction - 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 365,000 tons of CO2. Other pollutants that will be reduced include PM, NOx, HC, and CO.
- Employment Opportunities - The project is expected to generate employment for unskilled labourers during construction phase and the large number of skilled work force is required to operate and maintain the system during operation phase. During the construction phase, there will be requirements.
- 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 and improves the weather.
- 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.

VI. INFORMATION DISCLOSURE, CONSULTATION, AND PARTICIPATION

277. Consultation and inclusion of various stakeholders is 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.

278. The consultations were conducted during the field visits based on informal unstructured interviews and focus group discussions. The objective of the consultation was to disseminate the project information and obtain stakeholder's views on probable environmental and social impacts that may arise during the implementation of the proposed project. Consultations at project level were conducted at pre-identified, accessible locations along the alignment. The project affected families are limited in number (only 123 owners,137 tenants and 4 non-title holders) as the land being acquired for construction of viaduct is very less and the land required for construction of proposed metro stations is minimum as12 metro stations out of 17 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 stage of implementation of project.

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

- People at Kogilu Cross were very curious to know the alignment and the proposed stations to know the accessibility and distance from their settlements. Most of the public were happy to learn that the proposed metro project is passing near their settlements. They assured their support to the project as it helps them to commute quickly to other parts of the city.
- The participants were very keen to know the impact caused by the metro project on the land and structures. They were also eager to know the policy framework on the rehabilitation benefits extended for affected families. There were also requests for employing project affected people in Metro project/BMRCL.
- Some of the public requested to shift the metro station to avoid impact. It was explained to them that the station is proposed on other side of the airport road on the vacant land and the access to the station is being provided to their settlement.

280. Two other public consultation meetings for Phase 2B section were held at Muthu Mariyamma Temple, Jyothinagara, Outer Ring Road, KR Puram on 12 December2019and Kogilu Cross, Airport Road on 28 February2020.Stakeholders and project affected people were among the people who attended the meetings. The details on gender disaggregated ratio are given social impact assessment and resettlement plans prepared for the project. The main concerns raised by the stakeholders was on the how compensation will be decided, when compensation will be paid to them and when they have to vacate their houses. The key findings of the meeting are given in Tables6.1and 6.2 and the photographs are given in Figures 6-1and 6.2.

Table 6-1: Major findings of Public Consultation, Muthu Mariyamma Temple, ORR

Sl. No.	Name of Stakeholder / Project Affected Public	Grievance / Request	BMRCL's Response
1	Govardhan	When will the compensation be issued to property owners and when should they vacate the houses and shops?	Sufficient time of 15 days will be given to property owners to vacate and shift their articles after the publication of Notification.
2	Shankar	I am a commercial tenant. My shop is being affected. How much will I get for shifting my shop.	You will get Rs. 35,000 as shifting charges depending on the area of your shop and the GST being paid by you. Shifting allowance of Rs. 1,70,000 for 1000 sq ft and Rs. 4,00,000 for 1500 sqft will be given. Further, if the building is bigger, shifting allowance will be paid at the rate of Rs. 540 /sqft.
3	Rangamma	I have 5 children, I am leading my life by daily wage. I have one handicap daughter in my house. Please let me know the compensation for me.	You will be given compensation under the project as a special consideration
4	Govardhan	How do you pay for shifting houses with sheet roof and mold roof?	Rs. 1,00,000 of shifting allowance will be given for shifting of both type of houses with sheet roof or mold roof.
5	Sagar	My plot has a length of 15 m out of which only 10.5 m is being acquired by BMRCL. Can BMRCL take whole of my land and pay me the compensation. I have taken bank loan on the land being acquired. Please give me information.	Please submit your request to BMRCL Office which will be examined and suitable action will be taken.
6	Harish Reddy	Please let me know what is the compensation for converted land and the revenue land having survey number? You had acquired my land for which NGT had not allowed for land conversion. But now NGT has allowed conversion for my land. Please give more information on how BMRCL considers this and gives compensation.	Requested him to submit the request along with details and records on his land to BMRCL, so that BMRCL will take suitable action.
7	Radha	Time given for shifting to different place is not sufficient as I have children going to nearby school. Request BMRCL to give time till the annual examinations are over.	BMRCL will consider children going to school.

Sl. No.	Name of Stakeholder / Project Affected Public	Grievance / Request	BMRCL's Response
8	Prabhu	Please give alternative government land for us to shift.	Government land is not available and you are requested to shift to suitable places on your own.
9	Indrani / Vijayalakshmi	My granddaughter is handicapped, please help me.	Please share more information to BMRCL officials so that appropriate action will be taken.
10	Tenants	There are about 40 tenants being affected. Please give us government plots.	Tenants can be paid shifting allowance only. BMRCL cannot give either the cost of house or the plot. BMRCL can send a request to government on behalf of tenants.

Figure 6- 1: Public Consultation Meeting Photos, Muthu Mariyamma Temple, ORR

Table 6-2: Major findings of Public Consultation, Kogilu Cross, Airport Road

Sl. No.	Name of Stakeholder / Project Affected Public	Grievance / Request	BMRCL's Response
1	Subramani	Survey number 75 has many houses in a single plot with a space left for access road within the plot. Request was made to consider this space and give compensation.	BMRCL asked to submit the request along with relevant documents of ownership for claiming the compensation
2	Sarojamma	She requested to give more time for shifting after paying the compensation as they have to either look for new accommodation to purchase and it requires time.	Six months will be too long a time to consider. Time as per the provisions of Policy framework will be given.
3	Venkatesh	My land has already been acquired for National Highway by NHAI and the compensation given is not sufficient.	Compensation for NHAI acquired land cannot be paid by BMRCL.
4	Hemaraju	The compensation given is less than the market value	BMRCL has released amount to NHAI but NHAI has not yet released the compensation.
5	Srinivas, Raghavendra Condiments (tenant)	The shifting allowance is not sufficient as we have spent more for the furniture in the shop	Business loss allowance and shifting allowance will be paid to tenants based on the area of the shop
6	Raju Gowda	We don't know the amount of compensation being disbursed by BMRCL	BMRCL will communicate the amount of compensation to be released within 15 – 20 days, depending on individual loss.
7	Y M Gopal, Hotel owner	I don't know the extent of building being demolished. Please let me know.	BMRCL will let you know about the exact extent of building to be demolished after finalizing the drawings of proposed station at Kogilu cross.
8	Muniraj, Udupi Garden & Vandana Hotel	My land has been acquired several times by various agencies like NHAI, BBMP & BMRCL. The compensation given during previous acquisition is not sufficient.	BMRCL cannot help for previous acquisition and compensation but will give the compensation as per the latest market value with 100 % solatium for the land being acquired by BMRCL.
9	Naushad, Tenant, Mobile shop	Requested to give compensation for the furniture in the shop	There is no provision to pay for the furniture in the shop. They have to be shifted on their own.
10	Ramamurthy	I am losing underground water sump of size 14'X14'X14' and request you to consider for compensation	It will be considered
11	Syed Abdul Subhan, Famous Chicken Center	Do you pay for the employees in my shop	BMRCL does not pay for employees in shops
12	Abhishek Gowda & Kempamma tenant	Requested for alternate job as a compensation	There is no provision of this in BMRCL compensation policy

13	Ammayamma	She is not getting the rent after taking the notice from BMRCL. Will that be compensated?	Business and rental income loss will be considered based on the BMRCL compensation policy. It was informed that a notice will be served to the tenants also.
14	Jayamma	She has five daughters and distributed all the property to them. I require some livelihood assistance	BMRCL will look into the matter.
15	Mubharak, Real Estate Office	I have five employees, Will there be any assistance to them?	BMRCL does not pay for employees in shops
16	Manjunath B N (& Susheelamma B N)	I am handicap and dependent on rental income. Can I get employment in the metro?	The matter will be examined. Loss of rental income will be compensated as per BMRCL compensation policy.

Figure 6- 2: Public Consultation Meeting Photos, Kogilu Cross Airport Road

281. Consultations have also been organised for stakeholders at the regional level to collect the opinion / views on the proposed metro project. Consultation was organized with officers of concerned government department and non-government organizations (NGOs) in the city.

282. 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.

283. 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 Redressal Mechanism

284. A grievance redress mechanism (GRM) 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 Head Quarters. 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. Grievance re-dress mechanism framed by BMRCL and contact details (with name) of PRO will be displayed in the BMRCL website, project offices head office and at the project construction site prior to commencement of construction works.

285. 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. The small and local grievances will be dealt and resolved by the Contractor or Site Engineer in-charge or Tahsildar. 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. Issues related to environment and EMP implementation are directed to the Environment Officer (EO). Both Land Acquisition Department and Environment Department constitute to form Social and Environment Management Unit (SEMU). All the other technical issues are referred to 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) headed by Director (Projects and Planning) who acts as Chairman of GRC. The grievances and enquiries beyond the purview of GRC requiring to be cleared through judiciary will be referred and resolved through legal cell of BMRCL. The GRM flowchart is shown in the figure below.

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

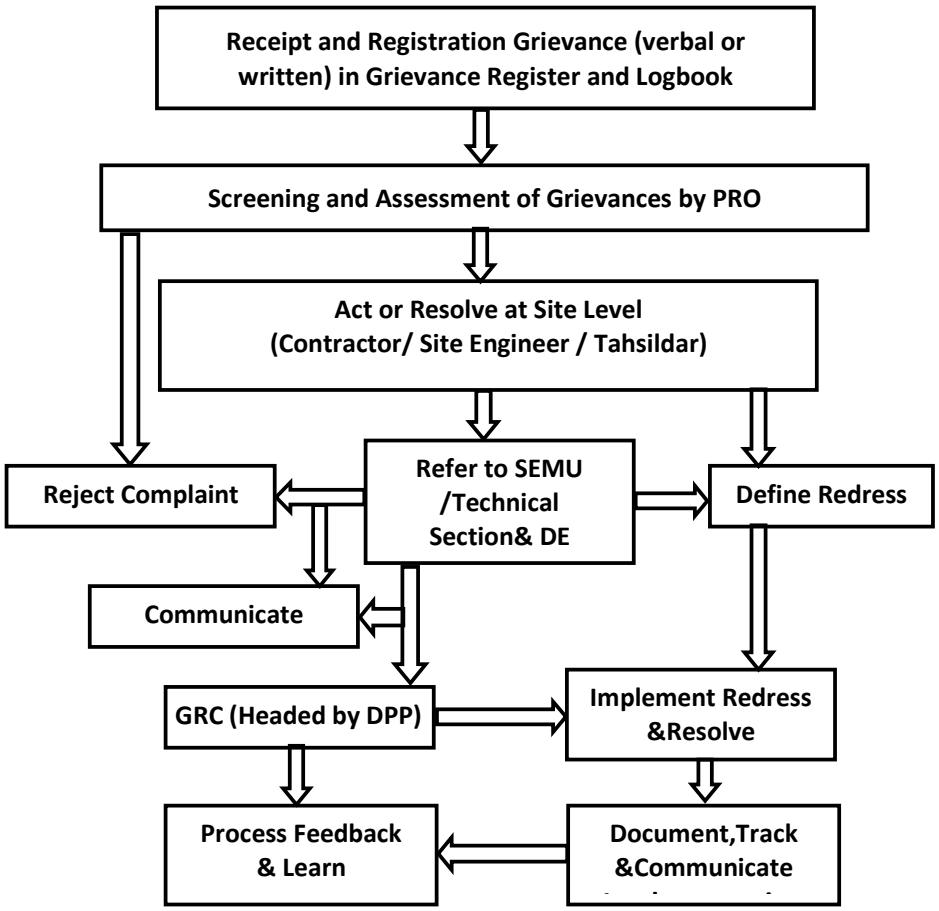
a. Director (Projects and Planning), Chairman
b. General Manager (LA & E), Convener
d. General Manager (F & A), Member
e. Chief Public Relation Officer, Member
f. Chief Engineer (respective Reach), Member
g. Manager (Transportation), Member
h. Tahsildar (Respective Reach)

287. 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.

