# Environmental Impact Assessment

February 2022

# India: Chennai Metro Rail Investment Project

Corridor 3

# Main Report

Prepared by the Department of Planning, Development and Special Initiatives, Government of Tamil Nadu, acting through the Chennai Metro Rail Limited (CMRL) for the Asian Development Bank.

## CURRENCY EQUIVALENTS
(as of 15 February 2022)

| Currency unit | – | Indian rupees (₹) |
|---|---|---|
| ₹1.00 | = | $0.0132 |
| $1.00 | = | ₹75.618 |

## ABBREVIATIONS

| | | |
|---|---|---|
| ADB | : | Asian Development Bank |
| AIIB | : | Asian Infrastructure Investment Bank |
| CBTC | : | Communication based Train Control |
| CGWB | : | Central Ground Water Board |
| C&D | : | construction and demolition |
| CMA | : | Chennai Metropolitan Area |
| CMDA | : | Chennai Metropolitan Development Authority |
| CMRL | : | Chennai Metro Rail Limited |
| CPCB | : | Central Pollution Control Board |
| CMP | : | Comprehensive Mobility Plan |
| CMFRI | : | Central Institute of Mining and Fuel Research |
| CRZ | : | Coastal Regulatory Zone |
| EHS | : | Environmental, Health, and Safety |
| EIA | : | Environmental Impact Assessment |
| EMP | : | Environmental Management Plan |
| EMoP | : | Environmental Monitoring Plan |
| ESF | : | Environment and Social Framework |
| ESP | : | Environment and Social Policy |
| ESHS | : | Environment, Social, Health and Safety |
| FTA | : | Federal Transit Administration |
| GoI | : | Government of India |
| GoTN | : | Government of Tamil Nadu |
| GC | : | General Consultants |
| GRM | : | Grievance Redress Mechanism |
| IMD | : | India Meteorological Department |
| JICA | : | Japan International Cooperation Agency |
| KLD | : | Kilo Litres Per Day |
| MoEF&CC | : | Ministry of Environment, Forests and Climate Change |
| MDBs | : | Multilateral Development Banks |
| MRTS | : | Mass Rapid Transit System |
| NDB | : | New Development Bank |
| NAAQS | : | National Ambient Air Quality Standards |
| NBWL | : | National Board of Wildlife |
| NGT | : | National Green Tribunal |
| PAP | : | Project Affected Persons |
| RDSO | : | Railway Design & Standards Organisation |
| RAP | : | Resettlement Action Plan |
| SIPCOT | : | State Industries Promotion Corporation of Tamil Nadu |

| | | |
|---|---|---|
| SPV | : | Special Purpose Vehicle |
| SIA | : | Social Impact Assessment |
| TNCZMA | : | Tamil Nadu Coastal Zone Management Authority |
| TBM | : | Tunnel Boring Machine |
| TNPCB | : | Tamil Nadu Pollution Control Board |
| WHO | : | World Health Organization |

## WEIGHTS AND MEASURES

| | | |
|---|---|---|
| $^0$C | - | degree Celsius |
| dB(A) | - | decibel acoustic |
| ha | - | hectare |
| km | - | kilometer |
| km/h | - | kilometer per hour |
| kWe | - | kilowatt-electric |
| kV | - | Kilo volt(s) |
| kVA | - | kilo Volt-Amps |
| kW | - | kilowatt |
| m | - | meter |
| mm | - | millimeter |
| MLD | - | Million liter per day |
| MVA | - | Megavolt Ampere |
| MW | - | Megawatt |
| $m^3$ | - | cubic meter |
| $m^3$/hr | - | cubic meters per hour |
| mg/l | - | milligrams per liter |
| m/s | - | meters per second |
| MTPA | - | metric tons per annum |
| MW | - | megawatt |
| ppm | - | parts per million |
| ppt | - | parts per thousand |
| rpm | - | revolutions per minute |
| µg/$m^3$ | - | microgram per cubic meter |

## NOTES

(i) The fiscal year (FY) of the Government of India ends on 31 March. FY before a calendar year denotes the year in which the fiscal year ends, e.g., FY2021 ends on 31 March 2021.

(ii) In this report, "$" refers to US dollars

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## EXECUTIVE SUMMARY

1. Chennai, the capital city of the state of Tamil Nadu, is part of the Chennai Metropolitan Area (CMA) that is home to over 8 million people and plays a vital role in the economy of South India.[1] Like other metropolitan areas in the country, CMA is currently facing the challenges of accelerated urbanization growth that have considerably strained the area's transportation system. The increase in economic activities has boosted the regional economy and job creation, which in turn necessitates improvement in ease of travel and connectivity.

