Environmental Impact Assessment

October 2020

India: Bengaluru Metro Rail Project

Phase 2A (Outer Road Ring Metro Line)

Volume 1
Main Report

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

CURRENCY EQUIVALENTS

(as of 9 June 2020)

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

ABBREVIATIONS

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

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

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

WEIGHTS, MEASURES AND UNITS

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

NOTES

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

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

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EXECUTIVE SUMMARY

A. Introduction

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

B. Project Description

2. The present proposal is for the implementation of Phase 2A Metro Line on the ORR and will be an elevated standard gauge corridor with double line section for a route length of 17.130 km (line length of 19.75 km) up to the depot. The corridor proposed is from terminal station at CSB to terminal station at KR Puram and further up to Baiyappanahalli Depot, the other stations being HSR Layout, Agara Lake, Ibbalur, Bellandur, Kadubeesanahalli, Kodibeesanahalli, Marathahalli, ISRO, Doddenakundi, DRDO Sports Complex and Saraswathi Nagar.

3. The project proposals involve construction of elevated viaduct generally passing on median of the road and the stations proposed above the road with entries planned from both sides of the road beyond the existing service road. The proposed stations will have two side platforms and the access to the platforms is through staircases, escalators and elevators housed in the paid area of concourse.

4. Total 13 stations are proposed along the ORR line and 7 stations out of 13 stations have been planned for commercial development for an area of about 1000 Sqm at each station at concourse level. The area at ground level will be used for intermodal transit and parking.

5. Provision of 6m wide service road has been proposed around the stations for integration with BMTC buses to ensure last mile connectivity for commuters. A provision for pocket track of 300m length at Kodibeesanahalli station and cross overs at Ibbalur-Bellandur-Kadubeesanahalli and Marathalli-ISRO-Doddenakundi stations are made for facilitating smooth train operations and to help in easy turnaround of trains during emergency.

6. For the convenience of implementation, the proposed Phase 2A metro project corridor has been divided into two different Contract Packages as given in Table E-1.The work includes road widening, utility diversion and allied works and construction of loops,

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

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

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

7. **Project Categorization** - Phase 2A ORR metro line and Phase 2B metro line from KR Puram to Kempegowda International Airport (KIA) are proposed for funding from the Asian Development Bank (ADB). Rail-based systems have been excluded from the scheduled list under the Environmental Impact Assessment (EIA) Notification of 2006 and its subsequent amendments under the under the Environment (Protection) Act, 1986. Therefore, the proposed Phase 2A Metro Project is not required to secure environmental clearance in the form of an approved EIA from the Ministry of Environment, Forest and Climate Change (MOEFCC) per national policies and regulations. Similarly, the metro stations and depots proposed along the metro rail corridor being part of Metro rail project do not attract EIA Notification prescribing environmental clearance.

8. A preliminary screening of the project was done using Rapid Environmental Assessment (REA) Checklist for environmental categorization as per the ADB's SPS considering the aspects of project location and potential environmental impacts during various stages of project implementation (Annexure – 1).

9. The project, being located in a highly urbanized area, has been assessed to have very minimal impacts on biodiversity and will not affect environmentally sensitive areas. However, the scale of the civil works will require a great number of workers and entail movement of large quantities of materials and operation of heavy machinery in a largely populated urban area, including several congested segments. As such, community and occupational, health and safety risks during the construction stage are considered significant. Therefore, the proposed lines have been classified as Category 'A' as per Safeguard Policy Statement (SPS), 2009. This EIA has been prepared and will be disclosed at least 120 days prior to board consideration of the project in compliance with ADB SPS requirements.

C. Policies, Regulatory Framework and Its Applicability

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

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

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

Table E- 2: Clearances required for the proposed project

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

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

D. Description of Environment

12. Baseline information on environment was collected from secondary sources of data for the macro environmental parameters like climate, physiography (geology and geomorphology), biological and socio-economic environment of the project influence area. The corridor specific environmental details have been collected from primary source of data such as reconnaissance survey, baseline environmental surveys on ambient air quality, ambient noise levels, surface and underground water quality, soil quality vibration survey, tree enumeration, etc. along the project area.

13. The atmospheric concentration of air pollutants has been monitored at 7 representative air pollution sensitive locations such as schools, colleges, hospitals, hostels and libraries adjacent to the proposed Phase 2A metro alignment in November 2019. Air Monitoring was carried out for parameters PM2.5, PM10, NOx, SO2, CO and Pb. The results show that the average concentrations for PM10 were within the prescribed CPCB limit of 100 µg/m^3 but exceeded the WBG guideline value of 50 µg/m3 at all monitored locations. The concentrations of PM2.5 were all within the prescribed CPCB limit of 60 µg/m3 but exceeded the WBG guideline value of 25 µg/m3 at 5 locations. The concentrations of all other monitored parameters were within the prescribed CPCB limit and WBG guideline values. The survey for ambient noise levels has been conducted at seven representative locations sensitive to noise pollution along the alignment and an additional 30 locations in between. The results indicate that the lowest recorded ambient noise levels during both day and night time exceed the project limits for silence, residential as well as commercial areas (limits applied as prescribed by CPCB and WBG, whichever is more stringent).

14. To know the impact of vibration due to construction activities and metro train operation, the study was conducted at five locations along the proposed metro alignment. Threshold limit (upper Limit) has been set to 0.5 mm/s which refers the event has been captured above 0.5mm/s. The vibration of 1.22 mm/s has been recorded at one location out of five monitored locations. Surface water, ground water and soil samples have been collected from the water bodies, borewells and parks located adjacent to the proposed alignment respectively and analysed to establish the baseline conditions.

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

E. Environmental Impacts and Mitigation Measures

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

16. It is estimated that a total of 53,475.27 m^2 of land needs to be acquired for stations viaduct of the metro project, Multi-level Parking and Bus stand at Central Silk board of which 20,899.33 m^2 is private land and 32,575.94 m^2 is government land.

17. Approximately 123,709 m^3 of excavated earth and 7,822 m^3 of concrete debris would be generated from the excavations for piles and pile cap. As far as possible, demolition and construction waste should be segregated and recycled. The unserviceable waste left after recycling should be dumped in pre-identified and pre-approved pits as per Construction & Demolition Waste Management Rules.

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

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

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

21. 29 air and 124 noise sensitive receptors were identified along the project corridor alignment. Dust mitigation by regular sprinkling of water and noise mitigation measures such as provision of barricades and noise barriers during construction will be made at all the identified air and noise sensitive receptors to reduce the impact.

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

23. As per BMRCL survey approximately 1,248 trees are impacted by the project under Phase 2A. Transplantation/felling of trees will be taken up according to the recommendations/directions of the Tree Expert Committee (TEC) re-constituted by Government of Karnataka, as per the orders of Honorable High Court of Karnataka dated 20 August 2020. Every tree felled is compensated at the rate of ten trees or as per the direction of TEC or Forest Department. In addition, at-grade median plantation will be taken up all along the proposed alignment.

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

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

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

F. Information Disclosure, Consultation, and Participation

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

G. Environmental Management Plan

28. Environmental Management Plan (EMP) deals with the implementation procedure of the guidelines and mitigation measures recommended to avoid, minimize, and mitigate foreseen environmental impacts of the project. The implementation of environmental management plan needs suitable organization set up and the success of any environmental management plan depends on the efficiency of the group responsible for implementation of the programme. It is proposed to carryout regular environmental monitoring to provide information to the management for periodic review and alternation of the environmental management plan as necessary so as to ensure that environmental protection is optimized at all stages of the project implementation.

29. Environmental monitoring is an essential component for sustainability of any developmental project. It is an integral part of any environmental assessment process. The monitoring programme consists of performance indicators, reporting formats and necessary budgetary provision. For each of the environmental condition indicators, the monitoring plan specifies the parameters to be monitored, location of the monitoring sites, frequency and duration of monitoring. The monitoring plan also specifies the applicable standards, implementation and supervising responsibilities. The monitoring will be carried out by PIU through an independent external monitoring the approved agency as per the requirements of ADB's Safeguard Policy Statement for Category 'A' projects and will be supervised by the Environmental Experts of the Designated Engineer, External Independent Monitoring Agency and PIU.

30. The contractor is primarily responsible for daily onsite implementation environmental monitoring and management works during implementation of road improvement project to ensure high level of safety and quality and that all statutory requirements are

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

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

32. The budgetary provision of INR 11,132 Lakhs for the implementing EMP of the project has been made.

H. Conclusion and Recommendations

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

34. Stringent mitigation measures and monitoring requirements for various phases of metro project implementation are included in the EMP. The BMRCL shall ensure that site specific EMP together with the Safety, Health and Environment (SHE) guidelines forms a part of bid document and civil works contract. The same shall be revised if necessary, during project implementation or if there is any change in the project design and with approval of ADB.

I. INTRODUCTION

A. Background

35. Bengaluru is one of the fastest growing cities in India. The city is also known as Silicon Valley of India. It is in forefront supporting the growth of Information Technology (IT) and several other service-based industries attracting people and business from across the nation. This has led to the unpredicted and uncontrolled growth of population and traffic leading to challenges in providing and extending basic infrastructure and services. Road transport has been facing severe stress in the recent past. Bengaluru as a multi-nodal city lacks road connectivity and suffers from traffic congestion due to narrow roads. There are no good transit corridors between different parts of the city and connectivity to airport. Bengaluru roads are too narrow and most of these roads are bordered with ribbon development of thick built-up sections all along the roads, making widening of these roads to cater to the growing numbers of vehicles an unviable option. Widening of these narrow roads requires more land to be acquired and demolition of structures which will causes significant social and environmental impacts. Further, widening of roads is not a complete solution as the number of vehicles is increasing uncontrollably, adding to city's problems such as congestion, air pollution, noise pollution and associated social problems.

36. Bengaluru's vehicle population grows at roughly 500,000 vehicles every year leading to frequent traffic jams and makes the road prone to accidents. As per the Comprehensive Traffic and Transportation Plan for Bengaluru, 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.

37. Rapid development of IT industries in Electronic City and whitefield areas of Bengaluru, has contributed to the phenomenal growth all along Outer Ring Road (ORR) between Central Silk Board and KR Puram. With these developments, traffic on this road has unmanageably increased. It is estimated that about half a million IT professionals are employed on this corridor of ORR between Central Silk Board and KR Puram. In addition to IT professionals, this corridor is known for housing various support services and indirect employment thus providing employment to one million people overall. The biggest challenge these people are facing is the long time spent during transportation thereby bringing down their efficiency and also affecting the overall economic efficiency in this corridor. The Phase 2 Metro Line passes through these two extremities of this corridor, one at Central Silk Board and other at KR Puram.

38. Though Phase1of the Metro network has been completed and Phase2 has been planned, this crucial corridor has been left untouched by both developments. Hence, the construction of Phase 2A ORR Metro Line starting from Central Silk Board (CSB) to KR Puram with a route length of 17.130 km (line length of 19.633 km) up to the depot has been proposed. The DPR for this line was prepared by BMRCL in October 2016 and updated during January 2019 incorporating the requirements prescribed in

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

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

B. Objective of the Project

39. The proposed Phase 2A ORR Metro line meets the objectives and norms set out in the Metro Rail Policy 2017. The proposed line seeks to provide efficient, effective sustainable mode of mass public transport for the business corridor having economic activities for 12% the country's IT exports. The project aims to support the goals of Comprehensive Mobility Plan (CMP) for complementing economic activities and increasing the share of public transport to 70% of all motorized trips. It also plans to facilitate systemic changes in road usage by incentivizing efficient, equitable and sustainable mobility options through economic and regulatory measures, while discouraging inefficient and unsustainable options through imposition of cost of negative externalities. This project will play a key role in mitigating the mobility-related binding constraints to IT eco-system in Bengaluru, which accounts for 40% of revenues of IT companies in India.

40. Phase 2A Outer Ring Road Metro Line and Phase 2B Airport Metro Link Line from KR Puram to Kempegowda International Airport (KIA) are proposed for funding from the Asian Development Bank (ADB).

41. For the convenience of implementation, the proposed Phase 2A Metro Project has been divided into two different contract packages as given in Table 1-1. The work includes road widening, utility diversion and allied works of Phase2A Metro Project and construction of loops, ramps for road flyover at CSB junction of approximate length of 2.84 km including road widening and allied works in Reach-5 line (R5/P4) of Bengaluru Metro Rail Project, Phase 2.

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

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

C. Project Proponent

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

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

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

D. Environmental Categorization

44. The Environmental Impact Assessment (EIA) Notification of 2006 and its subsequent amendments under the under the Environment (Protection) Act, 1986 provides for the requirement of prior environmental clearance for specified projects/activities from concerned regulatory authority. Rail-based systems have been excluded from the scheduled list and therefore the proposed Phase 2A Metro Project is not required to secure environmental clearance in the form of an approved EIA from the Ministry of Environment, Forest and Climate Change (MOEFCC) per national policies and regulations.

45. A preliminary screening of the project was done using Rapid Environmental Assessment (REA) Checklist for environmental categorization as per the ADB's SPS considering the aspects of project location and potential environmental impacts during various stages of project implementation (annexure – 1).

46. The project, being located in a highly urbanized area, has been assessed to have no impacts of biodiversity and environmentally sensitive areas. However, the scale of the civil works will require a great number of workers and entail movement of large quantities of materials and operation of heavy machinery in a largely populated urban area, including several congested segments. As such, community and occupational, health and safety risks during the construction stage are considered significant. Therefore, the proposed lines have been classified as Category 'A' as per Safeguard Policy Statement (SPS), 2009. This Environmental Impact Assessment has been prepared and will be disclosed at least 120 days prior to board consideration of the project in compliance with ADB SPS requirements.

E. Scope of the Study

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

F. Approach and Methodology

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

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

II. PROJECT DESCRIPTION

49. The Detailed Project Report (DPR) for constructing and commissioning of Phase 2A Metro Line was prepared by BMRCL in October 2016 based on the experience it gained while implementing the Phase1 Metro project. The DPR was revised during January 2019 incorporating the requirements prescribed in the Metro Rail Policy2017 issued by MOHUA, GOI. During the preparation of updated DPR, there was continuous interaction with government agencies like Directorate of Urban Land Transport (DULT), Bangalore Development Authority (BDA), Bruhat Bengaluru Mahanagara Palike (BBMP), Bangalore Metropolitan Transport Corporation (BMTC) and Transport Department responsible for development of Bengaluru city to come up with the most feasible design and alignment for the proposed project.

A. Proposed Project

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

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

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

B. Alignment of the Proposed Metro

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

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

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

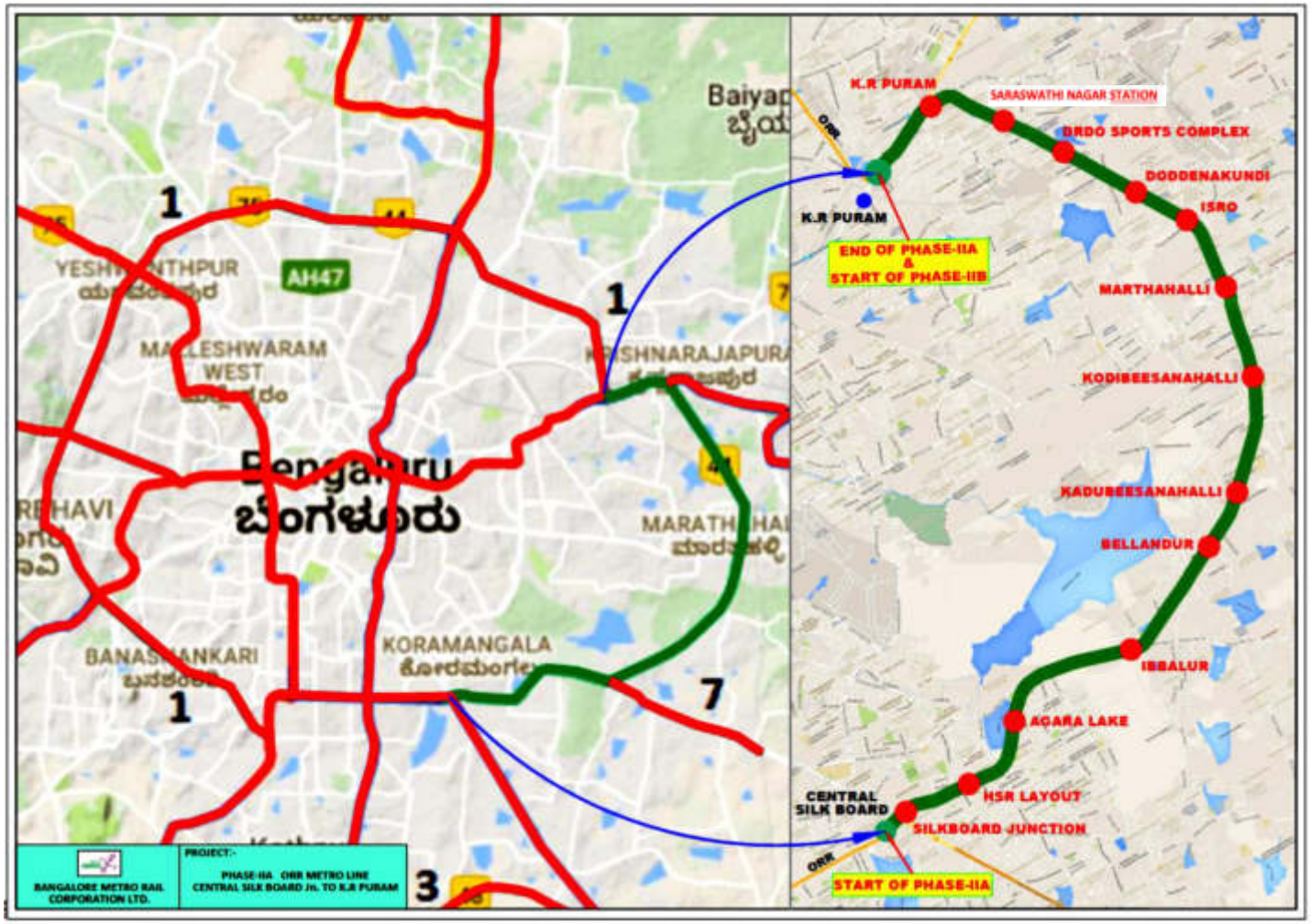


Figure 2- 2: Photos of Outer Ring Road along the proposed corridor

55. Vertical Alignment - A vertical clearance of 5.50m above road level shall be maintained by track supporting structures on elevated sections for movement of vehicular traffic. The rail level is planned to be generally 13.5 m above the road level to meet this requirement with the box girder design. This will also permit construction of elevated pedestrian walkways and footbridges (connecting bridges) for platform interchange for commuters at stations below the viaduct.