288. The flow chart of grievances redressal mechanism is indicated in Figure 6-3.

Figure 6- 3: The GRM Framework, BMRCL



Environmental Impact Assessment (Draft) Vol. 6 of 6

June 2020

India: Bengaluru Metro Rail Project

Phase 2B (Airport Metro Line)
KR Puram to Kempegowda International Airport

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

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.

VII. ENVIRONMENTAL MANAGEMENT PLAN

A. Introduction

289. The Environmental Management Plan (EMP) is the synthesis of all proposed mitigation and monitoring actions, set to a time-frame 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.

290. 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

291. 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

292. 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.

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

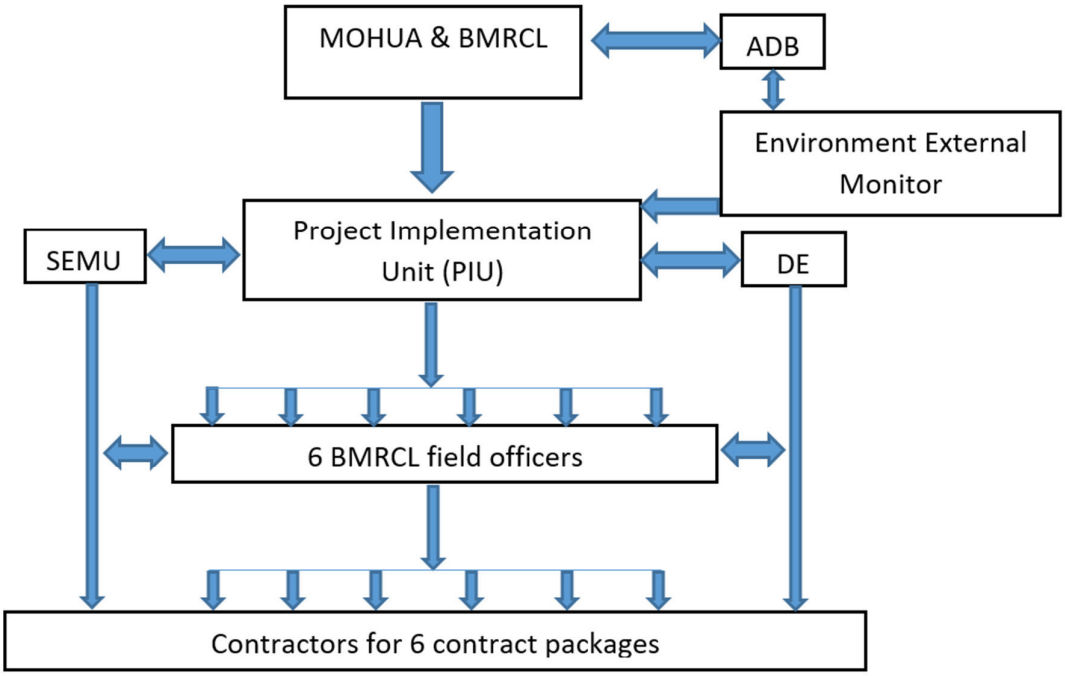
294. SEMU of BMRCL is in-charge of the environmental and social issues during the project preparation, implementation and operation with the assistance of the Environmental Specialist

of the Designated Engineer (DE) and Environmental Officer (EO) working for Contractor during construction phase.

295. 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.

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

Figure 7-1: Organizational Chart



297. Social and Environmental Management Unit (SEMU).

298. 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.

299. 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, minimise and resolve bottlenecks during the implementation of EMP.

300. 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.
- 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.

301. 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. EO will prepare monthly progress reports including updates on EMP implementation and submit these for review to DE Environment Specialist.

302. External Monitor. For Category A projects an external independent monitor will be engaged 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 minimise 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.

303. ADB's Responsibilities:

- 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

304. 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. 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.

305. The key anticipated adverse environmental impacts from phase 2B are:

- Dislocation or involuntary resettlement of people as there will be a need for land acquisition;
- Loss of about 1961 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.

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

i. Compensation for Loss of Land and Displacement of People

307. Phase 2B will require acquisition of about 313,519m^2 of land of which 297,019 m^2 is private land and 105,500 m^2 is government land. 123 owners, 137 tenants and 4 non-title holders 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

308. A total of 3541 trees will be affected by the project, many of the affected 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.

309. 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

310. 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

311. 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.

312. 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 night time 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

313. 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.

314. 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.

315.

vi. Air Pollution Control

316. 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

317. 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.

Table 7- 4: 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 and at some sharp curves along the Metro alignment.	– 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, the space between main highway and the service road along the airport 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	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
			Bengaluru Revised Master Plan (RMP) 2031 both account for proposal of Phase 2B by BMRCL. Proper permissions will be ensured from competent authorities before construction.					
3	Clearance of Encroachments / Squatters (Compulsory resettlement)	Social - There are 264 project affected people (PAP) within the Corridor of Impact (CoI) along the proposed metro alignment and metro stations of Phase 2B.	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 – The likely number is 3541 trees. Out of total trees enumerated, many of the trees are planned to be trans-located, which is tentative depending on the tree species, girth and health of the trees. The trees are located on the median of	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 removed shall be marked with paint. Contractor, under any circumstances shall not cut or damage trees unnecessarily. Trees identified under the project shall be cut only after	Throughout project corridor.	ROW width Number of trees to cut Compensatory plantation plan	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
		proposed route along the outer ring road and airport road impacting the ecology in the project vicinity. In addition to tree cutting, pruning of branches will be required at some locations.	receiving clearance from State Forest Department and after receipt of BMRCL's written permission. Transplantation of trees shall be taken up on priority suiting to the tree species, age, size, and health condition of the tree. Compensatory plantation shall be taken up at the rate of 10 trees for each tree being felled. Compensatory plantation taken up will be monitored regularly for their survival. Vegetation with girth size of over 30 cm shall only be considered as trees and shall be compensated. The tree saplings which do not survive during the first year after replanting will be compensated immediately.		Number of trees replanted			
5	Relocation of Utilities and Common Property Resources	Social - The proposed metro line interferes with community utilities like water pipes, sewers, OFCs, telephone wires. Skywalks, etc. throughout the corridor. This will create nuisance to	Permission from all concerned departments and BBMP should be sought before commencement of utility shifting works. All community utilities i.e. water supply lines, sewer lines, electrical lines, telephone and OFC cables shall be planned	Throughout the project alignment and station areas.	Area of land acquired and required for working space for the project.	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
		public and the commuters.	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.					
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. Dust suppression methods like water spraying shall be					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			adopted during utility shifting to encapsulate the dust.					
8		Safety – Workers and public will be exposed to safety threat such as excavation related safety hazards such as falls into trenches or excavations; tripping over equipment, debris and spoil; exposure to underground services, electrocution, etc.	Barricades of at least 2 m height will be installed to mark the boundary of the areas where public utilities are to be relocated. Workers shall be provided with appropriate PPEs and ensure to operate equipment in a safe manner during shifting works Utility shifting shall be coordinated such that information on utilities' locations is obtained before digging. Concerned departments shall be requested either to shift their utilities or to strictly supervise the shifting works to avoid any unforeseen safety hazards. Vehicles used for transporting utility equipment will be tied firmly and covered with tarpaulin to prevent them from falling onto the road surface. Vehicle speeds shall not exceed 30 km/hour in construction areas. Restoration of road surface, footpaths, signboards that are	At locations of utilities shifting.	Approval from competent authority and site observations.	Checking of documentation.	Agency engaged by BMRCL	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			damaged during relocation of public utilities immediately to the original conditions. The Contractor shall abide by the terms and conditions stipulated in Condition of Contract of Safety, Health & Environment Manual.					
9	Relocation of affected Cultural, Religious and demolition of private properties	Social – There is no major impact on the cultural and religious structures from the proposed metro alignment and metro stations. However, there will be impact on 70 properties mostly at the proposed metro stations at Kasturi Nagar, Horamavu, HRBR Layout, Kalyan Nagar, HBR Layout, Nagawara, Veerannapalya and Kempapura along the alignment.	Impact on any cultural and religious structure, if any will be relocated suitable location in consultation with public. Access to the religious centers in the vicinity of proposed construction zone shall be ensured by planning in advance. Public shall be consulted to inform such impact and address suitably in consensus with to mitigate adverse impacts. Owners of private buildings shall be compensated in line with Entitlement Matrix and KIADB Act, 1966. Unnecessary damage to the structure shall be avoided and the structures being impacted shall be suitably compensated on par with the applicable statutory requirements.	The areas with additional land acquisition is proposed for the project.	Number of structures affected.	Review of relevant documents, entitlement matrix and amount paid.	Contractor and agency engaged by BMRCL	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			Where possible, quieter demolition methods shall be selected. For example, sawing buildings into sections that can be loaded onto trucks results in lower cumulative noise levels than the demolition by impact breakers.					
10		Air – Dismantling of structures in the project location generates fugitive dust during dismantling, loading, hauling and unloading of dismantled and excavated material.	Barricading to a height of 2 m will be provided to reduce dust generation. Water sprinkling shall be done twice or thrice both at construction sites and haulage routes to encapsulate dust from the excavated heaps. Fugitive dust while loading and unloading should be controlled using water sprinkling. Trucks transporting dismantled debris and excavated soil to dump locations shall be covered with tarpaulins to prevent spillage of soil during transportation.	Throughout project corridor with excavation activities.	$PM_{2.5}$ and PM_{10} level measurements Dust pollution or complain of locals.	Standards CPCB methods Site observations and Public consultation	Contractor and agency engaged by BMRCL	BMRCL
11		Noise – Dismantling of structures, loading, unloading and trucks carrying excavated material will result in	Barricade of GI sheet up to a height of 2m will be erected on all sides of construction site to reduce the noise generated during loading and unloading	Throughout project section especially at construction	Noise levels measurements	As per Noise Rules,2000	Contractor and agency engaged by BMRCL	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		noise (typically in excess of 57 dB(A) at 10 m distance). The adverse impacts of noise will be significant near noise sensitive receptors (Appendix – 1) and proposed metro station locations where station areas spread into residential areas especially at Kasthurinagar Station, Horamavu Station, HRBR layout Station, Veerannapalya Station, Kempapura Cross Station.	being transmitted to the receptors. This will effectively cut down noise levels by 10-15 dB(A). Haulage of dismantled and excavated debris by trucks should be planned during non-peak hours.	sites near identified sensitive receptor locations.	Complaints from local people.	Consultation with local people		
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	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	At locations of changes proposed.	Approval from competent authority.	Checking of documentation.	Consultant	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			may be issued subsequently to see that the impacts are addressed properly.					
Pre-construction activities by the Contractor								
Sl. No.	**Environmental Issue/Activity**	**Impact**	**Mitigation Measures**	**Location**	**Monitoring**		**Responsibility**	
					indicators	**Method**	**Implementation**	**Supervision**
14	Contractor Preparatory Works (Upon issuance of Notice to Proceed)	Non-compliance with contract conditions and regulatory requirements.	The Contractor will complete the following activities no later than 30 days upon issuance of Notice to Proceed 1) Appoint Contractor's Health and Safety Officer (HSO) and environmental focal person to EC, 2) HSO will engage with BMRCL -Environment Specialist to a meeting to discuss in detail the EMP, seek clarification and recommend corresponding revisions if necessary 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	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
			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 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.					
15	Identification of Quarry (If opened exclusively for metro project)	Selection and finalization of quarry is very important to avoid impacts arising out of location.	The Contractor will finalize the locations in consultation with DE and BMRCL. The Contractor shall establish a new quarry with the prior consent of DE only if, the lead from existing quarries is uneconomical and alternative material sources are not available. Contractor shall finalize quarry for procurement of construction materials after assessment of	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
			availability of sufficient quantity of materials, quality and the logistic arrangements. Contractor shall also work out haul road network and report to Environmental Specialist of DE and DE shall inspect and in turn report to BMRCL before approval. All the required permissions / consents from SPCB shall be obtained, if it is new quarry. The Contractor shall prepare a redevelopment plan for the quarry site and get approved by the DE.					
16	Quarries &crushers (If established exclusively for metro project	Impacts from location - Selection of site for establishing quarries and crushers is very important to avoid impacts arising out of location.	Quarries and crushers shall be sited sufficiently (at least 500m) away from settlements and fertile agricultural lands preferably in the downwind direction. Quarries and crushers shall be located at a distance of 300 m from water bodies and sensitive ecosystems such as forests. Contractor shall submit a detailed layout plan for all such sites and approval from	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
			Environmental Specialist of DE shall be necessary prior to the establishment. Specifications for crushers and batching plants shall comply with the requirements of relevant emission control legislations. Consent for the Establishment and Operation from KSPCB shall be obtained before establishment and operation respectively and a copy should be submitted to the DE and BMRCL.					
17		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.					
18		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.					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			The general and specific conditions specified in the license and consents shall be strictly adhered and followed.					
19	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 procured, will produce noise, pollute air.	Vehicles, equipment and machinery procured for construction shall conform to the relevant Bureau of India Standard (BIS) norms. The discharge standards prescribed under the Environment Protection Act, 1986 and Motor Vehicles Act, 1988 shall be strictly adhered. The noiseless equipment available in the market shall be used in the construction. 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.	Project area.	Certificate from manufacturer and approvals from competent authority.	Checking of documentation.	Contractor	DE, BMRCL
20	Sourcing of Construction Water	Sourcing and Resource scarcity - Sourcing of	Construction Water Management Plan shall be prepared and implemented	Project site, camp areas	Approval from	Checking of documentation.	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		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.	after getting approval from Environmental Specialist of DE. Contractor shall arrange adequate supply and storage of water for whole of construction period at his own cost. The contractor shall submit a list of source/s from where water shall be used for the project to DE and BMRCL. The Contractor shall source the requirement of water preferentially by conjunctive use of Surface water and groundwater but with prior permission from the concerned Groundwater Authority. Copy of permission obtained shall be submitted to DE and BMRCL prior to initiation of construction. Contractor shall provide a list of locations and type of sources from where water for construction shall be extracted. Contractor shall extract water only from approved locations and consult Environmental Specialist of DE before finalizing locations to avoid disruption to other water users,	and batching plants.	competent authority.			