2. Chennai Metro Rail Limited (CMRL), a joint venture of the Government of India (GoI) and the Government of Tamil Nadu (GoTN) with equal equity ownership, is responsible for implementing, operating, and maintaining the city's metro system. CMRL developed the Comprehensive Mobility Plan for CMA in 2015 and identified three corridors (corridors 3, 4, and 5) for the second phase of the Chennai Metro Rail to alleviate CMA's transportation capacity constraints.

3. GoI requested the Multilateral Development Banks[2] (MDBs) to assist in the construction of SIPCOT depot and line and 10.1 km of line 3 after Sholinganallur station upto entry to SIPCOT stabling including 9 stations. This line is southernmost section of Chennai metro corridor 3 and will be referred to as MDB line 3 in this report. Sholinganallur station forms part of balance Corridor 3 from Madhavaram to Sholinganallur which is being implemented by JICA. This alignment has been finalized after examining alternatives. The total capital cost of MDB Corridor 3, excluding SIPCOT depot, is estimated to cost USD 290 million at 2018 prices. The project will be implemented from July 2021 to September 2025 in synchronisation with MDB Corridor 5. CMRL will take full responsibility of the implementation of MDB Corridor 3.

4. As per provisions of the EIA Notification 2006 and its subsequent amendments by the Ministry of Environment, Forests and Climate Change (MoEF&CC), Metro Rail Projects are exempted from requirements of prior environmental clearance.

5. This Environmental Impact Assessment (EIA) comprising baseline data on existing conditions of physical, ambient and ecological environment, together with the identified and anticipated environmental impacts and proposed mitigation measures, has been prepared in accordance with GoI's legislative framework and MDBs' environmental safeguard policies[3]. This MDB Corridor 3 will be financed by ADB.

6. Balance Corridor 3 from Madhavaram to Sholinganallur via Adyar which is being financed by JICA constitutes one of the Associated Facilities to MDB Corridor 3: the other Associated Facilities which are required for passenger trips forecast on MDB Corridor 3 to materialize are a) MDB Corridor 5 b) Phase 1 under operation, c) Phase 1A under construction d) MRTS and suburban railway.

7. Overall, Corridor 3 is expected to generate environmental and socio-economic benefits in terms of decreasing air pollution from traffic congestion and serving the growing travel demand. Category A was assigned to MDB Corridor 3 due to the significant impacts anticipated during construction.

8. MDB Corridor 3 consists of 9 elevated stations from Sholinganallur Lake to SIPCOT 2. Standard Gauge (1435mm) will be adopted with a minimum track center distance of 4000 mm,

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[1] Indian National Census, The Census Organization of India, 2011.

[2] Asian Development Bank (ADB), Asian Infrastructure Investment Bank (AIIB) and New Development Bank (NDB).

[3] ADB's Safeguard Policy Statement (SPS) 2009, AIIB's Environmental and Social Framework (ESF), and NDB's Environmental and Social Framework (ESF).

16-ton maximum axle load capacity and a design speed of 80 kmph. The viaduct is 2-level so as to accommodate space for a future elevated road at lower level and metro at the higher level. Implementing Agency for elevated road will be different from CMRL, timeline for construction of elevated road is not decided. Elevated metro is generally located on the road median 140 m long and 24 m wide. To reduce physical and visual impact of the elevated station, stations have been made transparent with minimum walls on the sides. Signaling system will be adopted for MDB Corridor 3 in line with balance length of Corridor 3. Rolling stock is of light weight stainless steel/aluminum body for energy efficiency. Universal accessibility has been reflected in the design following international best practices. Green building features like rainwater harvesting, solar energy panels at elevated stations' roofs, will be considered in station design.

9. The terrain along MDB Corridor 3 alignment is mostly flat. The soil along the alignment is rock overlaid by sandy soil. Corridor 3 alignment is located neither within an existing nor any proposed ecological sensitive zone known for providing habitat and movement corridor for any kind of wildlife. 164 trees are likely to be felled along the corridor.

10. Despite the seemingly abundant sources of water, Chennai suffers continuously from water stress since the entire basin is dependent on rainfall. Groundwater quality parameters are well within the prescribed permissible limits as per the Bureau of Indian Standards except for chlorides and coliforms. The water quality at Sholinganallur Lake meet the criteria for propagation of wildlife and fisheries.

11. Results of the air monitoring at 3 locations showed that all parameters were within the permissible level of National Ambient Air Quality Standards (NAAQS). However Particulate Matter exceeded WHO guideline.

12. The noise level monitored at 1 of the 6 receptors along the alignment was above the national and international permissible daytime limits. From initial noise modeling it is expected that noise barriers can mitigate construction noise. During operation a 3 meter high noise barrier would reduce operational noise to acceptable levels at impacted sensitive receptors. The noise modeling report also suggests noise barriers to be put in place near curves in the alignment and at station locations.