56. Viaduct - The most widely used precast segmental box girder/U-girder with post tensioning superstructure was selected for this project considering ease of construction and standardization of the formwork for wide span ranges. In this approach, segments are casted in a casting yard and then transported and assembled on site. This will be supported on single cast-in-situ reinforced concrete cement piers. Circular pier design with pier cap to support the bearings under the box girders will be adopted for this corridor.

57. Track Spacing- Track spacing on the viaduct through the stations shall be 4.2m providing for the extra clearance required due to end throw/mid throw and lean on curves of radius up to 120m while it will be changed beyond 4.2m in depots per provisions of the schedule of dimensions (SOD) of BMRCL 2015 for curves less than 120 to 100m.

58. Track Structures: UIC-60 (60 kg/m) rail section has been proposed considering the axle load frequency of train operation, maintainability, international practice. Rail grade on main lines should be 1,080 head hardened to accommodate sharp curves and steep gradients while 880 grade may be used for the depot lines.

59. Plinth type ballast-less track structure with RCC derailment guards integrated with the plinths is proposed on viaducts along with a suitable fastening system with a base plate to base plate spacing of 70 cm. The fastening systems for ballast less track should satisfy performance criteria issued by Government of India, Ministry of Railways in December 2015. Ballast-less track is also proposed for inspection and washing lines, and the workshop while ballasted track may be used for the rest of the line inside the depot.

60. The track structure is proposed to be joint-less even through the turnouts ensuring durability, minimum maintenance, and at the same time, having the highest level of safety, reliability and comfort, with minimum noise and vibrations.

61. Gauge - Standard gauge (1435mm) is commonly used for metro railways worldwide. 1 in 7 and 1 in 9 turnouts, which occupy lesser length, are feasible for this gauge, making it more suitable in the alignment which passes through heavily built-up areas as compared to 1 in 8 ½ and 1 in 12 turnouts required for broad gauge. The operational Phase 1 of Bengaluru Metro and Phase 2 which is under implementation are also adopting standard gauge. Given these, the standard gauge was also determined to be the best option for this alignment.

C. Depot Planning

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

63. Phase 2A requires 29 rakes with 2.5 minutes headway to cater to the traffic requirement of year 2041. These trains are planned to be stabled and maintained at

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

64. Phase 2B from KR Puram to Kempegowda International Airport is sanctioned for a length of about 38.00km. As such, the depot facilities are necessary at either end of the corridor to ensure seamless operation during any eventuality. Hence, to ensure feed from KR Puram end to Airport line, additional stabling and inspection facility at Baiyappanahalli Depot is proposed, necessitating remodelling of the facility. Considering the total length of Phase 2A and Phase 2B metro lines (56 km), a full-fledged depot at the end of Phase 2B is also proposed. Remodelling of Baiyappanahalli depot will also augment its capacity to cater for the complete operational needs of Phase 2B from either end.

65. A separate traction sub-station (TSS) shall be provided for depots to facilitate isolation of depot traction supply from mainlines in order to prevent the leakage of return currents to depot area. Tracks of depot areas shall also be isolated from main line through insulated rail joints (IRJ). Remote operated disconnection/sectionalizing switches shall be provided to feed power from depot to mainline and vice-versa in case of failure of depot TSS and nearest mainline TSS.

D. Rolling Stock, Traction and Signaling

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

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

E. Ridership on Proposed Metro Corridor

67. Ridership is the number of passenger trips. From the traffic study in the DPR[2] it is estimated that the daily ridership of this Metro corridor will be 3,38,466 in 2024, when the project is planned to be completed. It is projected to rise to 4,49,990 by 2031 and to 5,82,912 by 2041. Similarly, the Peak Hour Peak Direction Traffic (PHPDT) will be 19,573 by 2024 which is projected to increase to 26,023 by 2031 and to 33,704 by 2041.The ridership on the proposed metro corridor is important to assess the modal

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

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

68. The travel model generated for Revised Master Plan (RMP) 2031[3] has been used for the estimation of ridership for the proposed metro corridor from Silk Board to KR Puram. This metro line has been incorporated in the model. That assessment was complemented by a subsequent study done by Rail India Technical and Economic Service (RITES) in 2016 for demand assessment of metro lines up to year 2041. The total station-wise ridership is tabulated in Table 2-1 below.

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

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

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

F. Passenger Carrying Capacity

69. In order to maximize the passenger carrying capacity, longitudinal seating arrangement shall be adopted. The whole train shall be vestibuled to distribute the passenger evenly in all the coaches. Criteria for the calculation of standing passengers are 4 persons per square meter of standing floor area in normal state (AW2) and crush load 6 persons standee per sq. meter (AW3) and exceptional dense crush load of 8 persons/sq. meter (AW4).

70. Therefore, for the rail vehicles with 2.88 m maximum width and longitudinal seat arrangement, conceptually the exceptional dense crush capacity (AW4) of 43 seated, 273 standing thus a total of 316 passengers for a driving motor car (DMC), and 50 seated, 293 standing thus a total of 343 for a trailer car (TC) and motor car (MC) is envisaged. The seating and standee capacity of DMC, MC and TC in the unit of "DMC–TC–MC-MC–TC–DMC" with external sliding door are given in Table 2-2 below.

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

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

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

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

G. Power Requirements

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

72. The proposed power supply scheme detailed in the DPR is expected to ensure minimal interruptions during operations, optimum safety, reliability, and responsiveness to emergency situations. Information on power requirement both for traction and station as detailed in the DPR is given in Table 2-3.

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

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

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

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

H. Sub Stations

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

I. Analysis of Alternatives

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

"No Project" Scenario"

75. Travel demand forecasts detailed in the DPR show that all major work zones in the city are congested, with no room for further expansion. Volume to capacity ratio is forecasted to be above 1 for nearly all road network links. This level of congestion is projected to hamper bus operations such that trip frequency will drop even if the number of buses is doubled. Public transport share is also projected to drop from 48% in 2015 to 36% by 2031 fin the "do nothing" scenario.

76. Whether public transport system on a corridor in the city should be road-based or rail-based will depend primarily on the traffic density during peak hours on the corridor. Experience has shown that in mixed traffic conditions, comprising slow- and fast-moving traffic prevailing in most of our cities, road buses can optimally carry 8,000 peak hour peak direction traffic (PHPDT). When traffic density on a corridor exceeds 8,000 PHPDT, average speed of buses decreases, journey time and air pollution increase, and inconvenience to commuters is compounded. Thus, when the traffic density during peak hours exceeds this, rail-based mass transport, i.e. metro system should be considered.

77. Moreover, the metro system becomes an inevitable option when the traffic density on a corridor reaches 15,000 PHPDT. The growing economy and inadequate public transport services may cause the public to shift to private modes, as seen in the high vehicle ownership trends in the region. This would not only aggravate the congestion on the streets but also increase the pollution, highlighting the need to plan and provide for a medium capacity metro system in Bengaluru.

78. Traffic and transportation surveys like screen line volume count, turning volume count at junctions, road inventory survey etc., were carried out to assess the traffic and transport characteristic of the study area. The maximum PHPDT on Central Silk Board to K R Puram corridor has been assessed as 19,573 for 2024, 26,023 for 2031 and is likely to increase to 33,709 by 2041. Therefore, road based public transport will not be able to meet the demand.

Advantages of a Metro System

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

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

Types of Metros and their Capacity

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

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

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

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

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

Metrolite

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

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

86. In terms of cost, an elevated Metrolite will not result in significant cost reduction since the savings in civil engineering cost will be offset by the higher cost for rolling stock as it would require higher number of coaches which also have to be imported. The cost of other systems will also be the same to maintain close headway.

87. Metrolite system is to be adopted for passenger PHPDT envisaged from 2000 to15000. The PHPDT of the Phase 2A corridor is at 19,573, 26,023 and 33,709 in 2024, 2031 and 2041respectively while on Phase 2B corridor, it is 21,112, 35,705 and 46,252 in 2024, 2031 and 2041 respectively. With a PHPDT range at 2,000 to 15,000, adopting the Metrolite system already poses serious constraints at present and will become more serious impediment in the near future.

88. The corridor from Phase 2A to 2B will cover a total distance of 56km. Metrolite is planned with maximum operation speed of 60KMPH. The maximum operational speed of 60kmph for Metrolite system will restrict the average train speed to about 23 KMPH, increasing travel time and defeating the purpose of the project.

89. Because of the aforementioned reasons, Metrolite is determined to be unsuitable for the corridor as it is grossly inadequate to cater to the traffic demand. Instead, a medium capacity metro system was determined more suitable for the Phase 2A metro line.

Alignment Alternatives

90. The alternative alignments were evaluated considering the principal objective of the Comprehensive Mobility Plan of providing public transportation to the Bengaluru City public, particularly to the IT community congregated all along the Outer Ring Road, Electronic City, white field and Kempegowda International Airport, and addressing traffic congestion issues. Environmental issues such as the air pollution, noise pollution and safety issues along the outer ring road and airport roads were also considered. The existing traffic congestion due to due concentration of IT industries and IT professionals in the region and their dependence on the individual mode of transportation is the major cause of traffic congestion, air pollution, noise pollution, increased fuel consumption, etc. Social concerns such as increased travel time, ease of access to basic amenities, safety issues were also considered in choosing the alignment.

91. Alignment alternatives other than the proposed alignment are not feasible as the construction of both viaduct structures and metro stations requires large area of land. The cost of land in Bengaluru city is high and there is no land available to accommodate the viaduct structures and metro stations unlike the available space along the median and sufficient width of ORR. Another important factor to prove that the proposed alignment is best among any other alternative is the connectivity of ORR in the region.

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

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

93. If the metro were to pass underground, it will have structural implications as it will pass below the flyovers and RUB. Apart from this, underground metro takes longer to construct and entails barricading of wider road width for construction of the underground stations. Moreover, the cost of construction and operation of underground metro is much higher compared to an elevated metro and is preferred only where elevated metro is not feasible.

94. Construction of at-grade Metro on this corridor is ruled out as two lines of metro will occupy about 10m of the road width making the remaining road grossly inadequate for the flow of road traffic on this important ring road. Also, an at- grade metro corridor along the road splits the city into two and a number of underpasses/over bridges will have to be constructed for movement of people and vehicles from one side to the other side of the Metro Corridor.

95. The location of the stations is planned with the following considerations:

    - The stations are planned close to the commercial and residential establishments to facilitate the commuters and increase the ridership;
    - The stations are planned close to important crossroads for ease of commuters from these roads to reach the stations. This will also make operation of feeder services more convenient;
    - To reduce the cost of land acquisition and to make it less cumbersome the stations are generally planned in vacant lands and preferably in Government lands wherever possible.

96. Considering all the above aspects, elevated metro with elevated stations is proposed as the most suitable option for this corridor.

III. POLICIES AND THE REGULATORY FRAMEWORK AND ITS APPLICABILITY

A. Constitutional Provisions

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

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

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

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

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

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

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

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

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

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

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

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

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

H. Hazardous and other Waste (Management and Transboundary Movement) Rules, 1989 (As amended in2016)

104. 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)

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

J. Wildlife Protection Act, 1972

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

K. The Indian Forest Act, 1927

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

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

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

M. The Karnataka Preservation of Trees Act, 1976

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

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

N. The Ancient Monuments and Archaeological Sites and Remains Act, 1958 (as amended in the year2010)

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

O. Guidelines for Construction and Demolition Waste Management, 2016

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

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

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

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

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

Q. Biological Diversity Act 2002

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

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

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

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

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

T. Karnataka Industrial Area Development Board (KIADB) Act

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

U. Other applicable statutory requirements

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

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

119. The Asian Development Bank (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.

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

W. Clearances required for the Metro project

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

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

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

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

IV. DESCRIPTION OF ENVIRONMENT

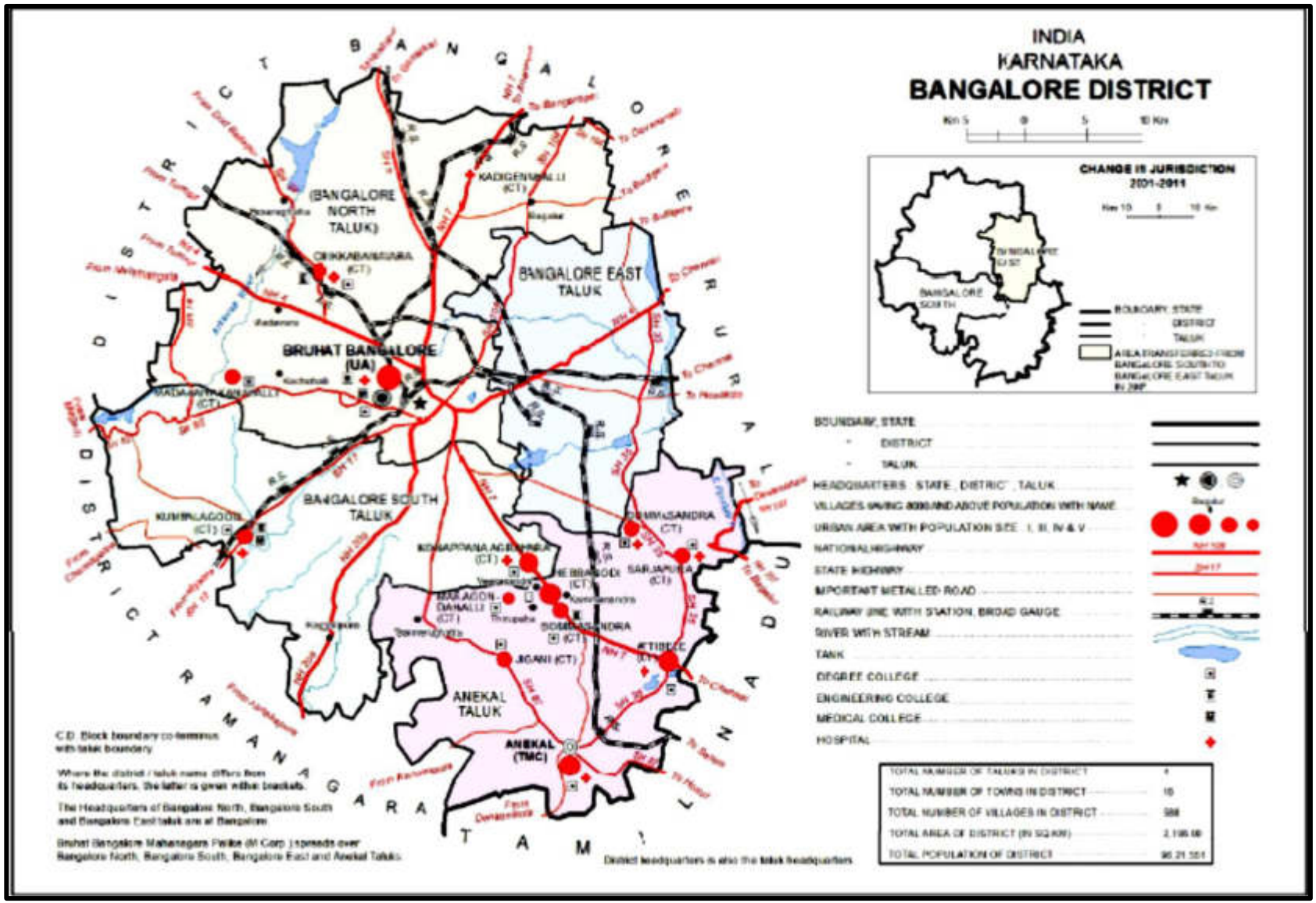
122. Assessment of the impacts of the proposed ORR metro project through actual site visits, review of secondary data and information on the environment including biophysical attributes and other relevant aspects, and obtaining baseline data on the environmental condition of the study area with respect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

A. Location

123. The proposed Phase 2A project starts from Central Silk Board to KR Puram and follows the median of Outer Ring Road. The complete alignment is located within the limits of Bengaluru Urban district.