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			The Contractor shall take all precaution to minimize the wastage of water during construction activities.					
21	Sourcing of Sand	Resource scarcity - Extraction of sand will destroy biodiversity on the river banks. In order to put an end to river sand mining, the state government had banned sand to encourage use of manufactured sand.	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. Contractor shall enter in to 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.	Location of sand quarry area.	Approval from competent authority.	Checking of documentation.	Contractor	DE, BMRCL
22	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	All construction camps	Camp health records Existence of proper first aid kit in campsite	Camp records Site observation Consultation with local	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			and consequent impacts on the local resources and surrounding environment. Labor camps shall be sited at least 500 m away from major settlements or villages; major surface water bodies and forests. All required consents / permissions shall be taken from State Pollution Control Board, District Health Department and Central Ground Water Authority (CGWA) to establish labor camps. Under SHE CoC, and under the Building & Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 the employer (contractor) is liable to arrange for health care facilities of labors, free of charge. Labor camps shall be constructed in semi urban / urban set-ups. Thus, sewage and other discharges from the labor camps can be discharged in public sewers. Refer to SHE Conditions of Contract (CoC).		Complaints from local people Availability of Safety gears to workers	people living nearby Interact with construction workers		

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			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).					
23	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.	Construction camps shall not be proposed within 500m from the nearest settlements to avoid conflicts and stress over resources and infrastructure facilities with local community. The batching plants, casting yards, construction camps for offices and construction plant sites shall be identified and located at a minimum distance of 500 m from any major surface water course or body. Contractor's camps shall be identified at least 2km away from the Forest Reserves. Consent to Establishment and Operate (CtE & CtO) shall be taken from State Pollution Control Board to establish batching plants, construction camps.	At the specific locations of plant established.	Approval from competent authority.	Checking of documentation.	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
24	Orientation of Implementing Agency and Contractors	Orientation to project implementing agencies and contractor will impart insight to the project features and guidelines to ensure minimum impact on the environment.	BMRCL shall organize orientation sessions and regular training sessions before the start of construction of project. This trailing shall include general as well as specific context of the project. These sessions shall involve all staff of BMRCL involved in implementation of EMP, Environmental Specialists of DE and Contractors.	Throughout the project.	Training plan and records	Checking of documentation.	DE	BMRCL
Construction Phase:								
25	Excavations (Clearing, grubbing and levelling of site)	Soil and Surface drainage - Clearing and leveling alters the soil texture and compactness affecting the infiltration and soil ecology. Leveling of site also involves alteration of natural drainage. Clearing, grubbing and levelling activities are common all along the proposed metro alignment and metro station locations.	Only ground cover / shrubs that impinge directly on permanent works or necessary temporary works shall be removed. A portion of this will be reused for backfilling. The remaining soil debris will be suitably disposed of to the pre-identified approved locations. Infiltration losses due to site leveling and could be countered by installing Rain Water Harvesting (RWH) pits at camp and plant sites.	Throughout the project areas and locations proposed for camps, plants and construction yards.	Presence of destroyed/ compacted agricultural land or land.	Site observations	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		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 65589 m3 & 4691 m3 respectively. (Source: Data provided by BMRCL)						
26		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
27		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.	Noise generated by these activities will be less. However, 2 m high barricade of GI sheet will be erected around the construction site which will effectively reduce transmission of noise to the receptors. Heavily loaded trucks shall be routed away from residential	Throughout the project areas.	Noise and vibration levels measurements	As per Noise Rule, 2000. Site observations and Public consultation	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		There are education institutions (Appendix – 1) which are sensitive to noise along the proposed metro route which are impacted temporarily by this activity.	roads or roads with fewer houses Vibratory rollers and packers shall be avoided near sensitive areas.					
28		Air - Fugitive dust will be generated during these construction activities. There are hospitals (Appendix – 1) along the proposed metro alignment which are impacted by air pollution temporarily during construction phase.	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 mutually decided by the contractor and BMRCL)	Throughout project corridor with excavation activities.	$PM_{2.5}$ and PM_{10} level measurements Dust pollution or complaint of locals.	Contractor	DE, BMRCL
29		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
30	Mechanical piling	Noise - Mechanical piling operations, generates noise which	Augur piling will be carried out in place of mechanical piling which will generate less noise (around 70-75 dB(A)).	Throughout project section	Noise levels measurements	As per Noise Rules,2000	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		may go up to 88-90 dB(A) at 5 m distance.	Barricade of GI sheet up to height of 2m 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 day time hours only. Augur piling methods will be used to reduce the impacts of noise. 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.	especially at construction sites, residential and identified sensitive locations.	Complaints from local people.	Consultation with local people		
31		Health and Safety - Noise and vibration generated during piling will affect the health and safety of the workers.	2 m tall screens of GI sheets will be installed between source (pile driver) and receptors (workers & nearby populations). Workers involved in piling will be provided with personal safety gears such as ear plugs, ear muffs.	Throughout project section especially at construction sites, residential and identified sensitive locations.	Noise levels measurements Complaints from local people.	As per Noise rule,2000 Consultation with local people	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
32		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
33	Loading/unloading and hauling of debris of excavations and dismantled structures	Air – Excavated material generates fugitive dust from road surface during loading, hauling and unloading of excavated material.	Barricading to a height of 2 m will be provided to reduce dust generation. Water sprinkling shall be done twice or thrice both at construction sites and haulage routes to encapsulate dust from the excavated heaps. Fugitive dust while loading and unloading should be controlled using water sprinkling. Trucks transporting excavated soil to dump locations shall be covered with tarpaulins to prevent spillage of soil during transportation.	Throughout project corridor with excavation activities.	$PM_{2.5}$ and PM_{10} level measurements Dust pollution or complain of locals.	Standards CPCB methods Site observations and Public consultation	Contractor	DE, BMRCL
34		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	Barricade of GI sheet up to a height of 2m 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	Throughout project section especially at construction sites near identified	Noise levels measurements	As per Noise Rules,2000 Consultation with local people	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		noise will be significant near noise sensitive receptors (Appendix – 1) and proposed metro station locations where station areas spread into residential areas especially at Kasthurinagar Station, Horamavu Station, HRBR layout Station, Veerannapalya Station, Kempapura Cross Station,	cut down noise levels by 10-15 dB(A). Haulage of excavated debris by trucks should be planned during non-peak hours.	sensitive receptor locations.	Complaints from local people.			
35		Social - Frequent movement of trucks during debris disposal could create social issues. Often observed near proposed Metro station locations at Kasthurinagar Station, Horamavu Station, HRBR layout Station, Veerannapalya Station, Kempapura Cross Station,	The local community has to be taken into confidence before the construction commences. Their advice has to be taken and incorporated in decision making. The routing, timing and logistics of the haul truck movement should be planned to have minimal impact son noise level. Strict speed limits should be followed at the settlement areas and on the haulage roads. Haulage of excavated materials should be planned during non-peak hours.	Throughout project corridor within construction zone.	Complaint of locals.	Public consultation	Contractor	DE, BMRCL
36		Traffic Congestion – Trucks hauling for	Movement of trucks transporting excavated debris					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		disposal of debris will add to the existing traffic congestion woes, especially at Kasthurinagar Station, Horamavu Station, HRBR layout Station, Kalyan Nagar Station, Veerannapalya Station, Kempapura Cross Station.	shall be planned during non-peak hours.	Throughout project corridor within construction zone.	Complain of locals.	Public consultation	Contractor	DE, BMRCL
37		Health & Safety - The movement of trucks will increase the safety concerns of the dwellers and commuters.	Movement of trucks shall be planned such that it causes least problematic and safer to the public. All required safety signboards precautions shall be erected along the haulage routes to ensure uninterrupted flow of traffic. Construction zone shall be separated from inhabited zones to avoid any unforeseen safety threats and consequences.					
38	Disposal of excavated materials	Social - Unscientific handling and disposal of debris from excavations and dismantling structures will lead to nuisance to	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.	At all approved dumping sites	Location of dumping sites	Field survey and interaction with local people	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		public and the environment.	All waste debris shall be completely cleared from construction sites on regular basis and disposed of in approved disposal sites and certified by Environmental Specialist of DE. Contractor shall prepare debris disposal plan to deal with surplus debris materials that are available after adjusting for all in-situ applications and submit it to Environmental Specialist of DE for approval. Waste debris shall be dumped in abandoned quarries or borrow pits in layers and compacted mechanically. Once the filling is complete, the entire debris disposal area shall be provided with a layer of good earth on the top and cover with vegetation. All arrangements for transportation during construction including provision, maintenance, dismantling and clearing debris, shall be considered incidental to the civil work and shall be planned and implemented by Contractor as		Public complaints			