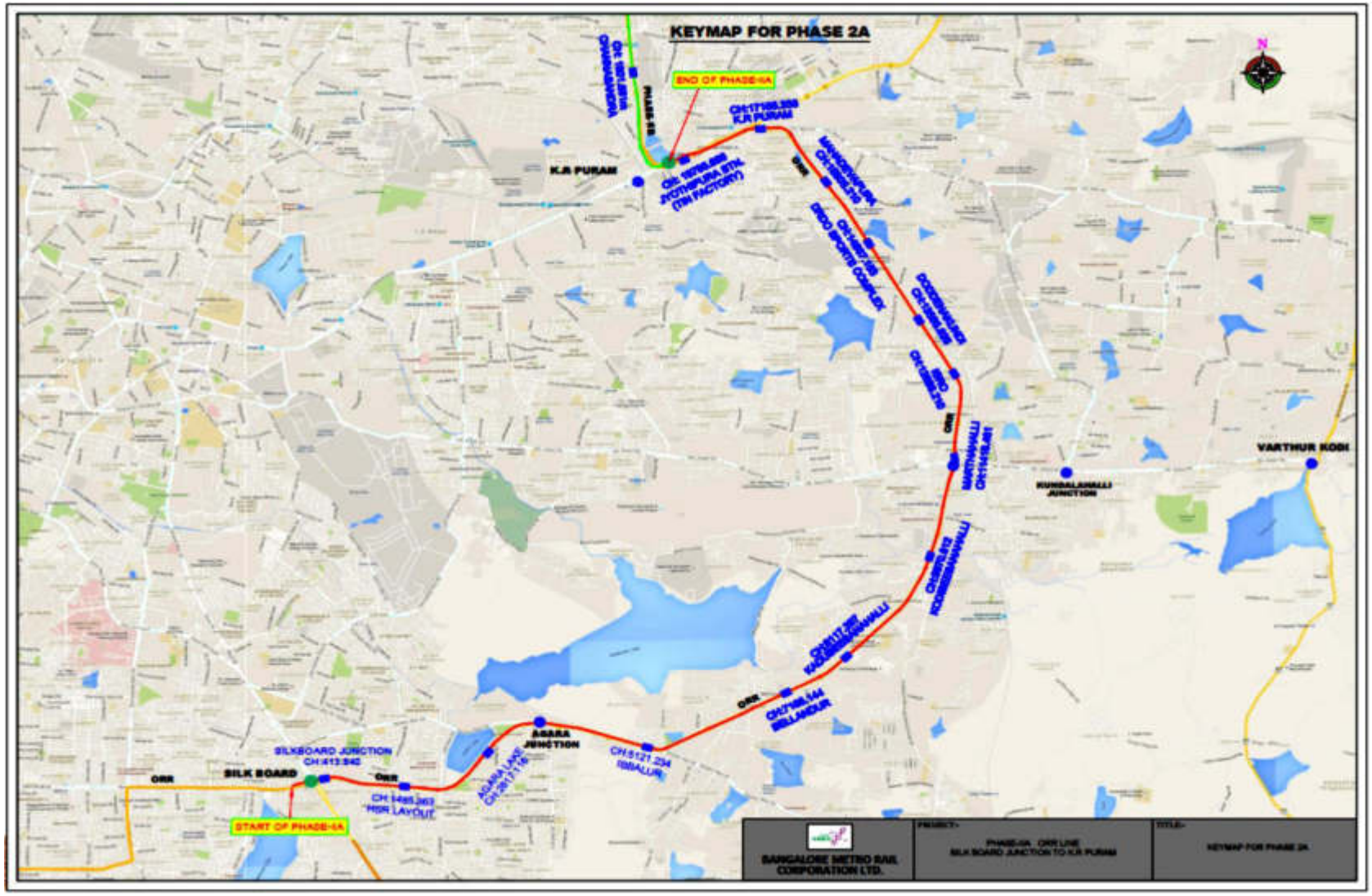
124. Bengaluru Urban District is located in the south eastern portion of Karnataka State with geographical area of nearly 2190 sq. km. It is bounded by Bengaluru Rural District on the south-western, western, northern and north-eastern sides and bordered by Tamil Nadu State on the south-eastern direction. The district lies between 12^0 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 4-2 illustrates the proposed ORR metro alignment along the ORR.

Figure 4- 1: Administrative map of Bengaluru Urban District



Source: District Census Handbook, Bengaluru, 2011

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



Note: Mahadevapura Station to be read as Saraswathi Nagar station

B. Physiography

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

C. Climate

126. Bengaluru has a tropical savanna climate (Koppen climate classification Aw) with distinct wet and dry seasons. Because of its elevation, Bengaluru, enjoys a pleasant and equable climate throughout the year.

127. **Rainfall:** Bengaluru receives about 970 mm of rain annually, the wettest months being August, September and October. The heaviest rainfall recorded in a 24-hour period was 159.7mm recorded on 1October1997.November 2015 (290.4mm) was recorded as one of the wettest months in Bengaluru with heavy rains causing severe flooding in some areas. Month-wise rainfall and annual total rainfall data for Bengaluru urban district is given in the Table 4-1.

128. **Humidity:** The average annual relative humidity in Bengaluru is 65.2% and average monthly relative humidity ranges from 45% in March to 79% in August. On an average, July is the most humid and January is the least humid month.

129. **Temperature:** The coolest month in Bengaluru is January with an average low temperature of 15.1 °C and the hottest month is April with an average high temperature of 35 °C. The highest temperature ever recorded in Bengaluru is 39.2 °C as there was a strong El Niño in 2016. The lowest ever recorded is 7.8 °C in January 1884. Winter temperatures rarely drop below 14 °C and summer temperatures seldom exceed 36 °C. Month-wise annual average temperature data for Bengaluru urban district is given in the Table 4-2.

130. **Wind:** Wind roses for Bengaluru are given in Figure 4.3. These month-wise wind-rose plots indicate the dominant wind directions and the direction of strongest wind speeds. The highest average wind speed of 14.1 mph was recorded in the month of July and the lowest average wind speed of 6.2 was recorded in the month of January. Highest calm condition prevailed in the month of February and lowest calm condition prevailed in the moths of June and July. Easterly winds are predominant during the months from November to March. Westerly winds are predominant starting from May to September. April and October months show the easterly and westerly winds.

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

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

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

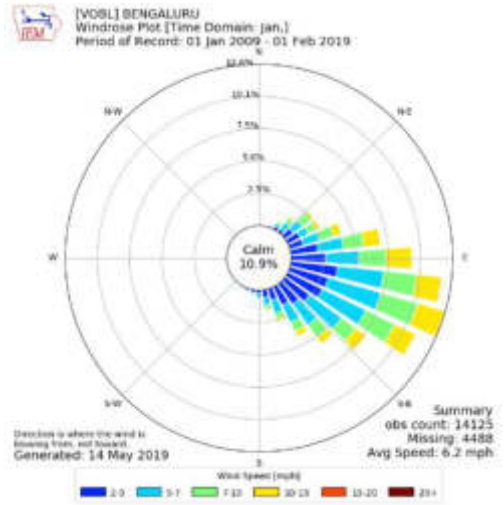
Table 4- 2: Month wise and annual average temperature for Bengaluru urban district in years 1885-2002

Temperature (^{0} Celsius)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Minimum	21.4	23.5	26.0	26.9	25.8	24.3	23.6	23.6	24.1	23.9	22.5	21.3	24.6
Average	22.7	24.7	27.0	28.1	27.3	25.1	24.3	24.3	24.9	24.5	23.5	22.2	24.9
Maximum	23.5	26.1	27.9	28.9	28.3	26.4	25.2	24.8	25.9	25.1	24.5	23.1	25.4

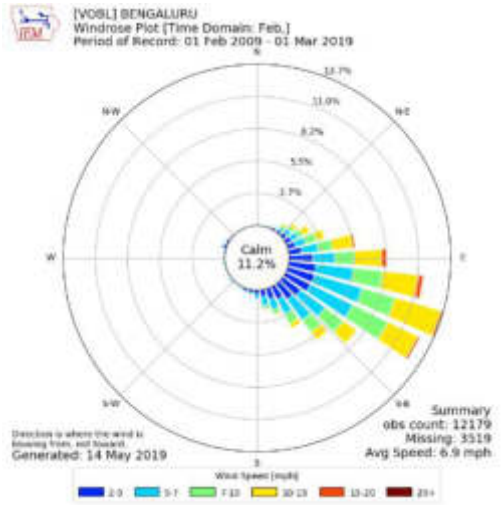
Source: http://www.indiawaterportal.org/met_data/

Figure 4- 3: Monthwise Windrose Plots for Bengaluru

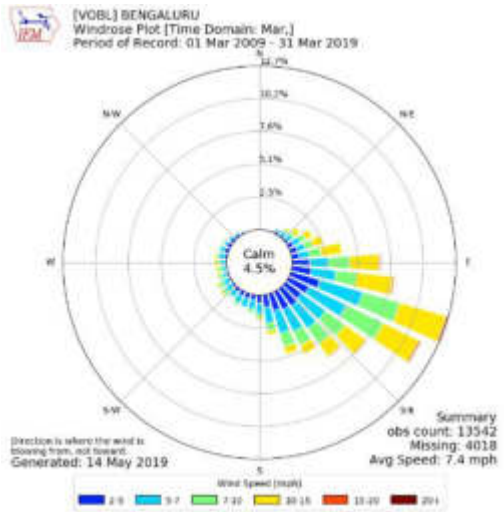
JANUARY



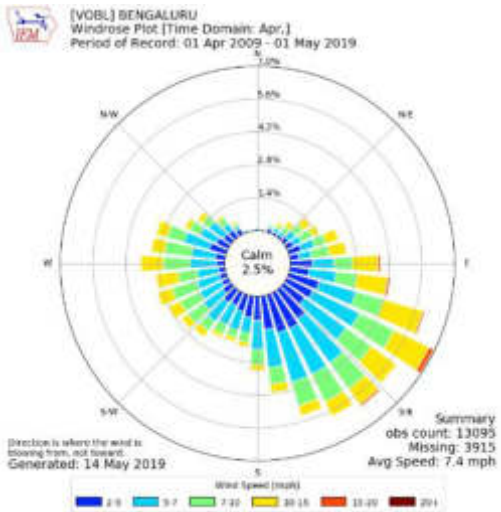
FEBRUARY



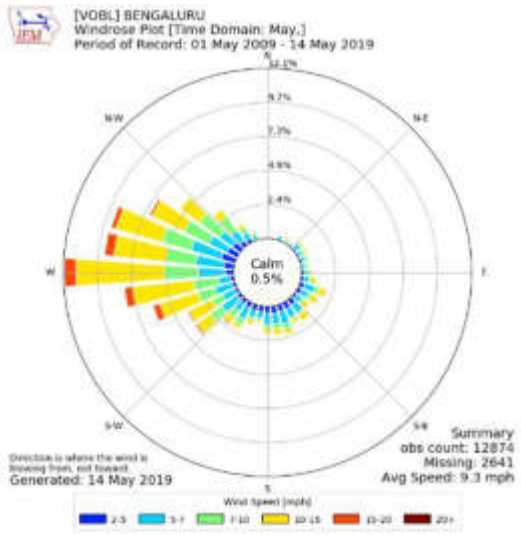
MARCH



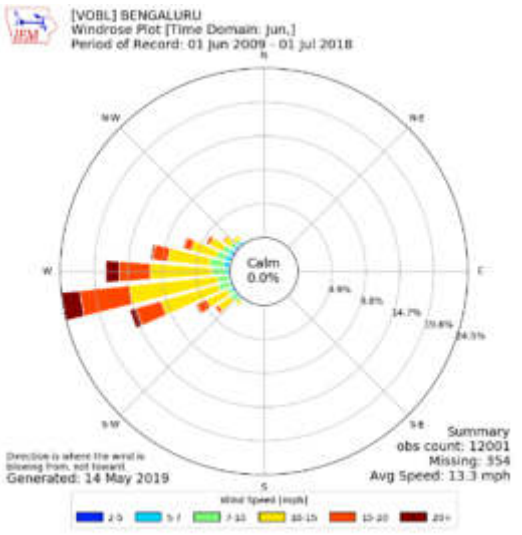
APRIL



MAY



JUNE



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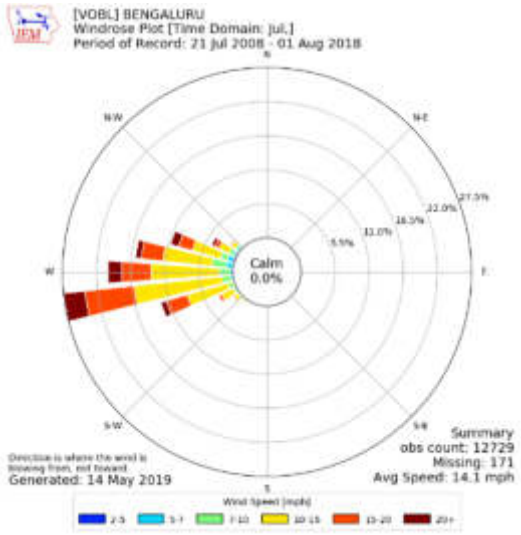
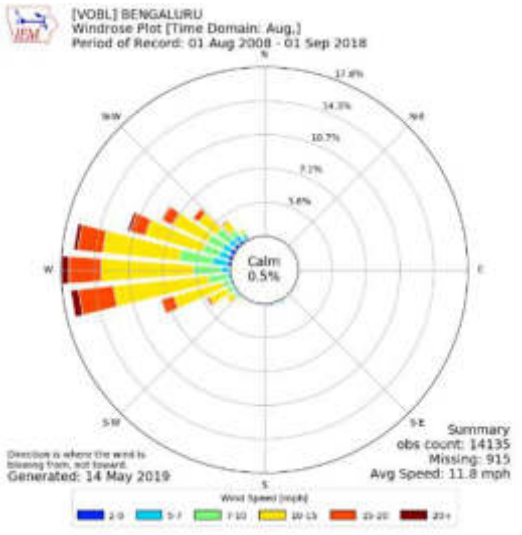
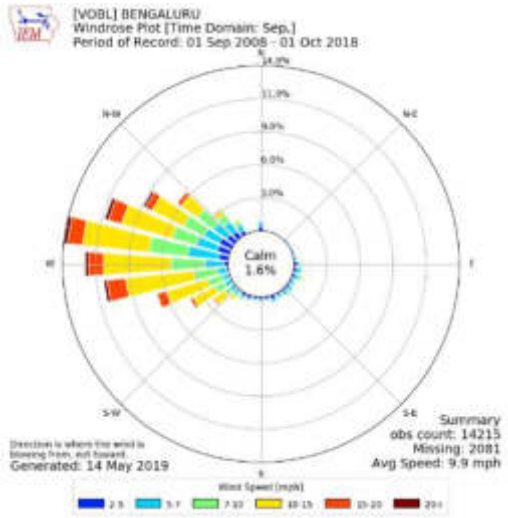


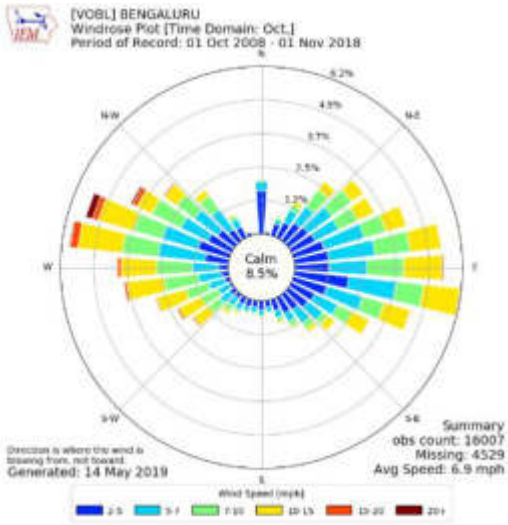
AUGUST



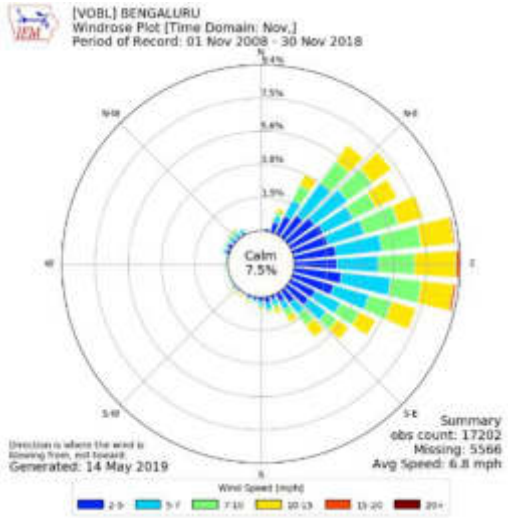
SEPTEMBER



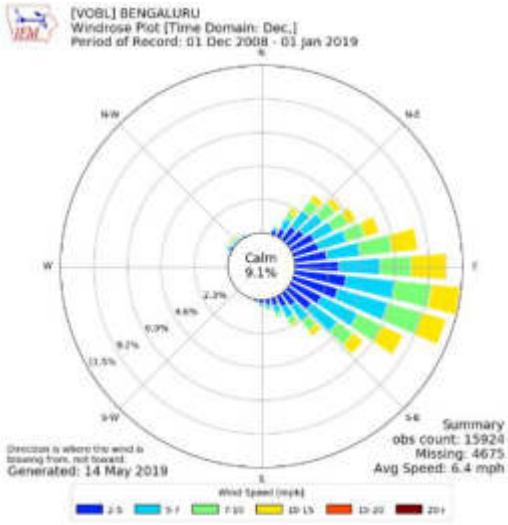
OCTOBER



NOVEMBER



DECEMBER



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

D. Ambient Air Quality

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

		Yearly average values (µg/m3)					**Air Quality Index Value**	**Cat.**
		PM10	**PM2.5**	**SO2**	**NO2**	**NH3**		
	WBG 1-year guideline values (µg/m3)	**20**	**10**	**-**	**40**	**-**		
No	**Monitoring station**							
1	Export Promotion Industrial Park, ITPL, White Field Road	92	33	2	27	25	91	S
2	AMCO Batteries, Mysore Road	90	36	2	29	26	90	S
3	Rail Wheel Factory, Yelahanka	92	29	2	26	25	89	S
4	Swan Silk Pvt. Ltd., Peenya Industrial Area	98	37	2	30	25	94	S
5	Victoria Hospital, K.R. Market	55	23	2	26	24	57	S
6	Yeswanthapura Police Station, Yeswanthapura	81	35	2	29	25	80	S
7	TERRI Office Premises, Domlur	86	31	2	28	25	85	S
8	Central Silk Board, Hosur Road	106	41	2	28	24	101	M
9	Mr. Madhachari's house, Kazisonnenihalli	83	30	2	26	23	83	S
10	Urban Eco Park, KSPCB Office Premises, Peenya	95	36	2	25	24	93	S
11	Indira Gandhi Children Health Care Centre	59	24	2	26	23	59	S
12	Banasawadi Police Station, Banasawadi	74	-	2	21	21	73	S
13	S.K.R Silver Jublee Building, K. R. Circle.	66	20	2	24	22	65	S

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

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

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

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

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

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

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

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

Parameter	Method/ Protocol Followed	Analysis Procedure
PM_{10}	IS-5182 (Pt-23)	- Sample collection for PM-10 with fine dust sampler NPM-FDS 2.5A without PM-2.5 inlet. - Sample collection for PM-2.5 with fine dust sampler NPM-FDS 2.5A with impactor. - Analysis by gravimetric method.
$PM_{2.5}$	IS-5182 (Pt-23)	
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- 4: Air and Noise Sampling Locations

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

Parameters	Sample	AAQ1	AAQ2	AAQ3	AAQ4	AAQ5	AAQ6	AAQ7
PM10 24 Hourly (in µg/m³)	NAAQS	100	100	100	100	100	100	100
	WBG	50	50	50	50	50	50	50
	Sample I	83.6	57.2	66.3	64.6	93.6	82.6	77.1
	Sample II	85.1	65.5	71.1	82.4	94.5	93.1	75.8
	Average	84.35	61.35	68.7	73.5	94.05	87.58	76.45
PM 2.5 24 Hourly (in µg/m³)	NAAQS	60	60	60	60	60	60	60
	WBG	25	25	25	25	25	25	25
	Sample I	28.8	17.8	24.2	25.1	35.4	30.3	28.6
	Sample II	23.2	21.2	27.3	24.2	30.08	37.5	22.4
	Average	26	19.5	25.75	24.65	33.1	33.9	25.5
SO2 24 Hourly (in µg/m³)	NAAQS	80	80	80	80	80	80	80
	WBG	20	20	20	20	20	20	20
	Sample I	9.30	10.34	9.56	7.28	8.21	12.06	9.41
	Sample II	10.18	8.36	8.81	9.07	11.09	10.54	8.56
	Average	9.74	9.35	9.185	8.175	9.65	11.3	8.985
NOX 24 Hourly (in µg/m³)	NAAQS	80	80	80	80	80	80	80
	WBG	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Sample I	24.79	31.13	27.66	30.91	24.77	31.02	29.92
	Sample II	26.93	25.50	24.08	26.38	28.03	27.70	25.06
	Average	25.86	28.315	25.87	28.645	26.4	29.36	27.49
CO 8 Hourly (in mg/m³)	NAAQS	4	4	4	4	4	4	4
	WBG	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Sample I	0.82	0.67	0.99	0.85	0.90	0.93	0.76
	Sample II	1.02	0.71	0.86	1.19	1.42	1.24	0.88
	Average	0.92	0.69	0.925	1.02	1.16	1.085	0.82
Pb, µg/ m3	NAAQS	1	1	1	1	1	1	1
	WBG	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Sample I	0.109	0.028	0.033	0.088	0.076	0.115	0.540
	Sample II	0.035	0.114	0.099	0.160	0.116	0.078	0.099
	Average	0.072	0.071	0.066	0.124	0.096	0.0965	0.3195

NAAQS: National Ambient Air Quality Standards
WBG: World Bank Group EHS Guidelines

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

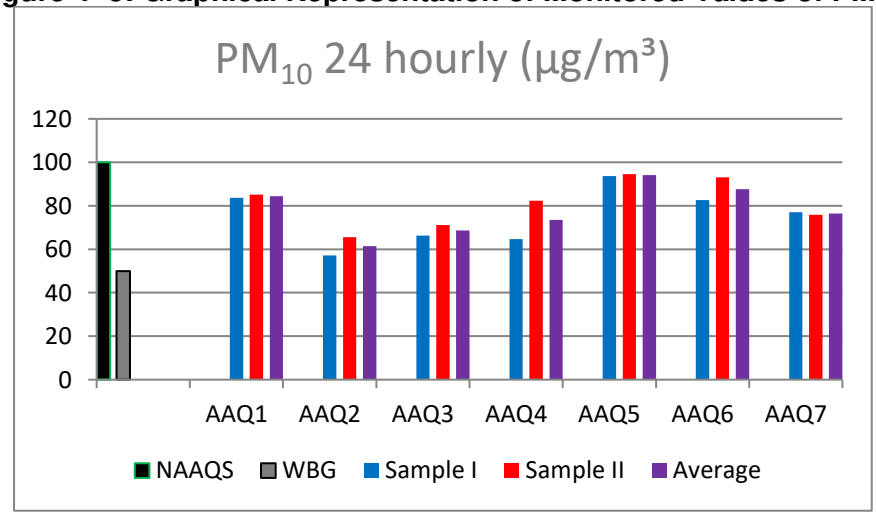


Figure 4- 6: Graphical Representation of Monitored Values of PM2.5

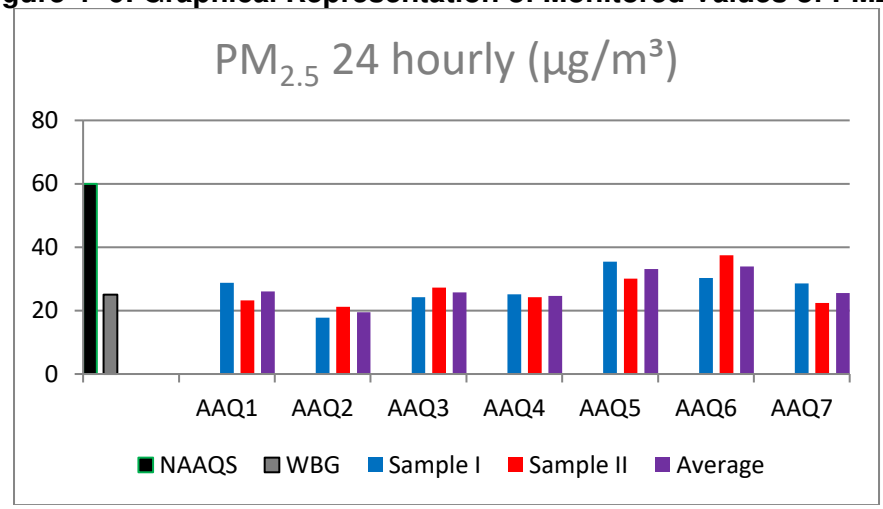


Figure 4- 7: Graphical Representation of Monitored Values of SO2

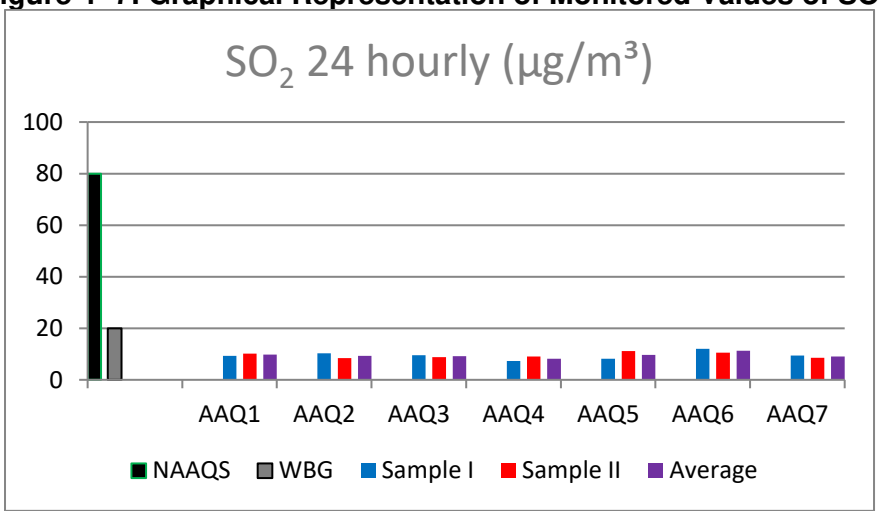


Figure 4- 8: Graphical Representation of Monitored Values of NOx

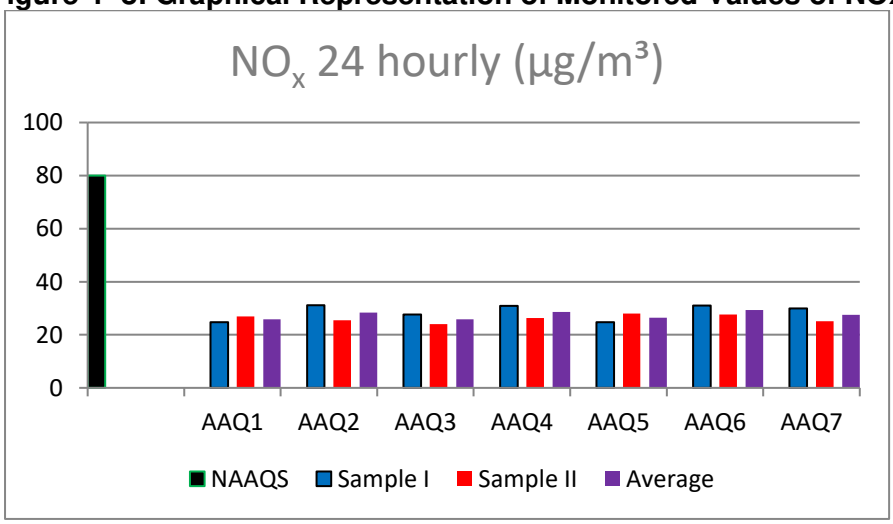


Figure 4- 9: Graphical Representation of Monitored Values of CO

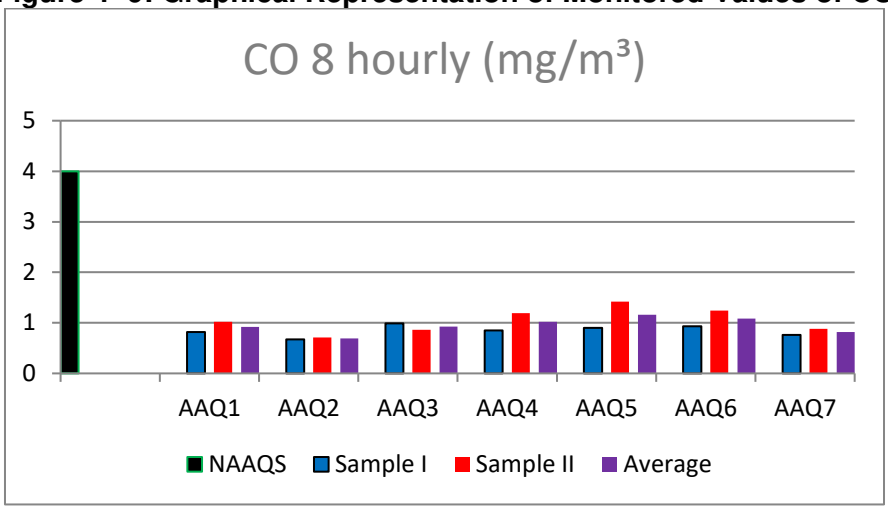


Figure 4- 10: Graphical Representation of Monitored Values of Pb

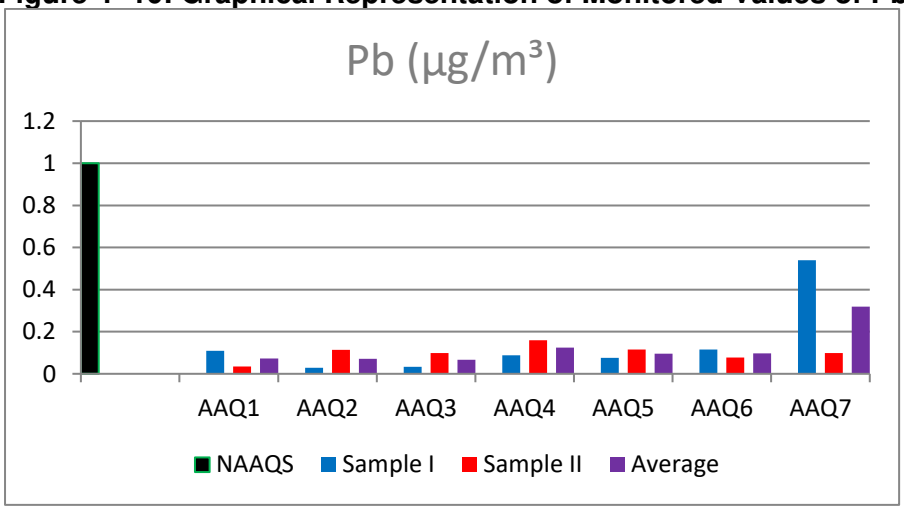


Figure 4- 11: Photographs of Air Quality Monitoring

	
AAQ 1 –Near JSS public School	AAQ 2 –Near Akme Harmony Apartments

AAQ 3 –Near New Horizon College of Engineering

AAQ 4 –Near VIMS Hospital, Marathhalli

AAQ 5 –Near ISRO, Sanjaynagar, Marathhalli

AAQ 6 –Near Bhagmane Tech Park, Mahadevapura

AAQ 7 – Near Lowry Memorial Educational Institutions

135. Table 4-6 shows that the average concentrations for PM_{10} recorded were within the prescribed CPCB limit of 100 µg/m^3 but exceeded the WBG guideline value of 50 µg/m^3 at all the seven monitored locations. The concentrations of $PM_{2.5}$ were all within the prescribed CPCB limit of 60 µg/m^3 but exceeded the WBG guideline value of 25 µg/m^3 at 5 out of 7 monitored locations. The concentrations of all other monitored parameters were within the prescribed CPCB limit or WBG guideline values.