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

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			corridor of the project. Environmental Specialist of DE shall approve the disposal sites after conducting a joint inspection of site with Contractor.					
40		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 Benniganahalli Lake at Ch 0+300 (RHS), and Nagawara Lake at Ch 9+500 (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
41		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 Dust pollution or complain of locals.	Standards CPCB methods Site observations and	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
						Public consultation.		
42	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 Kasthurinagar Station, Horamavu Station, HRBR layout Station, Kalyan Nagar Station, Veerannapalya Station, Kempapura Cross 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
43		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.					
44	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	Throughout the project corridor	Traffic Management plan	Review traffic management plan	Contractor	DE, BMRCL

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

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		movements. This will result in detour of vehicles especially at busy commercial areas along Outer Ring Road. This results in traffic congestion	weather conditions, construction in the built-up areas and volume of traffic).					
46		Air - Air pollution from vehicular congestion along the outer ring road and airport road during construction phase. Major pollutants like PM_{10}, $PM_{2.5}$, NOx, SO_2, CO, NMHC, Lead and VOCs are released.	Traffic diversions shall be properly planned and implemented during peak hours. Traffic marshals shall be posted near such detours. Proper signage shall be posted informing motorists about detours.				Contractor	DE, BMRCL
47		Noise – Restrictions on vehicular movement near the construction sites by barricading & detours may result into traffic congestion along outer ring road between KR Puram junction to Veerannapalya. 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 KR Puram junction Benniganahalli junction, Chennasandra junction,				Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			Horamavu junction, Hennur Junction, Thanisandra junction, Manyatha Tech Park junction, etc. to oversee the smooth flow of traffic.					
48		Travel time cost / Resource consumption - Detouring of traffic during construction will increase the road length to be travelled by vehicles. This essentially increases the overall fuel consumption and travel time of road users.	The detour shall be planned with traffic department such that road length to be optimum. 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.				Contractor	DE, BMRCL
49	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
50	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
51		Health & safety - Bar bending & other activities (including working at heights)	(a) Workers shall be provided with appropriate hand gloves. (b) Workers working at height or doing hot work shall seek permission from site HSE	Construction sites	Availability of Safety gears to workers	Site observation Review	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		might pose a health & safety risks to workers	manager and shall be provided with rigs, safety harness & safety belts (Please refer to SHE Manual, BMRCL)		Safety signage Training records on safety Number of safety related accidents	records on safety training and accidents Interact with construction workers		
52	Transporting construction materials and haul road management	Air pollution - During transportation of construction material, fugitive dust will be generated from re-suspension of dust from road surface and from the spillage of construction materials from a moving vehicle.	All vehicles delivering fine materials to the site shall be properly covered with tarpaulins to avoid spillage of materials. All existing roads used by vehicles carrying construction materials, shall be kept clear of all dust/mud or other extraneous materials dropped by such vehicles. Contractor shall arrange for regular water sprinkling as necessary for dust suppression of all such roads and surfaces.	Throughout project corridor within construction zone.	$PM_{2.5}$ and PM_{10} level measurements Dust pollution or complain of locals.	Standards CPCB methods Site observations and Public consultation.	Contractor	DE, BMRCL
53	Stacking & warehousing of raw material	Surface Water – The stacked earth or raw materials will be washed out and pose serious impacts on	Contractor shall construct silt fencing around the stockpiles at the construction sites including ancillary sites close to water bodies.	At construction	Method and location of	Contractor records	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		surface water bodies, If not managed properly. Water bodies like Benniganahalli Lake at Ch 0+300 (RHS) and Nagawara Lake at Ch 9+500 (RHS) are located along the proposed metro corridor are vulnerable to siltation.	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.	yards and work zones	construction site	Field observation		
54		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
55		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.					
56		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.					
57	RCC pouring (using concrete pump) and	Noise & vibration - RCC pouring using concrete pump generates low	Timing of using RCC pumps shall be planned and specified. RCC pumps shall be housed in small mechanical closets.	Throughout project section especially at	Noise and vibration levels measureme	As per Noise Rules,2000 and Public	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
	setting of concrete (using needle vibrator)	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. Needle vibrators generate low frequency noise when dipped in concrete but high frequency noise when raised. Sound level vary between 82-93 dB(A).	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. The Contractor shall abide by the terms and conditions stipulated in Condition of Contract on Safety, Health & Environment and Project Safety, Health & Environment Manual.	construction sites, residential and identified sensitive locations, refer to noise and vibration level prediction study report.	nts	consultation.		
58		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
59		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