E. Noise Environment

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

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

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

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

Table 4- 8: Noise Levels atdifferent noise monitoring stations

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

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

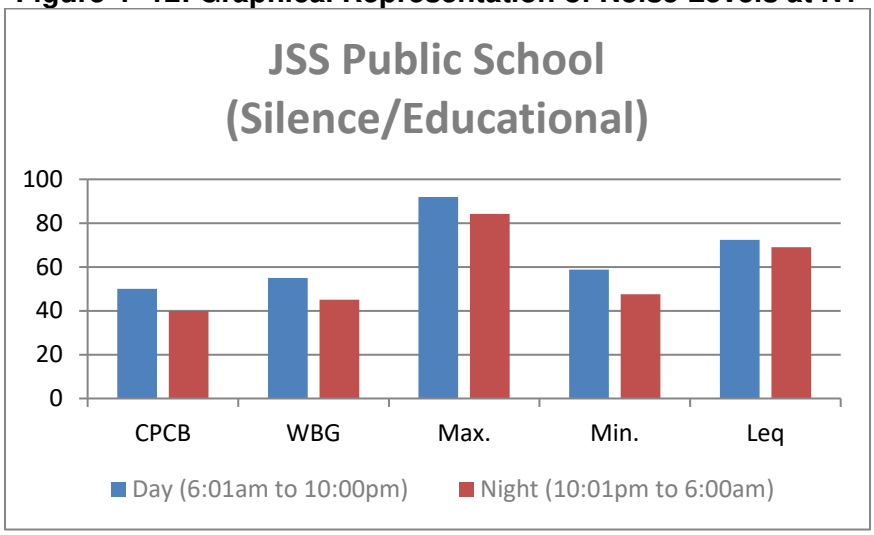


Figure 4- 13: Graphical Representation of Noise Levels at N2

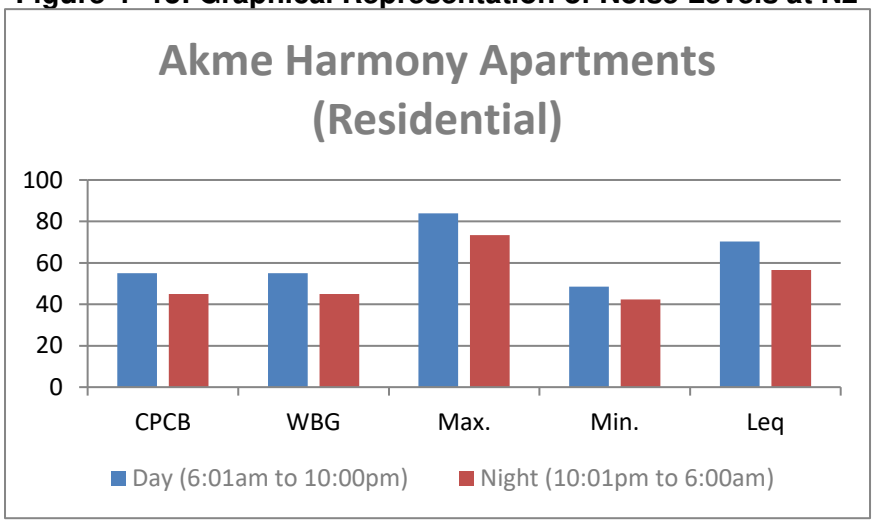


Figure 4- 14: Graphical Representation of Noise Levels at N3

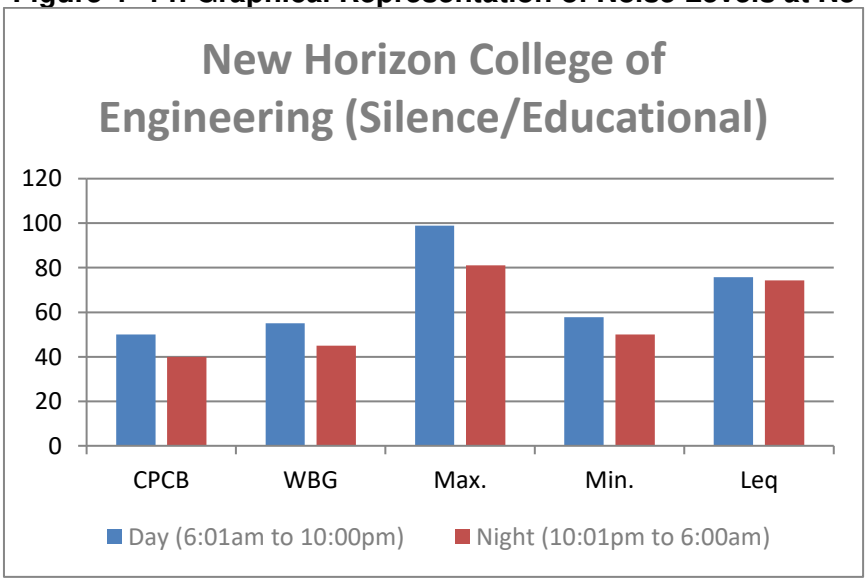


Figure 4- 15: Graphical Representation of Noise Levels at N4

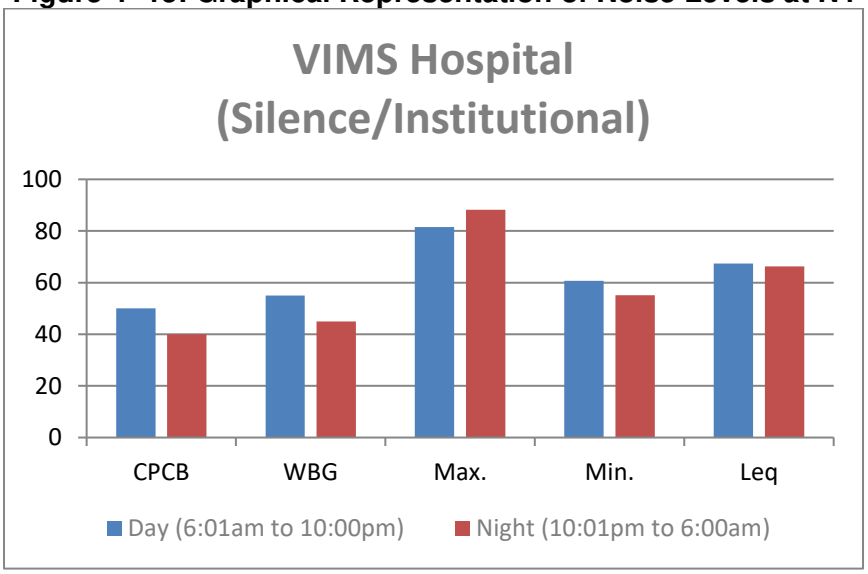


Figure 4- 16: Graphical Representation of Noise Levels at N5

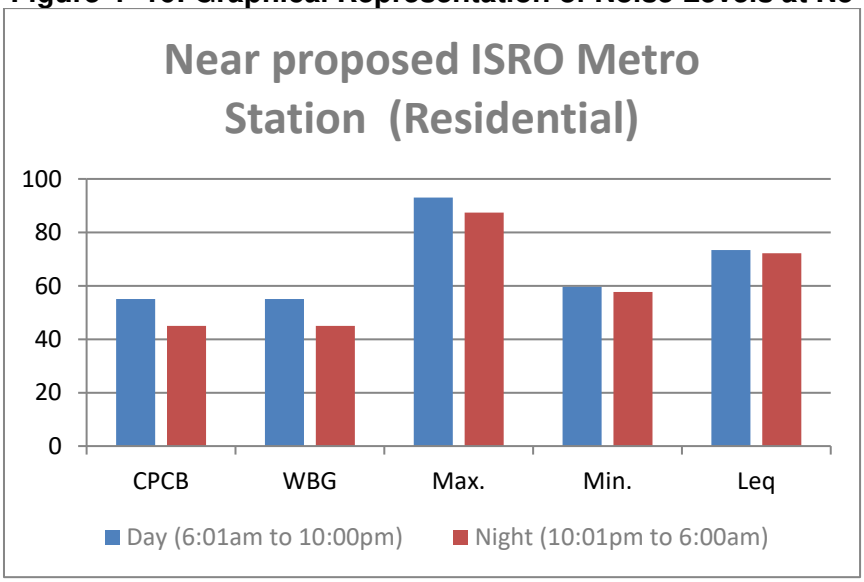


Figure 4- 17: Graphical Representation of Noise Levels at N6

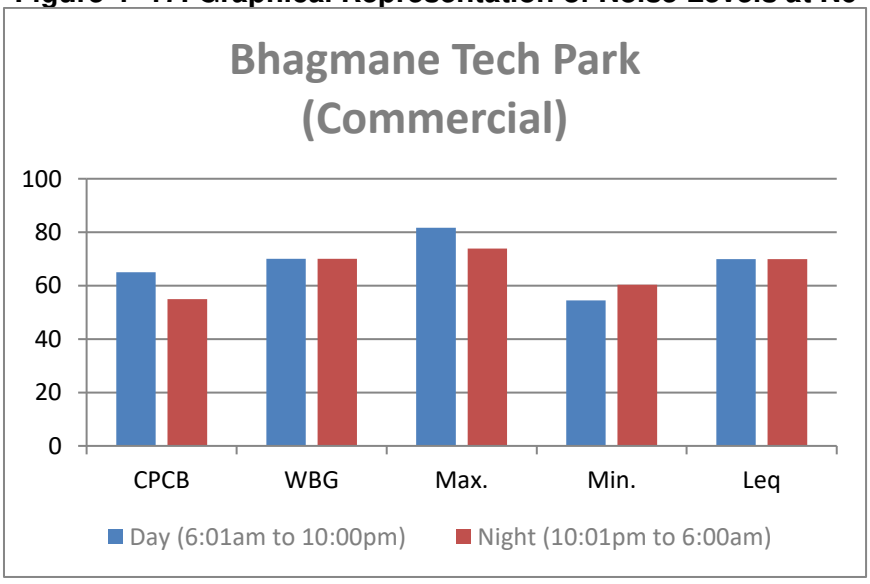


Figure 4- 18: Graphical Representation of Noise Levels at N7

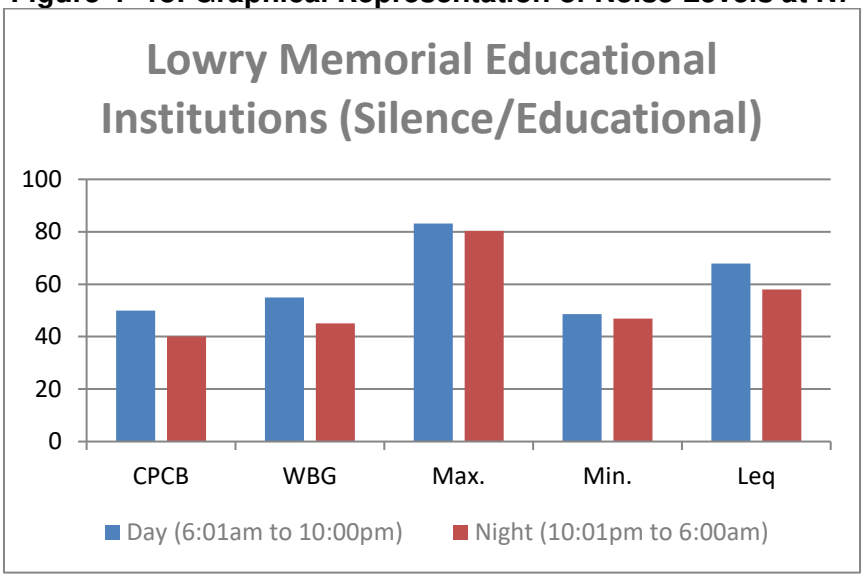


Figure 4- 19: Photographs of Ambient Noise Monitoring

N1 - JSS public School	N2 - Akme Harmony Apartments

N3 - New Horizon College of Engineering

N4 - VIMS Hospital

N5 - ISRO, Sanjaynagar, Marathhalli

N6 - Bhagmane Tech Park

N7 – Lowry Memorial Educational Institutions

138. A second set of noise measurements was performed between December 12 to 17 2019 to supplement the initial ambient noise monitoring and suffice the requirement for more detailed noise assessment. Details can be found in annex 5. With the additional measurements the density of data was decreased from 1:3.7 kms to 1:1 km which significantly improves the quality of the assessment. In contrast to the initial 24-hour measurement, the supplementary was shorter duration with each measurement spanning 30-minutes with 1-minute intervals. A shorter duration was made primarily to reduce cost, turnaround time and ability to represent one-hour Leq as required by the US Federal Highways Administration[4] Noise Measurement Handbook. A 30-minute measurement duration was selected in anticipation of widest range of noise fluctuations during the day of more than 30 dB(A). Below is a guide to determine the duration of short-term measurement based on anticipated fluctuations during the worst noise hour:

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

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

F. Vibration Monitoring

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

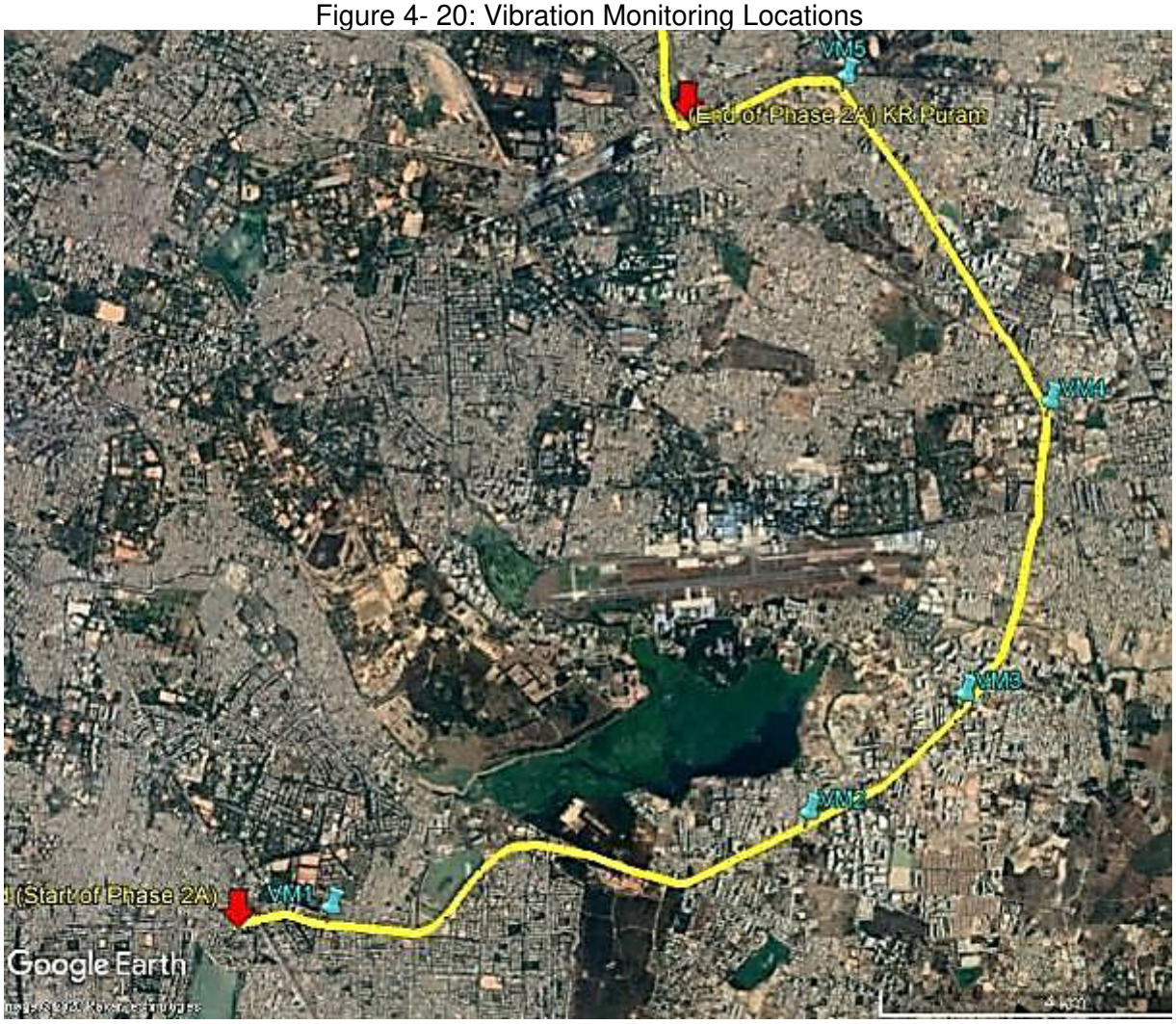
141. The values for noise and vibrations monitored along the proposed alignment are used to model and predict the impact of construction activities and train operation on the baseline noise and vibration. The detailed noise and vibration study is annexed to this report.

[4] US FHWA (2018). “Noise Measurement Handbook (Final Report)” FHWA-HEP-18-065 US Department of Transportation.

Table 4- 9: Details of Vibrationmonitoring locations

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

Figure 4- 20: Vibration Monitoring Locations



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

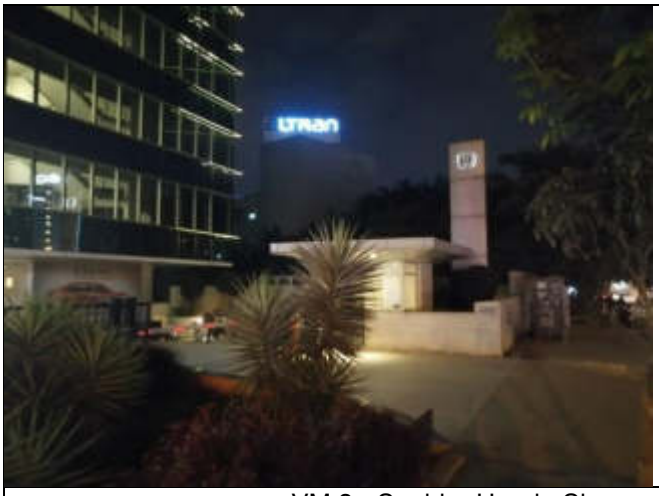
Table 4- 10: Results of Vibration Monitoring

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

Figure 4- 21: Photographs of Vibration Monitoring Locations

VM1 - Near HSR Apartment Bus Stop

VM2 - Krupanidhi College




VM 3 - Saphire Honda Show room Near Salarpuria Hallmark

VM 4 - Car Care show room near ISRO

VM 5 – Lowry Memorial Educational Institutions

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

G. Water Environment

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

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

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

146. After realizing the importance of waterbodies and the need for preservation and restoration of lakes, the Government transferred these lakes from Minor Irrigation Department to the Forest Department. Recently it wasproposed 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 4-12and the details of water bodies located adjacent to the metro alignment is given in Table 4-13 below.

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

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

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

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

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

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

148. **Bellandur Lake:** Bellandur lake spreads over 892 acres and is 300 m away on left hand side of the proposed metro alignment. The lake is one of the oldest and largest lakes in Bengaluru. It is connected to the Varthur lake and flows into the Pinakini river basin. The lake forms an important part of Bengaluru's drainage system. The lake once was an ecological system supporting wildlife and fauna, but has since ceased to serve this function due to influx of the city's wastewater. Recently, there have been fires on the lake and a layer of foam that formed over it as a result of extreme pollution. Despite repeated attempts to clean and revive the lake, none have so far succeeded, and the water quality is still very poor.

149. **Ibbalur Lake:** Ibbalur lake is located at chainage 5+600 km of Phase 2A metro project. The lake spreads over 18 acres in area. When the lake was under the control of Bangalore Development Authority in 2009, not much was done to develop and conserve the lake. During 2015 the lake was handed over to BBMP which took up lake rejuvenation. The current redevelopment marks the second major restoration of the lake in the last 15 years. The lakebed has been cleaned and levelled, the bund has been built, and bund walls pitched with stone. Water inlets and outlets have been constructed, and the newly built storm water drains along ORR will bring rainwater runoff into the lake.

150. **Nekkundi Lake:** Nekkundi Lake is located on RHS of proposed Phase 2A metro project. This 26 acre lake falls under two wards, Mahadevapura and Vignana Nagar. Nekkundi lake was once a much bigger ecosystem with a huge catchment area, it supported a lot of flora and fauna, including rare migratory and residential birds. Until 2015, the lake had a large open drain flowing into it, and garbage-filled storm-water drains around it, which were contributing waste water into the lake. The sewage was flowing into the lake from Kaggadaspura Lake. In 2015, the BBMP undertook a 10 crore project for rejuvenation of the lake by dredging, building bunds, de-weeding and fencing the lake area to prevent encroachment. At the moment the water quality is considered good and common native fauna is returning to the area.

151. **B Naranyanpura Lake:** B Narayanpura lake is located at chainage 16+300 km on LHS of the proposed metro alignment. The lake spreads over an area of 15 acres. Then lake land is encroached upon by temple, slums and other settlements. The lake is polluted mainly by sewage inflow. Recently the lake is rehabilitated by desilting and construction of bunds around the lake.

152. **Benniganahalli Lake:** Benniganahalli lake is located at the end of Phase 2A and start of Phase 2B metro corridors. The lake was developed by the Bengaluru Development Authority (BDA) two decades ago and handed over the lake to BBMP in 2016. The lake is spread over around 45 acres located near residential layouts such as Pai Layout. Benniganahalli was a favourite destination for morning and evening walkers. The developed portion of the lake has good water quality whereas the undeveloped portion is polluted with sewage from nearby layouts. In January 2018 BBMP took up the task of cleaning the lake by dredging, desilting and weed removal and constructed a channel to divert the sewage flow. This year, the lake is filled up with water from good monsoon received last year.

153. The above lakes located adjacent to the proposed metro alignment are facing problems such as ingress of sewage from adjacent residential areas; encroachment and unauthorised buildings, siltation and subsequent eutrophication. Most of these lakes are seasonal and completely dry up during summer. Water sampling has been done and water quality parameters have been analysed for Agara Lake, Nekkundi Lake and Mahadevapura Lake and the results of water quality is discussed in

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

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

Agara Lake

Bellandur Lake

Ibbalur Lake

Nekkundhi Lake

B Naryanapura Lake

Benniganahalli Lake

H. Hydrogeology

154. Granites and Gneisses of peninsular gneissic group constitute major aquifers in the urban district of Bengaluru. Laterites of Tertiary age occur as isolated patches capping crystalline rocks in Bengaluru north taluk. Alluvium of limited thickness of 20 to 25m and aerial extent that occur along the valley portions possess substantial groundwater potential. Groundwater occurs in phreatic or unconfined conditions in the weathered zone and under semi confined to confined conditions in fractured and jointed rock formations. The occurrence of groundwater movement and recharge to aquifers are controlled by various factors like fracture pattern, degree of weathering, geomorphological setup and amount of rainfall received. The yield in the bore wells is dependent upon factors like degree of weathering, presence of joints and fractures and its connectivity and the presence of intrusive bodies. Granites and gneisses of peninsular gneissic group constitute the major aquifers in the urban district. Ground water occurs in phreatic conditions in the weathered zone and under semi confined to confined conditions in fractured and jointed rock formations. The map for hydrogeology and ground water prospectus of Bengaluru District is given in Figure 4-23.The surface drainage network, water bodies and water shed boundaries for Bengaluru urban district is shown in figure 4-24.

155. Studies have been done on the ground water quality for Bengaluru Urban District by Central Ground Water Board (CGWB) based on hydro-chemical data of network hydrograph stations wells and exploration bore wells. Results show wide variations in its chemical composition. The shallow and deep groundwater is alkaline with pH value ranging from 7.8 to 8.5. Total hardness varies from 100 to 600 ppm. Fluoride content in general is less than 1 ppm. Major part of the district has fresh water with EC ranging from 250 to 2000 micro mhos/cm at 25° C.

156. Dependence on groundwater for water-supply in Bengaluru city is increasing due to accelerated growth, increasing per capita water use and poor reliability of supply of surface water from distant sources. Although surface water supply from the Bengaluru Water Supply and Sewerage Board (BWSSB) has increased over time, it has been unable to catch up with the rapid growth and expansion of city. As a result, groundwater is heavily used to make up the deficit. As a result, ground water provides a proportion of the current water consumption and is likely to continue to do so in most of the wards of the BBMP. There is no effective regulation of the use of groundwater for domestic, commercial and industrial or government agency purposes and use of this resource is unrestricted. Consequently, there is practically no reliable data on the rate and distribution of ground water withdrawals. Monitoring of the aquifers from which ground water is withdrawn is conducted by Department of Mines and Geology and the CGWB. However, it is not useful for assessing the state of the urban groundwater system as the density of existing monitoring network is very low and the frequency of monitoring by CGWB is once every few months which reveal larger, regional scale groundwater status over many years. Based on this sparse monitoring network, the CGWB has estimated that groundwater is more than 100% developed in Bengaluru, which means that the abstraction rate is more than the recharge rate to the aquifer.

157. In the urban area of Bengaluru district, main problems affecting groundwater are sewage pollution, industrial pollution, high nitrate concentration and overexploitation of ground water resources.[5] This is attributed to factors like rapid urbanization in the last three decades paving the way for commercial buildings, industries, new residential layouts. The green cover, tanks and lakes have been diminished leading to depletion of water levels. This rapid urbanization, IT boom, related economic activities, trade and commerce have exerted pressure, increasing the inflow of sewage waste into the lakes. Improper environmental planning has given room for establishment of new residential layouts without proper sewerage network

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

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

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

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

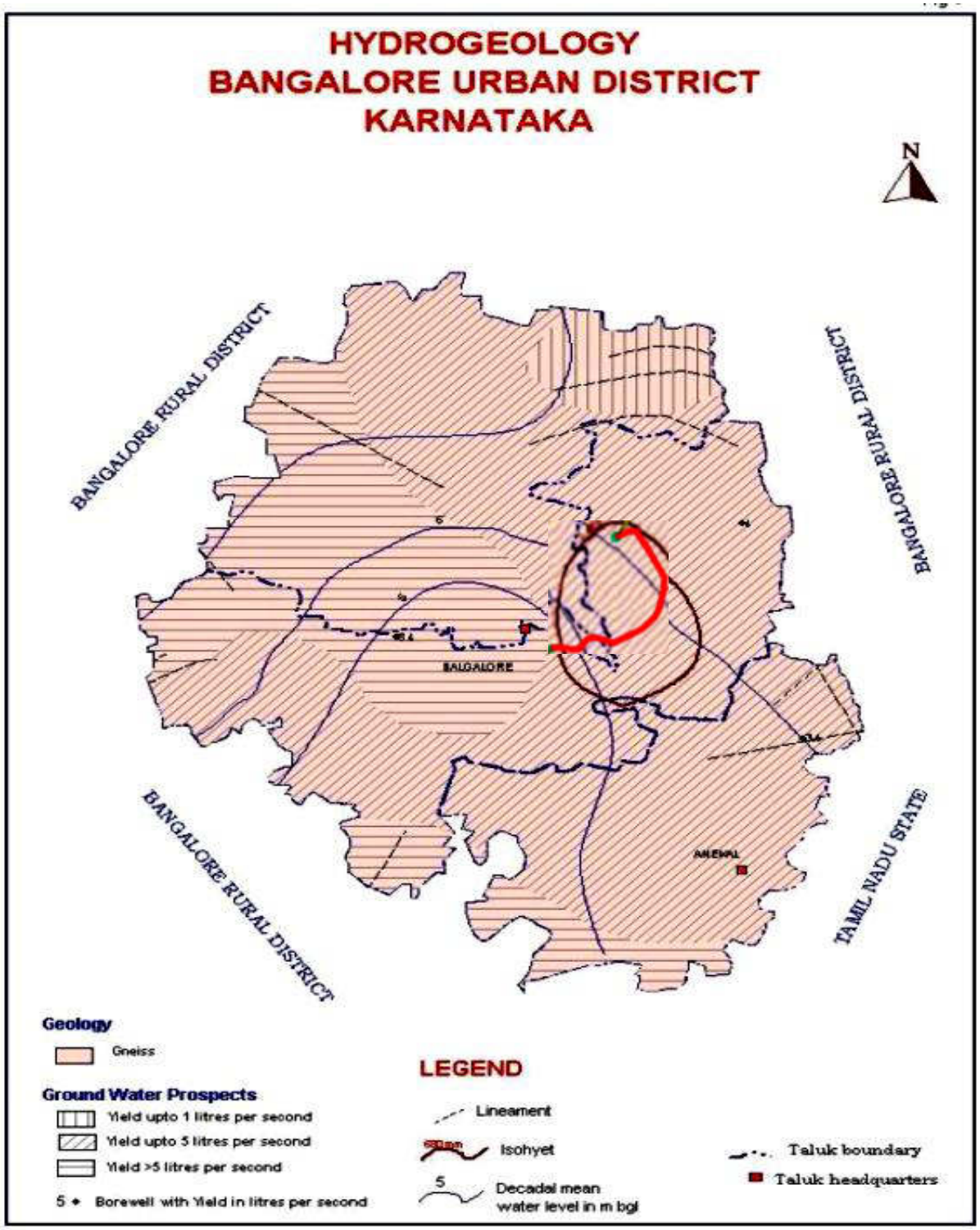
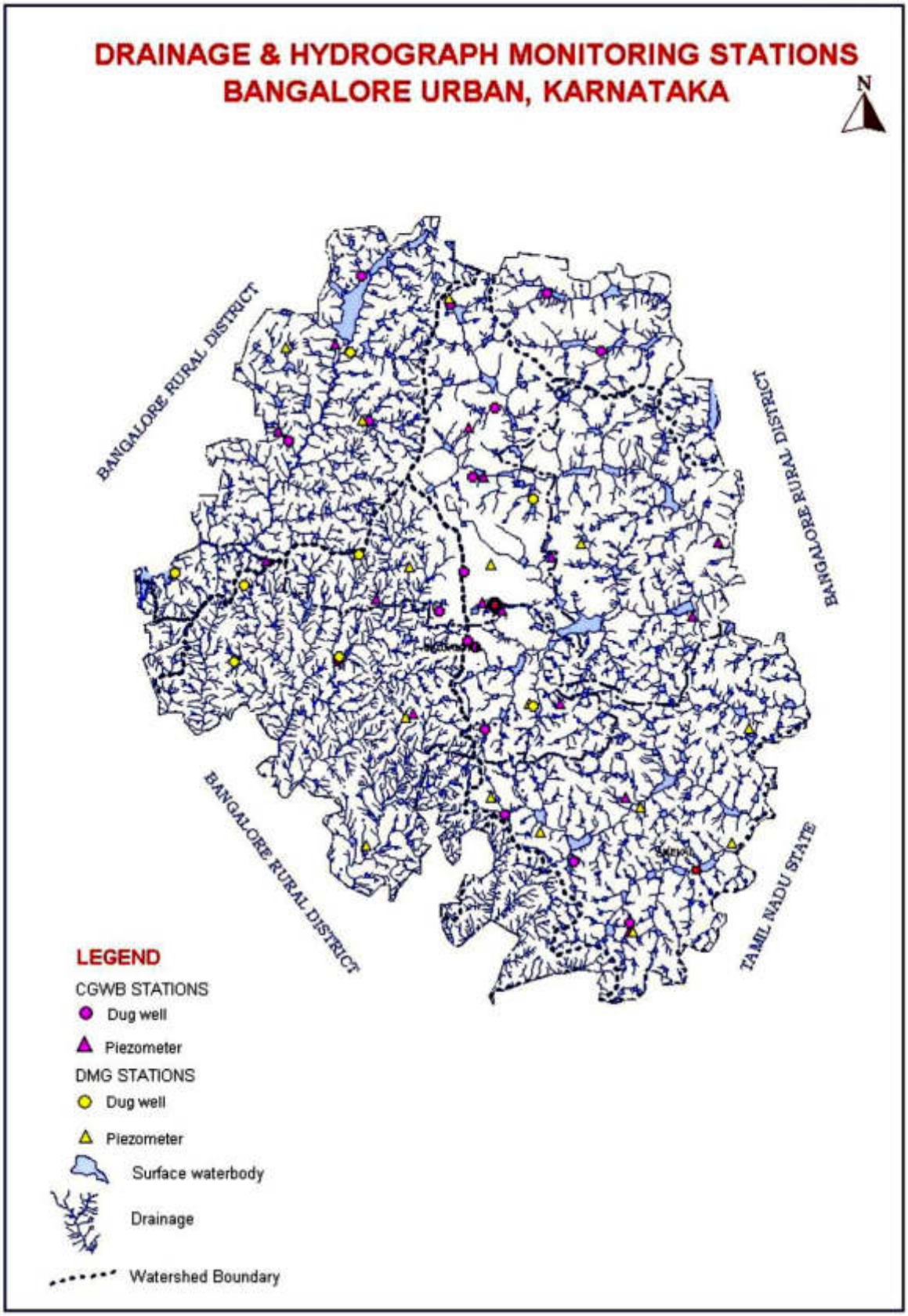


Figure 4- 24: Drainage map of Bengaluru Urban district



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

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

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

Figure 4- 25: Water Sampling Locations

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

Table 4- 14: Results of Surface Water Analysis

Sl. No.	Parameters	Unit	Water Quality Criteria					SW1	SW2	SW3
			A	B	C	D	E			
1.	pH	-	6.5-8.5					7.30	7.95	7.59
2.	Colour	Hazen	10	300	300	-	-	<1	<1	<1
3.	Odour	--	-	-	-	-	-	Disagreeable	Disagreeable	Disagreeable
4.	Turbidity	NTU	-	-	-	-	-	2.41	7.37	1.10
5.	Electrical Conductivity	µs/cm	-	-	-	1000	2250	417	955	489
6.	Total Dissolved Solids	mg/L	500	-	1500	-	2100	298	**651**	340
7.	Total Hardness as $CaCO_3$	mg/L	-	-	-	-	-	108	156	128
8.	Calcium as Ca	mg/L	-	-	-	-	-	30.4	41.6	40.0
9.	Magnesium as Mg	mg/L	-	-	-	-	-	7.77	12.63	6.80
10.	Chloride as Cl	mg/L	250	-	600	-	600	45.00	140.89	23.48
11.	Sulphate as SO_4	mg/L	400	-	400	-	1000	13.77	30.49	56.56
12.	Dissolved Oxygen	mg/L	6	5	4	4	-	**4.7**	**4.4**	**4.8**
13.	BOD (3 Days@27°C)	mg/L	2	3	3	-	-	**8.0**	**56.0**	**16.0**
14.	Chemical Oxygen Demand	mg/L	-	-	-	-	-	40	184	56.0
15.	Fluoride as F	mg/L	1.5	1.5	1.5	-	-	1.01	1.25	0.44
16.	Total Alkalinity as $CaCO_3$	mg/L	-	-	-	-	-	132	160	132
17.	Nitrate as NO_3	mg/L	20	-	50	-	-	6.38	13.04	3.54
18.	Phosphate as PO_4	mg/L	-	-	-	-	-	0.36	BDL	0.22
19.	Sodium as Na	mg/L	-	-	-	-	-	28.28	96.35	20.34
20.	Potassium as K	mg/L	-	-	-	-	-	9.93	17.30	10.31
21.	Iron as Fee	mg/L	0.3	-	50	-	-	0.18	0.13	0.15
22.	Manganese as Mn	mg/L	-	-	-	-	-	0.269	0.084	0.078
23.	Copper as Cu	mg/L	1.5	-	1.5	-	-	BDL	BDL	BDL
24.	Zinc as Zn	mg/L	15	-	15	-	-	0.006	0.011	0.008
25.	Mercury as Hg	mg/L	-	-	-	-	-	BDL	BDL	BDL
26.	Total Chromium as Cr	mg/L	-	-	-	-	-	BDL	BDL	BDL
27	Total Coliform	MPN Index /100ml	50	500	5000	-	-	**2400**	**3200**	**2800**
28	*E-coli*	MPN Index /100ml	-	-	-	-	-	84	220	170

Table 4- 15: Results of Ground Water Analysis

Sl. No.	Parameters	Std. IS 10500:2012 (Second Revision		Unit	GW1	GW2
		AL	PL			
1.	pH	6.5-8.5		-	7.22	8.02
2.	Colour	5	15	Hazen	<1	<1
3.	Odour	Agreeable		--	Agreeable	Agreeable
4.	Turbidity	1	5	NTU	0.11	0.11
5.	Electrical Conductivity	Not specified		µs/cm	998.0	1171
6.	Total Dissolved Solids	500	2000	mg/L	683	799
7.	Total Hardness as $CaCO_3$	200	600	mg/L	232	192.0
8.	Calcium as Ca	75	200	mg/L	64.0	48.0
9.	Magnesium as Mg	30	100	mg/L	17.49	17.49
10.	Chloride as Cl	250	1000	mg/L	74.35	172.20
11.	Sulphate as SO_4	200	400	mg/L	39.34	48.56
12.	Dissolved Oxygen	Not specified		mg/L	5.1	5.1
13.	BOD (3 Days @ 27°C)	Not specified		mg/L	BDL	BDL
14.	Chemical Oxygen Demand	Not specified		mg/L	3.2	BDL
15.	Fluoride as F	1	1.5	mg/L	0.88	0.50
16.	Total Alkalinity as $CaCO_3$	200	600	mg/L	312	208
17.	Nitrate as NO_3	45		mg/L	15.47	17.77
18.	Phosphate as PO_4	Not specified		mg/L	0.15	0.24
19.	Sodium as Na	Not specified		mg/L	54.0	108.84
20.	Potassium as K	Not Specified		mg/L	22.0	6.22
21.	Iron as Fe	0.3		mg/L	BDL	BDL
22.	Manganese as Mn	0.1	0.3	mg/L	0.010	0.154
23.	Copper as Cu	0.05	1.5	mg/L	BDL	BDL
24.	Zinc as Zn	5	15	mg/L	0.038	0.007
25.	Mercury as Hg	0.001		mg/L	BDL	BDL
26.	Total Chromium as Cr	0.05		mg/L	BDL	BDL
27.	Total Coliform	Not specified		MPN Index/100ml	<1.8	<1.8
28.	*E-coli*	Not specified		MPN Index/100ml	13	<1.8

161. **Water Quality Requirement for Different Uses:** For any water body to function adequately in satisfying the desired use, it must have corresponding degree of purity. Drinking water should be of highest purity. Each water use has specific quality need. Therefore, to set the standard for the 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 4-17.