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
60	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. Moisture retaining fabric coverings saturated with water shall be used for curing. Wet coverings such as wet gunny bags, hessian cloth, jute matting, straw etc., shall be wrapped to vertical surface for keeping the concrete wet. For horizontal surfaces saw dust, earth or sand are used as wet covering to keep the concrete in wet condition for a longer time. All the required permissions from the concerned local authorities shall be procured before use of water resources for construction and curing.	At construction yards and work zones	Approved layout for drainage of construction yards.	Field observation	Contractor	DE, BMRCL
61		Surface water – Excess of curing water will drain to the low-	Proper drainage shall be ensured to guide the curing water to the nearby drains.	At construction	Method and location of	Site observations	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		lying areas stagnate making it as mosquito breeding places and pollute water courses	Garland drainage is proposed to be constructed around the construction yard. This will intercept the runoff generated from site.	yards and work zones	construction site	and relevant records		
62		Ground water - Hydrating water requirement @ 0.38:1 water: cement + curing will require @ 0.06 kg/m2/hr. of water, most of it will be supplied from approved groundwater sources (through tankers) as per the Central Ground Water Board norms.	Groundwater from Central Ground Water Authority designated safe areas shall be used after procuring permissions from concerned authorities. Water can be harvested and made to percolate into the recharge pits (as a compensatory measure) should be practiced.	At construction yards and work zones	Permission from authority.	Site observations and relevant records	Contractor	DE, BMRCL
63		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.					
64	Use of Crane & Launchers	Noise - Operation of launchers and cranes generate noise which goes up to 85-90 dB(A).	Cranes and launchers shall be serviced and maintained regularly to prevent them making noise. Tall GI sheets of 2 m height barrier around the construction area shall be erected to control	Throughout project section especially at construction sites, residential	Noise and vibration levels measurements	As per Noise Rules, 2000 and Public consultation	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			the noise transmission from the source where the cranes and launchers are used. The construction workers working near construction equipment shall be provided with PPEs like ear plugs / muffs complying with relevant standards. Noise emitting crane and launching works at noise sensitive receptors like schools, colleges and hospitals shall be scheduled properly to avoid or reduce impact on them. The Contractor shall abide by the terms and conditions stipulated in Condition of Contract on Safety, Health & Environment and Project Safety, Health & Environment Manual.	and identified sensitive locations.				
65		Health & Safety - Cranes and launchers are a major safety concern during construction.	Contractor shall engage only qualified & trained crane/ launcher operators. Contractor shall ensure regular servicing and maintenance of cranes and launchers to avoid malfunction of equipment.	Construction sites	Availability of Safety gears to workers Safety	Site observation Review records on safety training and	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			Proper training shall be given to crane & launcher operators and labors before the commencement of work. Operation of launchers and cranes shall be done only under the strict supervision of a qualified engineer and a safety supervisor. The operating personnel should follow the operating and maintenance manuals supplied along with the cranes & launchers to understand the crane and operate the crane efficiently and safely. Instructions in Safety, Health & Environment Manual shall be followed. The Contractor shall abide by the terms and conditions stipulated in Condition of Contract on Safety, Health & Environment and Project Safety, Health & Environment Manual.		signage Training records on safety Number of safety related accidents	accidents Interact with construction workers		
66	Construction camps and Labor camp(s) and associated	Impacts related to location – Selection of labor camp location is important as it adversely impacts from	Contractor shall obtain permission from District Health Officer before establishing labor camps.	All construction camps	Camp health records Existence of	Camp records Site	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
	environmental issues	the discharge of sewage and solid waste from labour camps.	Contractor shall follow all relevant provisions of the Building and the other Construction Workers (Regulations of Employment and Conditions of Service) Act, 1996 for construction and maintenance of labor camp. 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.		proper first aid kit in campsite Complaints from local people Availability of Safety gears to workers	observation Consultation with local people living nearby Interact with construction workers		
67		Resource scarcity – Establishment of labor camps requires resources like water thus increasing pressure on local resources. Water required for domestic uses in labor camps and workers if drawn from existing community bore wells and nearby surface water resources may deplete groundwater.	The Contractor shall provide potable water facilities for drinking & cooking and uncontaminated water for washing in the labor camps.as per standards set by the Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996. The Contractor shall also guarantee the following: a) Supply of sufficient quantity of Potable Water in every workplace / labor camp (Site at suitable and easily accessible places and regular maintenance of such facilities.					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		Dependency of laborers on fuel wood for cooking and heating purposes will result in cutting of trees in and around labor camp.	b) If any water storage tank is provided that shall be kept such that the bottom of the tank at least 1 m above the surrounding ground level. c) If water is drawn from any existing well, which is within 30 m proximity of any toilet, drain or other source of pollution, the well shall be disinfected before water is used for drinking. d) All such wells shall be entirely covered and provided with a trap door, which shall be dust proof and water proof. e) A reliable pump shall be fitted to each covered well. The trap door shall be kept locked and opened only for cleaning or inspection, which shall be done at least once in a month. f) Analysis of water shall be done every month as per parameters prescribed in IS 10500-1991. Environmental Specialist of DE shall be required to inspect the labor camp once in a week to ensure the compliance of the EMP. Contractor shall provide sufficient quantity and timely					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			supply of liquid petroleum gas to the laborers to discourage cutting of trees and vegetation.					
68		Sanitation and Sewage System – Waste water generated at the construction camps and labor camps will pollute the soil, surface and ground water if disposed untreated. Impacts from storing, treating and disposing the sewage waste and solid wastes increases breeding sites of mosquitoes in turn increases the risk of vector borne diseases such as malaria. Supply of non-potable water will not only cause communicable diseases to laborers but also act as potential centers for spreading diseases There is also a possibility of spreading diseases such as HIV by having contact with local population.	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. The location, layout and basic facility provision of each labor camp shall be submitted to DE and BMRCL prior to their construction. The construction shall commence only upon the written approval of the DE. The Contractor shall maintain necessary living accommodation and ancillary facilities in functional and hygienic manner and as approved by the DE. The Contractor shall maintain sufficient and appropriate sanitary facilities available and maintain hygienic conditions functional in the labor camps. Necessary living accommodation and ancillary					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			facilities shall be provided in labor camps as approved by the DE. The Contractor shall ensure that - Waste water 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. - Separate toilets / bathrooms, for men and women are to be provided. (marked in local and English language) - Adequate water supply is to be provided in all toilets and urinals The Contractor shall arrange for – A readily available first aid unit including adequate supply of sterilized dressing materials and appliances as per the					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			Factories Rules in every work zone. - Arrangement for availability of suitable transportation at all times to take injured or sick person(s) to the nearest hospital. Contractor should ensure to conduct HIV awareness programs.					
69		Solid Waste - Poor sanitation and solid waste disposal in labor camps and work sites and possible transmission of communicable diseases from workers to local populations.	Domestic solid waste from construction and labor camps shall be segregated into biodegradable and non-biodegradable before being sent to treatment. Biodegradable wastes are treated by composting and non-biodegradable wastes are either recycled or disposed of to authorized land fill site. The Contractor shall provide garbage bins in the camps and ensure that these are regularly emptied and disposed of in a hygienic manner as per the Comprehensive Solid Waste Management Plan approved by the Environmental Specialist of DE.					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
70	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. 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).	Batching plants shall be sited at least 1 km in the downwind direction from the nearest human settlement. Vehicles delivering raw materials like sand and fine aggregates shall be covered to reduce spills on the roads. Water shall be sprayed on haulage roads within the premises of batching plants on a regular basis. The batching plants shall be fitted with dust extraction units and collectors to reduce exhaust dust. Batching plants / casting yards shall be barricaded and designated as a compulsory PPE zone to effectively reduce the impact from fugitive dust emissions. Required permissions for electrical connection and supply must be obtained from BESCOM by the Contractor. DG sets, if used, shall: (a) conform to height of stack norms as per CPCB rules;	At Batching plant sites	$PM_{2.5}$ and $PM_{10,}$ Noise level measurements, Compliance on terms and conditions in given permission for batching plant	Standards CPCB methods for air quality monitoring, relevant records on permission from authorities	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			(b) conform to emission norms as per Environment (Protection) Act, 1986; (c) noise level at 1 m distance from enclosure shall not be >75 dB(A). Diesel storage if done beyond threshold limit (1000 L) permission from CCOE should be obtained. Diesel should be stored on pukka platforms and spillages should be avoided.					
71		Noise - Batching plants will generate noise during operation	Batching plants / casting yards shall be barricaded and designated as a compulsory PPE zone. Workers working in close proximity of the batching plants shall be provided with suitable PPEs like ear muffs & plugs reduce the impacts of noise.					
72		Land - Soil compaction and contamination are envisaged at concrete batching plant and along access roads to these construction establishments.	As part of mitigation measures top soil 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 land owner.					
73		Water - Batching plant will use water for	Permission from CGWA must be obtained before digging and					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		concrete mixing. In most cases water will be supplied from groundwater.	operating bore wells. Water abstracted must be measured/ recorded periodically.					
74		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					
75	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
76	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	Standards CPCB methods Observations Public consultation	Contractor	DE, BMRCL
77		Noise – Transporting vehicles carrying concrete castings	The routing, timing and logistics of the haul truck movement shall be planned to					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		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.	have minimal impacts on the ambient noise levels.		complain of locals			
78		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.					
79		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.					
80	Use of DG sets at construction sites	Air - Air pollution from emissions of DG sets	Contractor shall prefer to utilize power from BESCOM as primary source and DG sets shall be used only as power back-ups to conserve the diesel which is a non-renewable resource.	At installation location of DG sets	Monitoring of ambient air quality and Noise levels Measurements, compliance with consent	Standards CPCB methods and as per Noise Rules,2000	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			(a) Emissions from DG shall adhere to CPCB prescribed norms (b) Stack height of DG sets shall be as per CPCB requirement (stack height = 0.2* (rating in kVA) 0.5] (c) Low Sulphur diesel shall be used in the DG sets.		taken from SPCB			
81		Noise - Noise & vibration will be generated from the use of DG sets	DG sets shall be insulated type to mitigate noise at source itself. DG sets shall be mounted on damping skids to reduce the vibration generated from DG sets.					
82	Storage of fuel and lubricants	Surface and Groundwater - Spillage of fuel from underground storage or above ground storage facility will adversely affect the quality of ground and surface water respectively	Spillage of fuel from underground storage facilities shall be avoided by taking required precautions during installations. Spillages reaching the soil from above ground storage facilities shall be avoided by storing on the concrete impervious platforms and installing oil interceptors at the outlet drains. The vehicle and construction equipment shall be properly maintained and refueling / maintenance of vehicles shall	Fuellingstation, construction sites, andconstructioncamps and disposal location.	Quality of soil nearStorage area Presence of spilled oil project area	Site Observation and check of records	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			not be done near the water bodies to avoid contamination from fuel and lubricants. Diesel Generator sets shall be placed on a cement concrete platform with oil and grease trap to control the oil ingress into soil/water bodies. A Contingency Plan shall be prepared by the Contractor to face and act immediately on spillage as per Petroleum Rules, 2002 and Petroleum (Amendment) Rules, 2018.					
83		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 could cause serious damage to health & safety of workers / property.	Proper onsite emergency plan shall be prepared by the Contractor and get approved through BMRCL. If the diesel storage crosses the threshold limits permissions from Chief Controller of Explosives (CCoE). Proper fire protection norms have to be undertaken as per National Building Code, 2016 (for buildings) / Oil Industry Safety Directorate Standard 117 (for installations).					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
84	Construction activities near water bodies	Construction works near water bodies especially Benniganahalli Lake at Ch 0+300 (RHS) and Nagawara Lake at Ch 9+500 (RHS) are susceptible for impact from construction activities.	While working close to water bodies, contractor shall not obstruct / prevent the inflow of water. Construction close to water bodies shall be avoided in monsoon and may be undertaken in the dry season. Chute drains with sediment trap or silt fence and garland drains shall be planned at erosion susceptible areas to avoid ingress of silt into the water bodies. Vehicles and construction equipment shall not be parked near water bodies. The construction vehicle parking locations, fuel / lubricants storage sites, vehicles, machinery and equipment maintenance and refueling sites shall be located at least 500 m away from water bodies and storm water drainages. The Contractor shall submit the locations and layout plans of such sites prior to their establishment and shall be approved by the Environmental Specialist of DE. The Contractor shall take necessary precautionary	At construction work zones, plants, constructions yards and camp areas.	Method and location of construction site	Contractor records Field observation	Contractor	DE, BMRCL