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

Designated-Best-Use	Class of water	Criteria
Drinking Water Source without conventional treatment but after disinfection	A	Total Coliforms Organism MPN/100ml shall be 50 or less
		pH between 6.5 and 8.5
		Dissolved Oxygen 6mg/l or more
		Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
Outdoor bathing (Organized)	B	Total Coliforms Organism MPN/100ml shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more
		Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	Total Coliforms Organism MPN/100ml shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more
		Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Propagation of Wild life and Fisheries	D	pH between 6.5 to 8.5 Dissolved Oxygen 4mg/l or more
		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

SW1 – Agara Lake

SW2 – Nekkundhi Lake (Mahadevapura Lake)

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

i. Inference on the water quality analysis

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

SW-1 –Agara Lake:

163. Based on the measured values for the water quality parameters with respect to dissolved oxygen, biological oxygen demand (3 days @27^{0}C) and total coliform water sample from Agara lake is likely to conform to Class 'D' fit for propagation of wildlife and fisheries.

SW-2 - Nekkundhi Lake (Mahadevapura Lake):

164. Based on the measured values for the water quality parameters with respect to total dissolved solids, dissolved oxygen, biological oxygen demand (3 days @27^{0}C) and total coliform water sample from Nekkundhi lake is likely to conform to Class 'D' fit for propagation of wildlife and fisheries.

SW-3 - B Naranyanpura Lake:

165. Based on the measured values for the water quality parameters with respect to dissolved oxygen, biological oxygen demand (3 days @27^{0}C) and total coliform water sample from B Narayanapura lake likely to conform to Class 'D' fit for propagation of wildlife and fisheries.

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

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

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

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

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

I. Land Environment

168. Bengaluru (Urban) district consists of Charnokites and peninsular gneisses complex. The peninsular gneiss is the dominant group of rocks and covers two-thirds of the area and includes granites, gneisses and migmatites with intrusions. Small patches of porphyritic granite are also seen in Bengaluru South and Bengaluru North taluks.

169. Bengaluru district lies over a hard and moderately dense gneissic basement which dates back to Archean era (2500-3500 million years). The principal rock formations are upper Vindhyan super group, Deccan traps and Inter-trappean beds, alluvium and laterite. These rock types represent different time segments within Archean era. The study area is predominantly covered by red loamy and sandy soils, laterite soil. Red loamy and sandy soils generally occur on undulating land slope on granite and gneissic terrain. The soils are light textured and are highly leached in nature with good infiltration rate. It is mainly seen in the eastern and southern parts of Bengaluru North and South taluks. Laterite soils occur on undulating terrain forming plain to gently sloping topography of peninsular gneissic region. It is mainly covered in Anekal taluk and western parts of Bengaluru North and South taluks.

170. Five soil samples from the proposed metro alignment vicinity were analysed for 20 different parameters. The details of sampling locations and results of soil quality analysis are presented below in Tables 4-18 and 4-19.

Table 4- 17: Details of Soil Sampling Locations

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

Table 4- 18: Results of Soil Quality Analysis

Sl. No	Parameters	Unit	S1	S2	S3	S4	S5
1	pH	-	7.10	7.3	7.15	7.53	6.80
2	Electrical Conductivity	µs/cm	148	120	193	111.1	222
3	Organic Carbon	Percent	0.23	0.28	0.34	0.40	0.17
4	Sand	Percent	70.96	62.96	64.96	58.96	56.96
5	Silt	Percent	19.28	27.28	25.28	29.64	31.28
6	Clay	Percent	9.76	9.76	9.76	11.76	11.76
7	Porosity	Percent	57.94	50.82	56.22	53.15	46.42
8	Texture	-	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam
9	Available Nitrogen as N	kg/ha	280.98	204.68	182.64	375.06	205.47
10	Available Potassium as K	kg/ha	462.89	510.60	780.19	462.11	475.88
11	Available Phosphorus as P_2O_5	kg/ha	158.01	167.08	182.62	132.11	172.26
12	Calcium as Ca	meq/L	7.3	4.9	8.0	4.9	13.0
13	Magnesium as Mg	meq/L	1.3	0.9	1.0	1.6	1.0
14	Sodium as Na	mg/100gm	5.60	2.89	8.09	1.66	9.30
15	Boron as B	mg/100gm	BDL	BDL	BDL	BDL	BDL
16	Iron as Fe	Ppm	78.059	107.702	40.53	71.67	62.22
17	Zinc as Zn	mg/kg	9.6	24.2	8.5	41.4	19.6
18	Manganese as Mn	mg/kg	210.4	108.3	137.8	125.4	110.6
19	Molybdenum as Mo	mg/kg	BDL	BDL	BDL	BDL	BDL

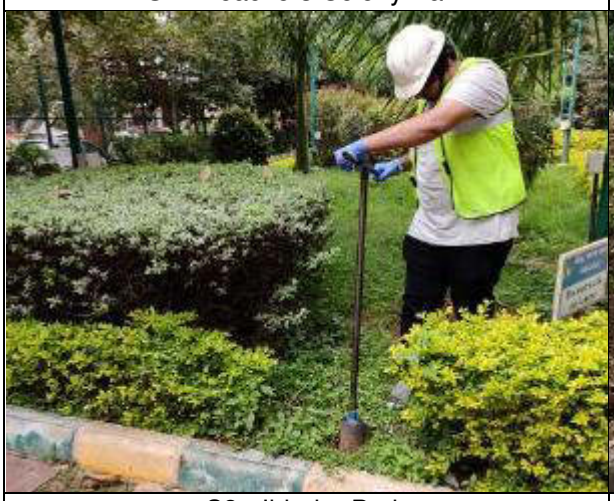
Sl. No	Parameters	Unit	S1	S2	S3	S4	S5
20	Copper as Cu	mg/kg	8.6	18.2	8.3	9.4	10.8
21	Aluminium as Al	mg/kg	3521.8	4580.6	2246.4	3111.7	3037.0

BDL: Below Detectable Limit.

Figure 4- 27: Photographs of Soil Sampling

S1 - Teachers Colony Park

S2 - Agara Park



S3 - Ibbalur Park

S4 - BBMP Park

S5 - Narayanapura Park

Figure 4- 28: Soil Sampling Locations

J. Land use pattern

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

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

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

Land use Class	Urban		Vegetation		Water		Others	
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

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

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

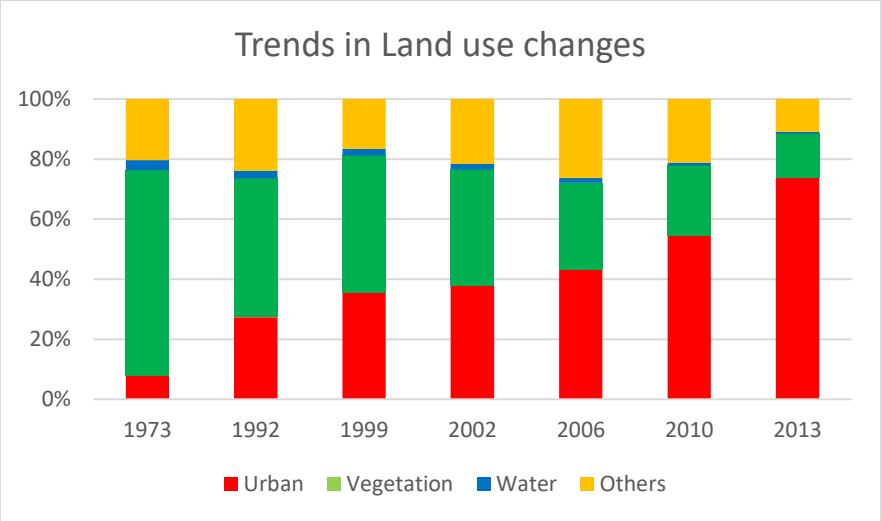
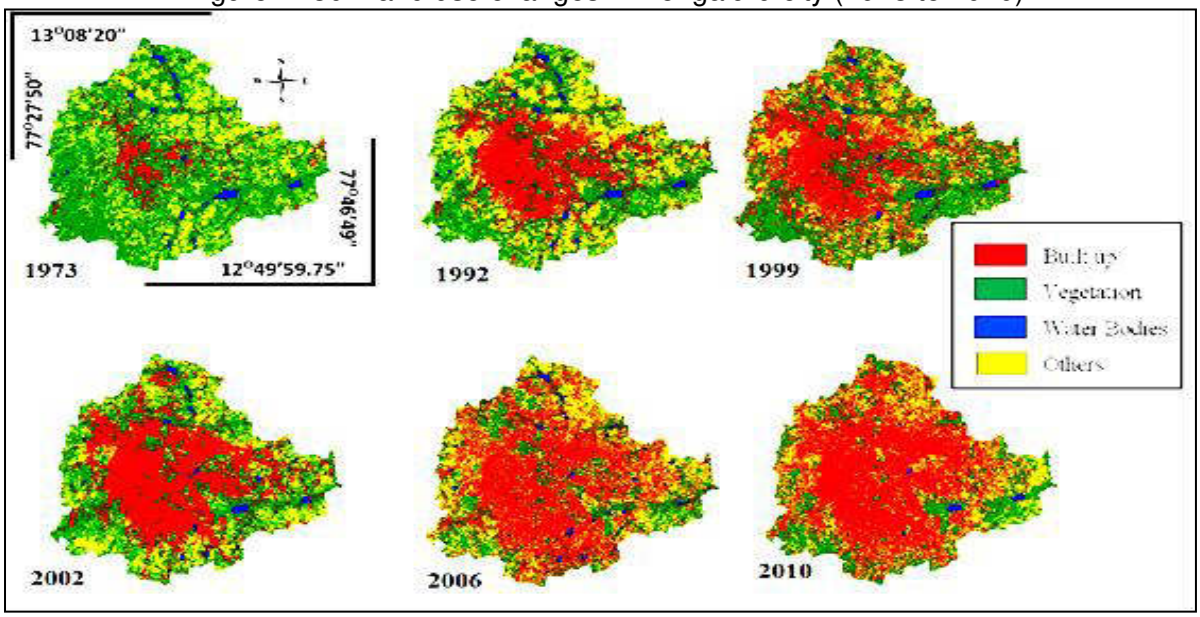


Figure 4- 30: Land use changes in Bengaluru city (1973 to 2010)[6]



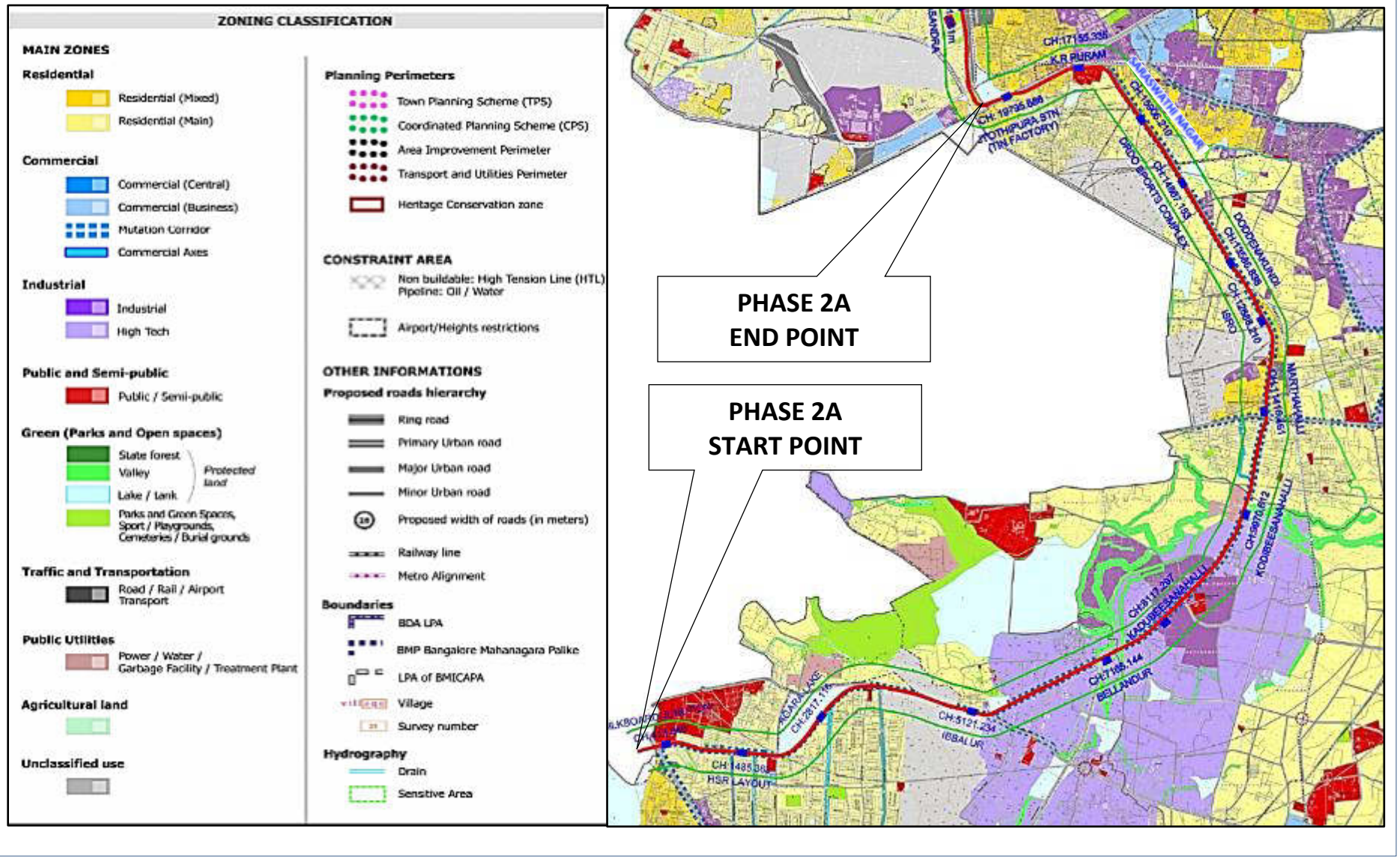
173. The land use map along the proposed Phase 2A metro alignment is presented in Figure 4-32 and the details of land use classes are given in Table 4-21.

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

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

[6]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.

Figure 4- 31: Landuse adjacent to proposed project corridor



K. Biological Environment

174. Bengaluru has been well known for its green spaces and lakes. In recent years, city has witnessed accelerated and unplanned growth leading to transformation of green lung spaces into a concrete jungle flats and commercial agglomerations. Bengaluru, the Garden City of India has two nationally renowned botanical gardens Cubbon Park which is located at the centre of Bengaluru city at a distance of 6.5 km from the proposed alignment and Lal Bagh which is also located at the centre of Bengaluru city at a distance of 5 km from the proposed alignment. The Cubbon Park was established in the year 1870 by John Meade and has a history of over 100 years. Indigenous and exotic botanical species are found in the park. There are about 68 genera and 96 species with a total of around 6,000 plants/trees. Some of the indigenous species found in the park are Artocarpus species, Cassia fistula, Ficus species, Polyalthias, etc., and exotic species such as Araucaria, Bamboo, Castanospermumm Australe, Grevillea robusta, Millettia, Peltophorum, Schinusmolle, Swieteniamahagoni, Tabebuia species, etc. Lalbagh, is a botanical garden and has been a treasure house of plants. The rich floral wealth of Lalbagh extends over an area of 97 hectares (240 acres) accommodating 1,854 species 673 genera and 890 cultivars of plants. It is also home to numerous wild species of birds and other wildlife.

175. In 1982, a Forest Division was created under the name Bengaluru Green Belt Division which was entrusted with the job of greening of Bengaluru Metropolitan Region. Later on, the same has been enlarged to cover the Bengaluru Urban District. The natural vegetation consists of species like Albizzia amara, Albizzia lebbek, Anogiessuslatifolia, Acacia species, Shoreatalura and Santalum album, etc.

176. The geographical area of Bengaluru Urban (Forest) division is 2,17,410 ha. The extent of forestlands within the division is 4,298.43, ha which includes both notified and other Government lands constituting 1.97 % of the geographical area. The forests in the division are of tropical dry deciduous type mostly containing Acacias, Albizzia, Wrightiatinctoria, Zizyphus, Pongamia, etc.

177. As per the Working Plan of Bengaluru Urban forest division, the total area has been divided into five territorial ranges comprising of reserved forests, protected forests and other Government lands. The details of ranges reserved and protected forests, other Government lands and lakes are given in Table 4-22.

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

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

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

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

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

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

180. The following Table 4-23 shows the details of names of the forests and their extent in the jurisdiction of Bengaluru Urban Division.

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

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

Critical Habitats

181. The nearest wildlife sanctuary which is adjacent to Bengaluru Urban District is Banneraghatta National Park. Bannerghatta National Park is notified under the Wildlife (Protection) Act, 1972. It is located at distance of 9 km from the proposed metro alignment. Most of the animals found in these protected areas are also found in the forests of Bengaluru urban division. Wild animals like elephant, wild boar, bear from the sanctuary destroy agricultural crop raised by farmers in and around their habitations. There are also instances of human beings and domestic cattle being killed by wild animals. Often elephants are found migrating from adjacent forests of Banneraghatta National Park.