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

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

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

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

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

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
90	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
91	Risk from electrical equipment		The Contractor shall take all required precautions to prevent danger from electrical equipment and ensure that. ➢ No material shall be so stacked or placed as to cause danger or inconvenience to any person or public. ➢ All necessary fencing and lighting shall be provided to protect the public from electrical hazards in construction zones.	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
			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 order; regularly inspected and properly maintained as per IS provision and to the satisfaction of the Environmental Expert of DE.					
92	Risk force measure		Contractor shall take reasonable precautions to prevent danger to the workers and public from emergency spillage, fire, flood, etc. resulting from construction activities. Contractor shall make required arrangements so that in case of any mishap all necessary steps can be taken for prompt first aid treatment. Construction Safety Plan prepared by the Contractor shall identify necessary actions in the event of an emergency.	The project.	Conditions on contractors' contract.	Checking of document.	Contractor	DE, BMRCL
93	First Aid		The Contractor shall arrange for – A readily available first aid unit including an adequate supply of sterilized dressing materials and appliances as per the	Construction sites	Availability of first aid boxes Number of safety	Site observation Review records on accidents	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
			Factories Rules in every work zone. Availability of suitable transport at all times to take injured or sick person(s) to the nearest hospital.		related accidents	Interact with construction workers		
94	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 IC.	Construction sites	Installation of project informatory boards.	Site observation.	Contractor	DE, BMRCL
95	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. 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	All fossils, coins, articles of value of antiquity, structures and other remains of archaeological interest discovered on the site shall be the property of the Government and shall be dealt with as per provisions of the relevant legislation. The Contractor shall take reasonable precautions to prevent his workmen or any other persons from removing and damaging any such article or thing. He shall, immediately upon discovery thereof and before removal acquaint the Environmental Specialist of DE	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 importance.	of such discovery and carry out his instructions for dealing with the same, waiting which all work shall be stopped. The DE shall seek direction from the Archaeological Survey of India (ASI) before instructing the Contractor to recommence the work in the site. The Archaeological structures identified along the project sites should be protected/ preserved or enhanced as per the law.					
96	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. National Standard of Air, Noise and Water given in Appendix-. 3.	The project sites.	Baseline monitoring and monitoring during works.	Monitoring reports.	Contractor	DE, BMRCL
97		Continuous Community Participation	The Environmental Specialist of DE shall have continuous interactions with local people around the project area to ensure that the construction activities are not causing undue	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
			inconvenience to the locals residing in the vicinity of project site under construction due to noise, dust or disposal of debris etc.					
98		Clean-up operations, restoration and rehabilitation	Contractor shall prepare site restoration plans, which shall be approved by the Environmental Specialist of DE. The clean-up and restoration operations are to be implemented by the Contractor prior to demobilization. The Contractor shall clear all temporary structures; dispose all garbage, night soils and Petroleum, Oil and Lubricants wastes as per waste management plan and as approved by DE. All disposal pits or trenches shall be filled in and effectively sealed off. Residual topsoil, if any shall be distributed on adjoining/proximate barren land or areas identified by the Contractor and approved by the Environmental Specialist of DE in a layer of thickness of 75 mm – 150 mm. All construction zones and construction establishments	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
			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 Environmental Specialist of DE.					
Operation Phase:								
99	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
100		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	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.	Project alignment.	Noise level prediction modelling results.	Assessment reports.	BMRCL	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		aerodynamic noise. About 400-meter stretch from chainage 2+400 to 2+800 km at Horamavu is susceptible for noise and vibration because of nearness of the metro 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 background noise level in these areas is already on higher side. Suitable noise barriers are suggested for the affected length at chainage2+500 to alleviate the impact of noise generated during operation of metro trains. Use of vibration resilient pads in tracks will absorb vibration. Hence, the increase in noise levels at the road level will be insignificant and will be marginally different from baseline ambient noise generated from traffic. Since the train coaches are enclosed and air conditioned, the impacts of noise on the travelers will be insignificant.					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
101		Social – Implementation of metro will have a positive impact on the livelihood of society in terms of employment, commutability, improved access, comfortable travel and decreased travel time.	The employment generation capacity has to be extended to the needy and underprivileged people. This positive impact should be enhanced to larger canopy of people by integrating with other modes of transportation to establish last mile connectivity. Metro services should be extended to support disabled, students, senior citizens through special programmes. Parking facilities for private vehicles shall be planned and provided to attract users of metro.	Working areas/offices, stations and depot	Number of Eemployment generated.	Check of relevant documents.	BMRCL	BMRCL
102		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
103		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	This positive impact should be enhanced to larger canopy of people by integrating with other modes of transportation to establish last mile connectivity.					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
		risk of exposure to accidents.						
104		Ancillary development - Ancillary developments will take place along with metro corridor.	Ancillary development should be monitored and only specific types of developments should be encouraged. A stringent land use policy should be developed & followed. There should be balanced and sustainable developments along the metro corridor.	Feeder route and connected stations.	Commuter satisfication and complaints.	Site observations and consultation with users.	Appointed agency.	BMRCL
105		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 upkeep of metro coaches & metro stations.				Facility Contractor	BMRCL
106		Water pollution – Washing of metro coaches in metro workshops will have oil & grease in the waste water 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 waste water and then dispose it suitably.	Stations and Depot locations.	Water quality paramters.	As per CPCB requirements	BMRCL	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
107	Use of DG sets	Air – Use of DGs will release air pollutants to the environment.	It shall be preferred to use power source from BESCOM and DGs shall only be used as power backups. Emissions from DG shall conform to CPCB norms and height of the stacks of DG shall be as prescribed by CPCB. High Speed Diesel containing low Sulphur content shall be used to run DGs.	Stations and Depot locations.	Air quality and noise level parameters. Conditions mentioned in consent letter for DG sets	As per CPCB requirements .	BMRCL	BMRCL
108		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. The DG sets shall be mounted on damping skids to reduce the vibration from DG sets.	At location of installations at stations or power back-up.	Air quality and noise level paramters	As per CPCB requirements	BMRCL	BMRCL
109	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.	Site observation and compliance check on given permission.	BMRCL	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
110		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).		Approval from competent authority.			
111	Monitoring Operation Performance	Non-compliance – Failure to monitor operation performance will lead to non-compliance of statutory requirements of project.	The BMRCL shall monitor the operational performance of the various mitigation / enhancement measures carried out as a part of the project.	Metro operations	Commuter satisfication and complaints.	Site observations and consultation with users.	BMRCL	BMRCL
112	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

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	implementation	Supervision
113	Environmental Monitoring	Construction of metro project and associated works may impact air quality, noise levels, surface and ground water quality and soil quality.	The periodic monitoring of the ambient air quality, noise level, water (both ground and surface water) quality, soil quality in the selected locations shall be done as suggested in environmental monitoring plan through the approved monitoring agency.	Project alignment	Environmental parameters monitoring	Reports on monitoring	Approved Monitoring Agency	BMRCL
114	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

318. 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.

319. The monitoring programme consists of performance indicators to be monitored, location, sampling and analysis methods, frequency compared to standards; reporting formats (Appendix – 5) 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.

320. 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.

321. 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.

322. 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- 5: Environmental Monitoring Plan Matrix

Attribute	Parameters to be monitored	Locations and Frequency	Frequency	No of samples	Implementation
Ambient Air	PM_{10}, $PM_{2.5}$, SO2, NOx, CO and Pb using High volume sampler to be located within 50m from project area in the down wind direction.	**Three** locations at representative air sensitive receptors (schools & Hospitals) along the Metro alignment + **One** location at each metro station + **One** location each at casting yard & Batching plant + **One** location at Construction camp.	(1 sample/ season for three seasons (excluding monsoon) during two years of construction stage and one-year operation stage)	**342**	BMRCL / Contractor through an approved Independent Agency
Ambient Noise levels	Noise levels as per National Ambient Noise Standards and WB 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	**342**	BMRCL / Contractor through an approved Independent Agency
Vibration	PPV mm/s (Federal Transit Administration Guideline standards)	**Two** 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	**144**	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 Benniganahalli Lake, Nagawara 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.	**117**	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.	**243**	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.	**186**	BMRCL / Contractor through an approved Independent Agency
Stack Monitoring	Monitoring of DG sets for emissions - All DG sets must be monitored for Velocity, Temperature, PM, SO2, NOx, CO	One sample each at the proposed metro stations.	Two samples per year during two years of construction stage and one year of operation stage.	**114**	
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

F. Reporting system

323. 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.

324. 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.

325. 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.

326. 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.

327. 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 7- 6: 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 & top soil preservation	Weekly	Weekly	Monthly	Quarterly
Quarry areas / Crushers / Debris disposal areas	Regular	Weekly	Monthly	Quarterly
Tree cutting	Weekly	Weekly	Monthly	Quarterly

Item	Contractor	Designated Engineer (DE)		BMRCL to oversee compliance monitoring
		Supervision	Reporting to BMRCL	
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

328. The Environmental Impact Assessment exercise provides a full description of the project corridor environment, and significant positive and negative impacts on natural environment owing to the proposed project. The proposed Phase 2B Airport metro alignment will not pass through any environmentally sensitive areas as the entire alignment is located within a highly urbanized area

- It is estimated that approximately 313,519 Sqm of land to be acquired along the alignment of the proposed Phase 2B corridor. Most of the land acquired is for viaduct, metro stations and depot which are integral parts of the proposed project.
- Approximately 273,586 Cum of excavated earth and 14,096 Cum of concrete debris would be generated from the excavations for piles and pile cap. Unserviceable materials shall have to be disposed in borrow pits or abandoned quarries in an environmentally sustainable manner.
- There are 6 major water bodies like Benniganahalli Lake, Chalkere Lake, Nagawara Lake, Hebbala Lake, Hunasemaranahalli Lake and Lake near Chikkajaaalaare in the vicinity of project corridor. There are no significant adverse impacts by the project on these water bodies. However, appropriate mitigation measures will be taken up to avoid and reduce the impact during construction phase.
- Wastewater generated at construction camps and labour camps will be treated to the standards prescribed by CPCB to water pollution in the vicinity of the project associated construction camps and labour camps.
- City traffic, particularly along the Outer Ring Road will get disrupted during the construction phase of the project due to traffic diversions which will be handled by effective traffic management and diversion plans.
- Generation of dust by the project activities like site preparatory earthworks; demolition of existing structures; foundation excavation works; erection and use of heavy equipment & machinery; loading, transporting and unloading soil and construction materials and material handling; traffic diversion; etc. 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.
- 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 after implementation of the project.

- Project corridor alignment has more than 54 air and noise sensitive receptors such as schools, colleges, hostels, hospitals, libraries. 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.
- 3541 trees are impacted by the project which seems to be the most significant to Bengaluru city. Sincere efforts shall be made to transplant many of the trees. In addition, at-grade median plantation will be taken up all along the proposed alignment. In addition, every tree impacted is compensated at the rate of ten trees or as per the direction of Tree Committee or Forest Department.
- The project would impact on the livelihood, public services, health and safety of community and labourers temporarily during construction of the project. Inconveniences caused by utility shifting, excavations, unplanned stacking of excavated earth and traffic diversions in the vicinity of project corridors.

329. Recommendations:

- This EIA report is considered a draft will be reviewed and revised as necessary after getting feedback from stakeholders and reviewers.
- BMRCL having one of the larger metro networks in the country should strengthen its capacity to monitor and manage social and environmental 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;
- Set up capacity building mechanisms helping BMRCL to manage all environment, health and safety management tasks;
- Felling of trees for metro project is one of 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.
- There is Chikkajala Fort an ancient structure which is of archaeological significance which needs to be protected and conserved. Care is necessary not to impact this structure which is in the proximity of proposed project corridor.
- 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.

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ANNEXURES

ANNEXURE - 1: Rapid Environmental Assessment (REA) Checklist prepared by BMRCL

Country/Project Title: India: Bangalore Metro Rail Corporation Limited Project (Phase 2 B)

Sector Division: K. R. Puram to KIA

SCREENING QUESTIONS	Yes	No	REMARKS
A. Project Siting – Is the Project area adjacent to or within any of the following Environmentally sensitive areas?			
• Cultural heritage site		X	There is no Cultural heritage site is located close to the alignment and nearby. However, there is one ancient Chjikkajala fort at chainage 22+600 km on RHS of the alignment which is already in dilapidated condition during widening of National Highway. Construction of metro project near the Chikkajala fort do not require special clearance but the required care should be taken not to damage the existing structure.
• Protected Area		X	There is no Wildlife Protected Area is located close to the proposed alignment and nearby (Bannerghatta National Park is located at a distance of approximately 9.5 km from the project alignment.
• Wetland		X	There are no protected or classified wet lands located close to the project alignment.
• Mangrove		X	Project is not located in Coastal Area.
• Estuarine		X	None
• Buffer zone of protected area		X	None
• Special area for protecting biodiversity		X	None.
B. Potential Environmental Impacts - Will the Project cause…			
• Encroachment on historical/cultural areas; disfiguration of landscape by road embankments, cuts, fills, and quarries?		X	There are no notified cultural heritage sites along the proposed metro alignment.
• Encroachment on precious ecology (e.g. sensitive or protected areas)?		X	There is no ecologically sensitive or protected area along the proposed alignment except it involves cutting of some trees which are either being transplanted or compensated suitably, and attempt will be made to minimize cutting of trees.
• Alteration of surface water hydrology of waterways crossed by roads, resulting in increased sediment in streams affected by increased soil erosion at construction site?		X	The proposed metro alignment does not cross any waterways but passes adjacent to 12 water bodies. However, there is no change in surface water hydrology of water bodies by construction of metro structure (Which is elevated in nature).
• Deterioration of surface water quality due to silt runoff and sanitary wastes from worker-based camps and chemicals used in construction?	X		There is no significant deterioration of surface water quality as most of the water bodies are 30 to 50 m away from the proposed metro alignment and the metro alignment is following the median of the outer ring road. Further, solid barricades will be erected to prevent any silt spill out of construction site. Other mitigation measures such as construction

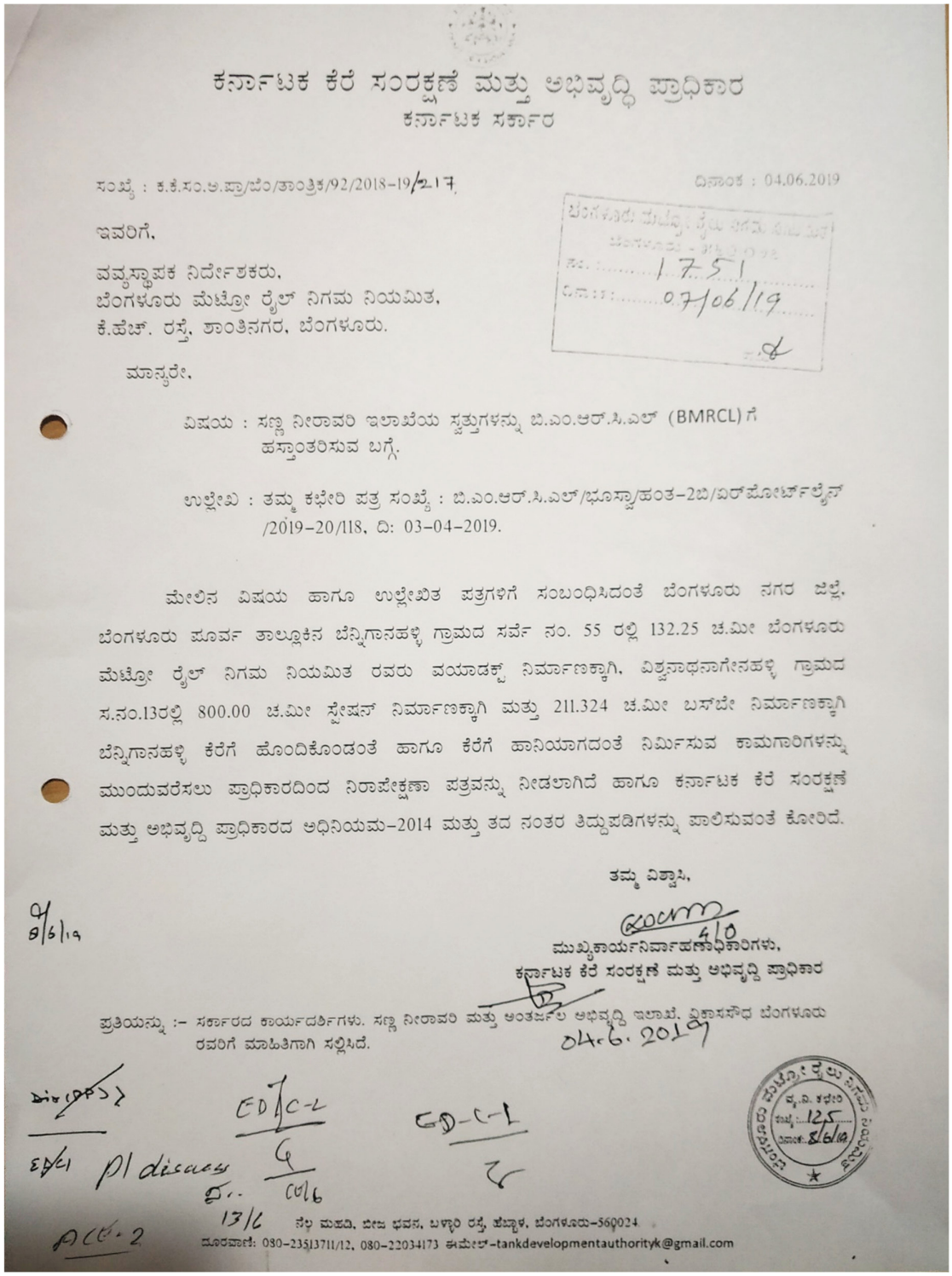
SCREENING QUESTIONS	Yes	No	REMARKS
			of garland drain and silt traps at construction sites will be taken to minimize the silt runoff. Construction camps and labor camps shall be sited away from the surface water bodies. Waste water from labor camps shall be disposed after suitable treatment.
• Increased local air pollution due to rock crushing, cutting and filling works, and chemicals from asphalt processing?	X		Impacts on air quality during construction stage are transitory in nature and can be largely prevented by mitigating measures. Rock crushing units will be sited away from the human settlements, sensitive ecosystems such as forests. SPCB consents for establishing and operating will be obtained and conditions laid will be complied. Air pollution due to cutting and filling works at construction sites will be prevented by mitigation measures. There is no hot mix plant required for metro projects except for minor road restoration works.
▪ Risks and vulnerabilities related to occupational health and safety due to physical, chemical, biological, and radiological hazards during project construction and operation?	X		Minimal occupational health and safety risks are involved in the project during construction and erection as the project alignment is passing through dense traffic corridors. Risks and vulnerabilities related to health and safety hazards during project construction are addressed through risk prevention and reduction by onsite safety monitoring and management; imparting training and skill development on occupational health and safety to construction workers; insisting contractor to comply with all the applicable labor laws applicable to the construction workers employment, health, safety and welfare; ensuring provision of Personnel Protective Equipment (PPE); conducting periodical safety audits; preparing traffic management plans; taking necessary precautions to maintain the health and safety of construction workers and ensuring medical staff and first aid facilities at the construction site.
▪ Noise and vibration due to blasting and other civil works?	X		Project does not involve blasting works as there is no construction of underground tunnels. However, there will be insignificant noise and vibrations from pile foundation excavation and construction activities. Noisy equipment such as DG sets will be provided with enclosures and mufflers. People working near excess noise producing equipment and machinery will be provided with ear plugs.
▪ Dislocation or involuntary resettlement of people	X		About 279 families will be dislocated due to the project particularly at metro station locations. The BMRCL will adopt the Resettlement and

SCREENING QUESTIONS	Yes	No	REMARKS
			Rehabilitation (R and R) Policy and suitable compensation to address the adverse impacts arising from the project in line with the National Policies and Asian Development Banks Safeguard Policy 2009.
▪ Dislocation and compulsory resettlement of people living in right-of-way?		X	There is no dislocation and compulsory resettlement of people living in right of way as the metro alignment of Phase 2B follows the median of outer ring road and space between main highway and the service road. However, about 279 families will be dislocated due to the project particularly at metro station locations. Resettlement Plan will be prepared in accordance with the guidelines of National Policy and Asian Development Banks Safeguard Policy 2009 to address dislocation and compulsory resettlement.
▪ Disproportionate impacts on the poor, women and children, Indigenous Peoples or other vulnerable groups?		X	There are no disproportionate impacts on the poor, women and children, Indigenous Peoples or other vulnerable groups by the proposed metro project. Proposed project impacts positively by providing quicker, comfortable and safe access to offices and other necessary services thus improving the quality of life of poor, women and other vulnerable groups.
▪ Other social concerns relating to inconveniences in living conditions in the project areas that may trigger cases of upper respiratory problems and stress?		X	Construction activities of metro stations near residential areas and operating construction equipment generate insignificant quantity of dust which is limited to construction phase only. All precautionary and mitigation measures for mitigating dust such as sprinkling water along the haulage roads on a regular basis during construction period; siting of construction establishments away from the human habitats; installing pollution control devices and increasing the stack height of DG sets; covering the truck carrying loads of construction materials; etc. will be taken up to prevent and reduce dust generation which causes upper respiratory problems and stress.
▪ Hazardous driving conditions where construction interferes with pre-existing roads?	X		As the alignment is proposed in the median of outer ring road there will be hazardous driving conditions during construction phase of the project. Site specific traffic management plans will be prepared. Assistance from local police will be taken. Temporary diversions will be provided by maintaining adequate carriage way for diversion traffic. Barricades, traffic safety signs, caution boards, road markings, flags, lights and flagmen as may be required will be provided to avoid

SCREENING QUESTIONS	Yes	No	REMARKS
			interference to the flow of traffic at pre-existing roads.
▪ Poor sanitation and solid waste disposal in construction camps and work sites, and possible transmission of communicable diseases from workers to local populations?		X	Construction camps will be provided with sanitary latrines and urinals. The sewage system will be operated properly to avoid health hazards, ground water and soil contamination. Garbage and other biodegradable wastes generated from the camps will be properly collected, transported and disposed of. Construction and labor camps will be sited away from human settlements to avoid possible transmission of communicable diseases from workers to local populations.
▪ Creation of temporary breeding habitats for mosquito vectors of disease?		X	Better sanitation will be maintained in construction and labor camps. Open pits near settlements will be filled with construction debris and covered with soil.
▪ Gaseous and odor emissions to the atmosphere from processing operations?	X		Construction equipment, transportation vehicles and DG sets will emit gaseous emissions to atmosphere during construction phase. Consents to establish and operate will be obtained from State Pollution Control Board and mitigation measures will be strictly adhered as per the consent conditions.
▪ Uncontrolled in-migration with opening of roads to forest area and overloading of social infrastructure?		X	The project does not have any forest in the vicinity and do not cause uncontrolled in-migration and overloading of social infrastructure doesn't arise.
▪ Accident risks associated with increased vehicular traffic, leading to accidental spills of toxic materials and loss of life?		X	Should an accidental spill occur, the applicable emergency spill procedure such as stopping the flow; removing ignition source; initiating emergency response; cleanup and safe disposal will be followed.
▪ Increased noise and air pollution resulting from traffic volume?		X	After the completion of project, there will be a significant reduction in noise and air pollution as the metro operation will reduce the traffic volume along the outer ring road and contributes to smooth and uniform flow of traffic.
▪ Increased risk of water pollution from oil, grease and fuel spills, and other materials from vehicles using the road?		X	There is no increased risk of water pollution from small quantities of oil, grease and fuel spills and other materials from vehicles using the road.
▪ Social conflicts if workers from other regions or countries are hired?		X	Construction laborers shall be hired locally to avoid any sort of social conflicts. If workers are hired from other regions, construction camps shall be located away from human habitations to avoid the social conflicts rising between locals and laborers.
▪ Large population influx during project construction and operation that causes increased burden on		X	Construction laborers shall be hired locally. If workers are hired from other regions, construction camps shall be located away from