182. There are no critical habitats except Bannerghatta National Park which is located at a distance of 9.5 km from the proposed project alignment. This national park is peculiarly shaped having a length of 59 km and varying width from 0.3 km to 13.8 km which is mainly due to the impact of urbanization. This park establishes crucial wildlife landscape by connecting the Eastern and Western ghats which mainly support elephant habitat. The State Government has notified the eco-sensitive zones – buffer zones – around this protected space declaring approximately 200 sq km as buffer zone based on the conservation standpoint. Forest Department has taken up barricading, trenches and

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

183. The other key biodiversity areas found within 10 km of the project area is Hoskote Kere which is at a distance of 11.8 km from the proposed project. Other identified habitats like Hesarghatta Lake, Hosur Forest Division, Nandi Hills, Ramanagara Reserve Forest, Thippagondanahalli Reservoir which are within 50 km distance are not key biodiversity areas notified under Wildlife Protection Act, 1972 and are not impacted by the proposed project.

184. With the lack of key biodiversity areas close to the project site, with only water bodies that vary in quality due to the inflow of sewage and pollution, it is unlikely that the project will have any significant impact on key flora and fauna.

L. Social Economic Environment

185. Bengaluru had population of 9,621,551 as per 2011 Census, of which male and female were 52.20 % and 47.80 % respectively. In contrast, as per 2001 Census, Bengaluru had a population of 6,537,124 of which males were 52.42 % and remaining 47.58 % were females. The Census data shows that population density of 4,381 people per sq. km in 2011 in the district as against 2,985 people per sq. km in 2001.

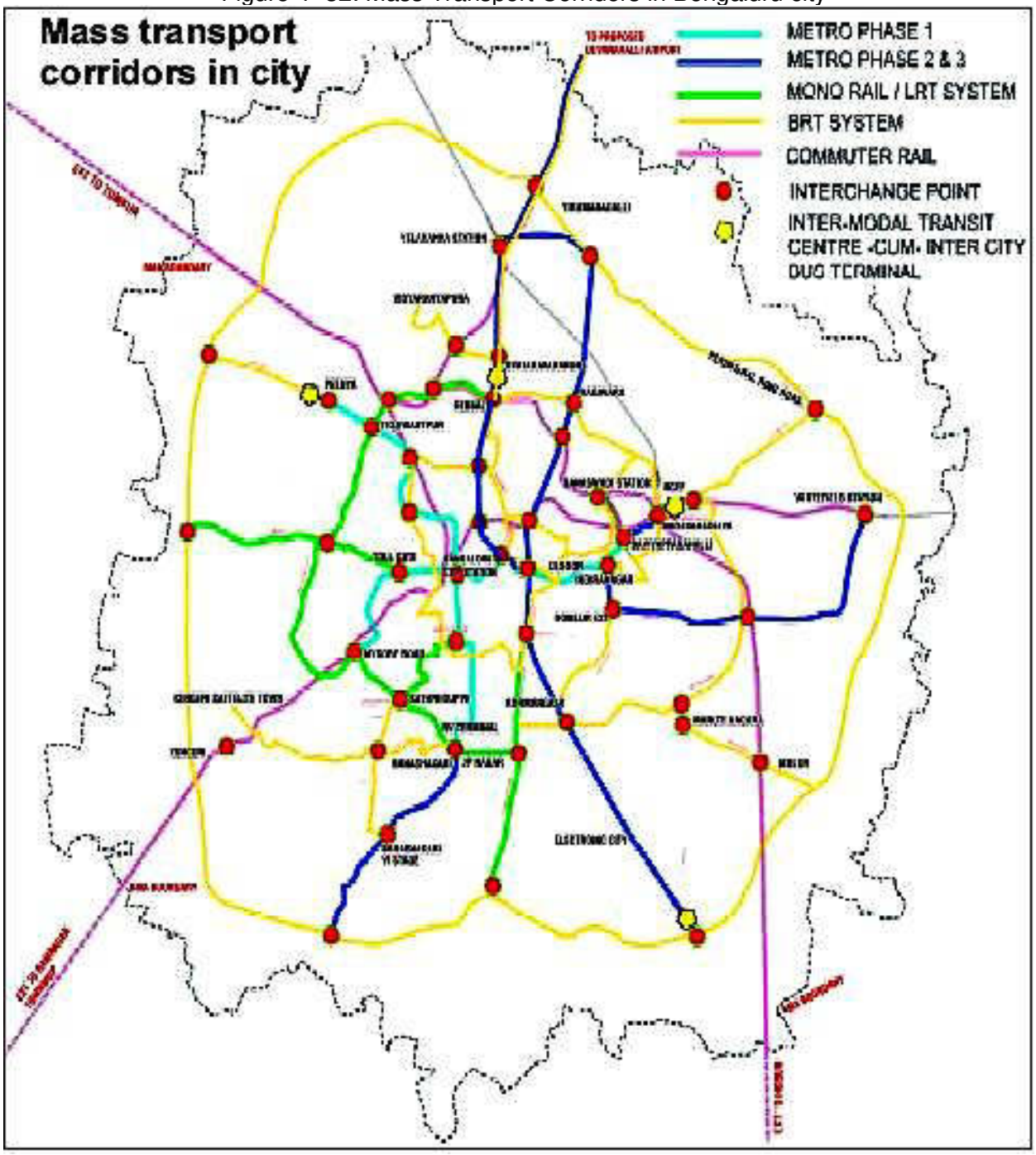
186. Average literacy rate of Bengaluru in 2011 were 87.67 compared to 82.96 of 2001. Gender wise, male and female literacy were 91.01 and 84.01 respectively. For 2001 census, same figures stood at 87.92 and 77.48 in Bengaluru District.[7]

187. Infrastructure: Annual average power consumption by Bengaluru district is about 14,225 MU and 28% of it is industrial requirement and 33% is for domestic consumption. Power transmission in the district is provided by Bengaluru Electricity Supply Company Limited (BESCOM).At present BWSSB is supplying treated Cauvery Water to Bengaluru City under the Cauvery Water Supply Scheme, Stage I, II, III and Stage IV Phase I and II with total installed capacity of 1,440 MLD as against the current city's demand of 1,575 MLD. Water is sourced from Arkavathi and Cauvery Rivers for drinking purpose. The quantity of water provided to the core areas of BBMP including city municipal councils and town municipal council area, covering a total area of 575 sq.km. BWSSB is finding it difficult to meet the water requirements even after implementation of CWSS Stage IV, Phase II scheme. Considering the water demand, Stage V Scheme has been proposed for implementation in two Phases i.e., Phase I of 500 MLD capacity and Phase II of 275 MLD capacity.[8] Bengaluru Urban has 46 water tanks of various capacities serving the irrigation needs and has 52 reservoirs and 118 ground level reservoirs.

188. Bengaluru district has a total national highway length of 147 km. NH44 and NH 75 passes through the district. The district has a total railway route of 148.32 km. KIA is the fourth busiest airport in India. Bengaluru Metro (Namma Metro) – Mass Rapid Transit System extends for a total length of 137 km under different phases of execution (Figure 4-32).

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

Figure 4- 32: Mass Transport Corridors in Bengaluru city



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

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

190. **Agriculture** - Bengaluru has 14.09% of its land for cultivation. Amongst this, cereals and pulses occupy 66.36% and 9.94% of the land respectively. Bengaluru is best known for ragi, especially in Anekal Taluk which is called 'Ragi Bowl' in the State. Bengaluru Urban is recognized as Class A destination for floriculture projects. Major crops grown are paddy, ragi, maize, horse gram and oilseeds along with horticultural crops like banana, grapes, papaya, mango sapota, pomegranate and plantation crops like coconut and rose. The district also has 649 milk co-operatives that annually produce 119 Million liters of milk, 34.7 million Eggs, and 5,880 tonnes of meat.

191. **Business and Industries** - Bengaluru Urban district is a vital business hub with 315 large scale industries with an investment of INR 147.9249 billion, 211 medium scale industries with an investment of INR 134.233 billion and 74,282 small-scale industries with a massive investment of INR 412.13 billion. The district has 16 odd industrial areas and Peenya has the largest industrial cluster in Asia. Thirteen industrial estates and 14 notified operational SEZ in Bengaluru forms the framework to the rich industrial landscape in the region.

192. The district is India's highest IT-related exporter with 35% of the 1 million IT pool of India employed here. Bengaluru has India's largest bio-cluster with 40% of India's biotechnology companies present here. It houses 137 of 340 units in India at Electronic city. Bengaluru also anchors aerospace industries in India. Bengaluru is the headquarters of ISRO and DRDO, and many internationally renowned institutions like HAL, DRDO, ISRO, ADA, NAL, IISC, and Antrix Corporation. Also, 4 out of 9 RD Centres of HAL and DRDO's 5 Aeronautic Centres are in Bengaluru.

193. Bengaluru city hosts number of autonomous institutions with high calibre medical professionals, such as National Institute of Mental Health and Neuroscience (NIMHANS) and the Jayadeva Institute of Cardiology. Further, a huge private sector caters to the health needs of the population. Bengaluru is a hub for medical tourism, with super-specialty hospitals boasting state-of-the-art treatment facilities.

194. The land acquisition and resettlement for the proposed line will affect private assets, mainly land and structures which are being acquired by BMRCL following the Karnataka Industrial Area Development Act, 1966. Line 2A will entail impacts on 108 households comprised of 46 titled-owners and 62 tenants. The total land acquisition for the section is 40,403 sqm, of which 21,817 is private land and the rest are government land. Details about land acquisition can be found in the separate Resettlement Plan for the project.

M. Sites of Tourist interest and Environmental significance

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

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

Figure 4- 33: Lal BaghandCubbon Park

Lal Bagh

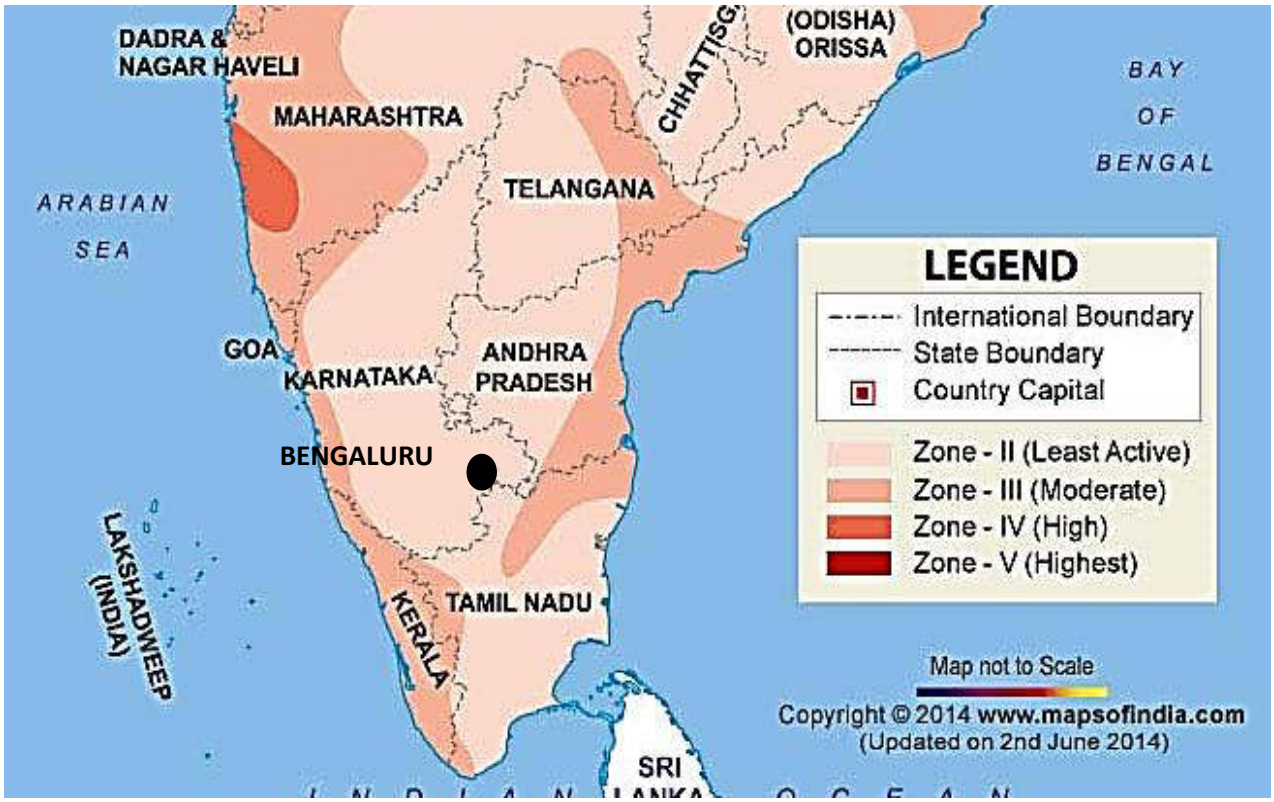
Cubbon Park

N. Seismicity

197. Bengaluru Urban district lies in a seismically stable region, Zone II(Figure 4-34). Bengaluru has been untouched by major seismic events with only mild tremors recorded in the past. The Indian Peninsular region which was once considered to be seismically stable is experiencing many earthquakes recently. As a part of micro-zonation programme, Department of Science and Technology, GOI has carried out seismic hazard analysis of Bengaluru region considering the regional seismo-tectonic activity based on faults, lineaments, shear zones and historic earthquake events of more than 150 events in about 350 km radius around Bengaluru city. About 21 numbers of faults and lineaments are identified as vulnerable sources as a first step. The vulnerable source for Bengaluru city is identified as Mandya – Channapatna – Bengaluru lineament (Figure 4-35) with an earthquake moment magnitude of 5.1[10].

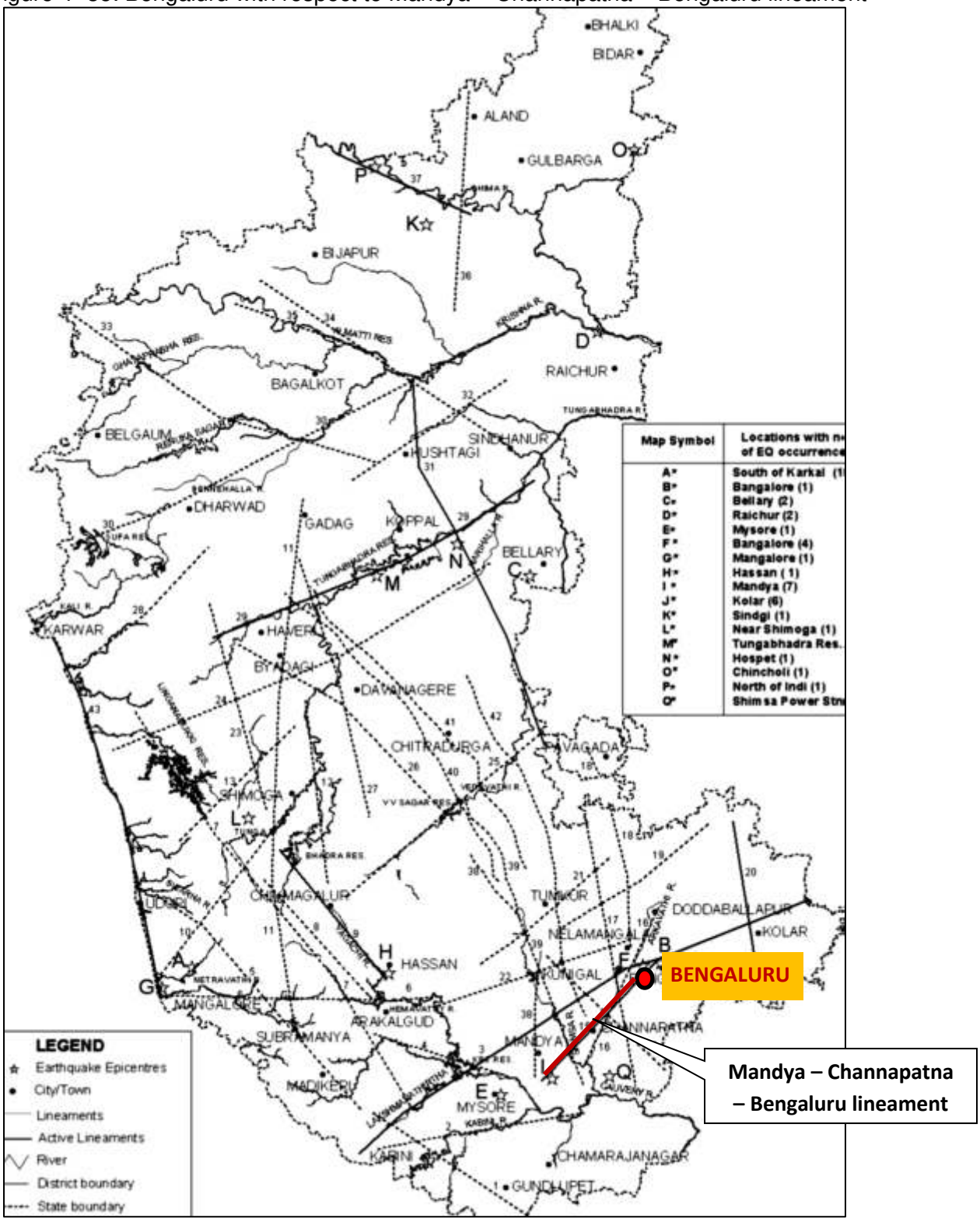
[10]http://civil.iisc.ernet.in/~microzonation/index_files/NCW-5.pdf

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



Source: www.mapsofindia.com

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



V. ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

A. Methodology

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

i. Identification of environmental components

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

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

ii. Type of impact on the VECs

200. The type of impact can be described as:

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

iii. Area of impact assessment

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

iv. Significance of impacts

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

v. Screening of impacts

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

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

Table 5- 3: Screening of environmental impacts

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

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

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

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

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

: positive impact : minor negative impact : moderate negative impact : major negative impact