SCREENING QUESTIONS	Yes	No	REMARKS
social infrastructure and services (such as water supply and sanitation systems)?			human habitations to avoid the increased burden on social infrastructure and services such as water supply and sanitation systems, etc.
▪ Risks to community health and safety due to the transport, storage, and use and/or disposal of materials such as explosives, fuel and other chemicals during construction and operation?		X	Statutory rules such as Hazardous Waste (Management and Handling) Rules, 1989 governing transport, storage and handling of hazardous chemicals shall be strictly adhered. Hazardous Waste Management and Disposal Plan shall be prepared to avoid risks associated with transport, storage, and use and/or disposal of materials such as explosives, fuel and other chemicals during construction and operation. Accident Safety and Hazardous Chemical Spill Management Plan including details of detours in case of emergency shall be prepared for an accidental release or spill of such chemicals. Training and awareness shall be given to transport crews and personnel handling such substances.
▪ Community safety risks due to both accidental and natural causes, especially where the structural elements or components of the project are accessible to members of the affected community or where their failure could result in injury to the community throughout project construction, operation and decommissioning.	X		Community safety risks due to accidental causes will be prevented by erecting proper barricades and enclosures to seclude community entering construction sites accidentally. If the project activities pose potential safety risks to the members of the affected family by structural elements used in the project, it shall be disclosed along with relevant project-related information to enable the affected communities to understand these risks and potential impacts, all efforts shall be made for prevention, mitigation including emergency response measures. Efforts shall also be made to design, construct, operate and decommission the structural elements of the project giving special consideration to potential exposure to natural hazards, especially where the structural elements are accessible to members of the affected community. All necessary measures for the safety of affected community and traffic during construction by providing, erecting and maintaining barricades, signboards, pavement markings, flags, lights and flagmen as proposed in the Traffic Management and Control Plan.

ANNEXURE - 2: Clearance from Lake Development Authority for Benniganahalli Lake



ಕರ್ನಾಟಕ ಕೆರೆ ಸಂರಕ್ಷಣೆ ಮತ್ತು ಅಭಿವೃದ್ಧಿ ಪ್ರಾಧಿಕಾರ
ಕರ್ನಾಟಕ ಸರ್ಕಾರ

ಸಂಖ್ಯೆ : ಕ.ಕೆ.ಸಂ.ಅ.ಪ್ರಾ/ಬೆಂ/ತಾಂತ್ರಿಕ/92/2018-19/217 ದಿನಾಂಕ : 04.06.2019

ಇವರಿಗೆ,

ವ್ಯವಸ್ಥಾಪಕ ನಿರ್ದೇಶಕರು,
ಬೆಂಗಳೂರು ಮೆಟ್ರೋ ರೈಲ್ ನಿಗಮ ನಿಯಮಿತ,
ಕೆ.ಹೆಚ್. ರಸ್ತೆ, ಶಾಂತಿನಗರ, ಬೆಂಗಳೂರು.

ಬೆಂಗಳೂರು ಮೆಟ್ರೋ ರೈಲು ನಿಗಮ ನಿಯಮಿತ
ಸಂ: 1751
ದಿನಾಂಕ: 07/06/19

ಮಾನ್ಯರೇ,

ವಿಷಯ : ಸಣ್ಣ ನೀರಾವರಿ ಇಲಾಖೆಯ ಸ್ವತ್ತುಗಳನ್ನು ಬಿ.ಎಂ.ಆರ್.ಸಿ.ಎಲ್ (BMRCL) ಗೆ ಹಸ್ತಾಂತರಿಸುವ ಬಗ್ಗೆ.

ಉಲ್ಲೇಖ : ತಮ್ಮ ಕಛೇರಿ ಪತ್ರ ಸಂಖ್ಯೆ : ಬಿ.ಎಂ.ಆರ್.ಸಿ.ಎಲ್/ಭೂಸ್ವಾ/ಹಂತ-2ಬಿ/ಏರ್‌ಪೋರ್ಟ್‌ಲೈನ್ /2019-20/118, ದಿ: 03-04-2019.

ಮೇಲಿನ ವಿಷಯ ಹಾಗೂ ಉಲ್ಲೇಖಿತ ಪತ್ರಗಳಿಗೆ ಸಂಬಂಧಿಸಿದಂತೆ ಬೆಂಗಳೂರು ನಗರ ಜಿಲ್ಲೆ, ಬೆಂಗಳೂರು ಪೂರ್ವ ತಾಲ್ಲೂಕಿನ ಬೆನ್ನಿಗಾನಹಳ್ಳಿ ಗ್ರಾಮದ ಸರ್ವೆ ನಂ. 55 ರಲ್ಲಿ 132.25 ಚ.ಮೀ ಬೆಂಗಳೂರು ಮೆಟ್ರೋ ರೈಲ್ ನಿಗಮ ನಿಯಮಿತ ರವರು ವಯಾಡಕ್ಟ್ ನಿರ್ಮಾಣಕ್ಕಾಗಿ, ವಿಶ್ವನಾಥನಾಗೇನಹಳ್ಳಿ ಗ್ರಾಮದ ಸ.ನಂ.13ರಲ್ಲಿ 800.00 ಚ.ಮೀ ಸ್ಟೇಷನ್ ನಿರ್ಮಾಣಕ್ಕಾಗಿ ಮತ್ತು 211.324 ಚ.ಮೀ ಬಸ್‌ಬೇ ನಿರ್ಮಾಣಕ್ಕಾಗಿ ಬೆನ್ನಿಗಾನಹಳ್ಳಿ ಕೆರೆಗೆ ಹೊಂದಿಕೊಂಡಂತೆ ಹಾಗೂ ಕೆರೆಗೆ ಹಾನಿಯಾಗದಂತೆ ನಿರ್ಮಿಸುವ ಕಾಮಗಾರಿಗಳನ್ನು ಮುಂದುವರೆಸಲು ಪ್ರಾಧಿಕಾರದಿಂದ ನಿರಾಪೇಕ್ಷಣಾ ಪತ್ರವನ್ನು ನೀಡಲಾಗಿದೆ ಹಾಗೂ ಕರ್ನಾಟಕ ಕೆರೆ ಸಂರಕ್ಷಣೆ ಮತ್ತು ಅಭಿವೃದ್ಧಿ ಪ್ರಾಧಿಕಾರದ ಅಧಿನಿಯಮ-2014 ಮತ್ತು ತದ ನಂತರ ತಿದ್ದುಪಡಿಗಳನ್ನು ಪಾಲಿಸುವಂತೆ ಕೋರಿದೆ.

ತಮ್ಮ ವಿಶ್ವಾಸಿ,

ಮುಖ್ಯಕಾರ್ಯನಿರ್ವಾಹಣಾಧಿಕಾರಿಗಳು,
ಕರ್ನಾಟಕ ಕೆರೆ ಸಂರಕ್ಷಣೆ ಮತ್ತು ಅಭಿವೃದ್ಧಿ ಪ್ರಾಧಿಕಾರ

ಪ್ರತಿಯನ್ನು :- ಸರ್ಕಾರದ ಕಾರ್ಯದರ್ಶಿಗಳು, ಸಣ್ಣ ನೀರಾವರಿ ಮತ್ತು ಅಂತರ್ಜಲ ಅಭಿವೃದ್ಧಿ ಇಲಾಖೆ, ವಿಕಾಸಸೌಧ ಬೆಂಗಳೂರು ರವರಿಗೆ ಮಾಹಿತಿಗಾಗಿ ಸಲ್ಲಿಸಿದೆ.

ಬೆಂಗಳೂರು ಮೆಟ್ರೋ ರೈಲು ನಿಗಮ ನಿಯಮಿತ
ಕೆ.ಹೆ.ರಸ್ತೆ
ಸಂಖ್ಯೆ: 125
ದಿನಾಂಕ: 8/6/19

ನೆಲ ಮಹಡಿ, ಬೀಜ ಭವನ, ಬಳ್ಳಾರಿ ರಸ್ತೆ, ಹೆಬ್ಬಾಳ, ಬೆಂಗಳೂರು-560024
ದೂರವಾಣಿ: 080-23513711/12, 080-22034173 ಈಮೇಲ್-tankdevelopmentauthorityk@gmail.com

ANNEXURE - 3: List of Birds and Reptiles commonly found around Bengaluru

330. The list of important birds commonly found in and around Bengaluru in addition to Nandi hills and Bannerghatta forest ranges roughly extending 40 km around the city center are Common quail, Grey jungle fowl, Indian peafowl, Lesser whistling-duck, Bar-headed goose, Spot-billed duck, Northern shoveler, Common teal, Greater flamingo, Lesser flamingo, Painted stork, Asian open bill, Black-headed ibis, Red-napped ibis, Eurasian spoonbill, Little egret, Grey heron, Purple heron, Intermediate egret, Cattle egret, Indian pond heron, Spot-billed pelican, Great white pelican, Little cormorant, Indian cormorant, Great cormorant, Oriental darter, Crested honey buzzard, Brahminy kite, Grey-headed fish eagle, Egyptian vulture, Indian vulture, Crested serpent eagle, Marsh harrier, Montagu's harrier, Eurasian sparrow hawk, Indian spotted eagle, Common buzzard, Red-necked falcon, Laggar falcon, Great Indian bustard, White-breasted water hen, Water cock, Grey-headed swamp hen, Common moorhen, Eurasian coot, Barred buttonquail, Pacific golden plover, Common ringed plover, Yellow-wattled lapwing, Grey-headed lapwing, Red-wattled lapwing, Pheasant-tailed jacana, Bronze-winged jacana, Eurasian woodcock, Marsh sandpiper, Common sandpiper, River tern, Whiskered tern, Painted sandgrouse, Chestnut-bellied sandgrouse, Rock pigeon, Spotted dove, Red turtle dove, Yellow-footed green pigeon, Rose-ringed parakeet, Pied cuckoo, Indian cuckoo, Common cuckoo, Grey-bellied cuckoo, Asian koel, Barn owl, Oriental scops owl, Indian scops owl, Mottled wood owl, Jungle owlet, Common kingfisher, White-throated kingfisher, Stork-billed kingfisher, Blue-bearded bee-eater, Blue-tailed bee-eater, Chestnut-headed bee-eater, Indian grey hornbill, Brown-capped woodpecker, Yellow-crowned woodpecker, White-cheeked barbet, Coppersmith barbet, Indian golden oriole, Black drongo, White-bellied drongo, Indian paradise flycatcher, White-bellied tree pie, House crow, Red-whiskered bulbul, White-eared bulbul, Yellow-throated bulbul, Paddy field warbler, Common starling, Common myna, Jungle myna, Indian blue robin, House sparrow, Yellow-throated sparrow, Red munia, Forest wagtail, Common rose finch, etc.

331. Snakes such as Cobra, Russels Viper, Common Krait, Saw Scaled Viper, Checkered Keel back, Common Verm or Blind Snake, Russell’s Earth Boa, Trinket Snake, Rat Snake, Indian Python, etc. and many types of lizards and insects.