13. Peak VdB vibration level at 3 out of 4 monitored locations is found to exceed acceptable human annoyance impact criteria for ground borne vibration prescribed by the Federal Transit Administration (FTA) USA. However the observed levels at all 4 locations are well below the construction vibration damage criteria as per Caltrans and the Directorate General of Mines Safety (DGMS).

14. Initial vibration modeling shows that for the elevated section of corridor 3, masonry building structures within a maximum distance of 29 m will be affected if 80 kmph design speed is considered. A full baseline will be collected prior to contractor's mobilization to elaborate the current baseline.

15. Based on analysis of project and environmental settings, a detailed assessment of potential impacts due project location and design, construction and operation has been carried out. For each of these adverse impacts, mitigation measures have been proposed. The key positive environmental impacts include reduced use of private vehicle leading to reduction in pollutants and a modest reduction in greenhouse gas emissions; road safety improvements and increased accessibility and mobility,. The main negative impacts of MDB Corridor 3 include fugitive and point source dust emission, surface noise from excavation, construction and demolition, disposal of large quantities of construction wastes, and occupation and community health and safety, which are mainly temporary and localized.

16. The main mitigation measures proposed are as follows: (i) to plant twelve saplings for each tree to be cut as against ten saplings ordered for infrastructure projects by the Honorable Madras High Court, with estimated compensatory afforestation cost in place accordingly; (ii) noise reduction measures (i.e. noise barriers at sensitive receptor locations); and (iii) reuse of excavated material where feasible and disposal of construction waste in a regulated manner; and (iv) design features, equipment and procedures for increased public and occupational health and safety. MDB Corridor 3 will take into consideration the climate change effects of an anticipated continuous increase in ambient temperature, intensity of cyclones and storm surge, heavy precipitation events, and sea level rise in the future. Climate change considerations to be integrated into MDB Corridor 3 design include: (i) using solar panels on station buildings and roofs to reduce the extensive use of grid-generated electricity supplied to the station for its operation and maintenance; and (ii) through better station roof design of stations, providing for rainwater harvesting by channeling rainwater through gutters and pipes to either harvesting pits in the ground or to recharge groundwater.

17. Various alternatives such as modes of transport, alignment, proposed design etc. have been considered and analyzed for its likely impacts on various environmental parameters. Additionally, an evaluation of potential environmental impacts in terms of ‘with’ and ‘without’ project situation has been considered for the justification of MDB Corridor 3.

18. Meaningful public consultations were carried out with communities on the alignment during EIA preparation and will continue before start of implementation of MDB Corridor 3 and throughout its implementation. Public consultations highlighted opinions of participants on benefits of Metro in terms of reducing congestion on roads. Individual consultation of PAPs will also be carried out during implementation. Information disclosure will follow the procedure for MDBs’ Category A projects.

19. Grievance Redress Mechanism (GRM) has been proposed for Corridor 4 that comprises the procedures to address grievances i) first at the Project Implementation Unit (PIU) level, ii) second at Grievance Redress Committee for Environment (GRC-E), to ensure grievances from PAPs and workers are addressed to facilitate timely project implementation. A GRC-E will be formed which will have representatives from Contractor, General Consultant (GC), CMRL, assisting NGO and PAPs and representatives. Unsatisfied PAPs will have the option to escalate the grievances from PIU level to GRC at any point of time and the GRC will not bar them from approaching a Court of Law.

20. An Environmental Management Plan (EMP) with institutional arrangements, budgetary provisions, schedule for EMP implementation and its monitoring has been prepared, including appropriate mitigation measures, provisions related to occupational health and safety, labour camp and construction site management, and traffic and public utility management etc. to address all impacts during Project pre-construction, construction and operation phases. The EMP has been developed in conjunction with general safety, health and environment provisions (which are included in the standard bidding document) and it forms part of the contract document of the contractors. Semi-annually monitoring reports will be prepared by GC and submitted to MDBs through CMRL. A third-party monitor will also monitor work independently and submit reports to CMRL and MDBs. The preliminary estimated cost of the EMP including implementation and monitoring is USD 1.496 million (INR 109.5 million). This cost estimate is exclusive of land acquisition and resettlement & rehabilitation cost.

21. Benefits far outweigh negative impacts. Overall, the major social and environmental impacts associated with MDB Corridor 3 are limited to the construction period and can be mitigated to an acceptable level by implementation of recommended measures and by best engineering and environmental practices. In addition, stringent monitoring requirements and

actions have been included in the Environmental Monitoring Plan (EMoP) on noise and vibration levels that will be generated during construction. CMRL will ensure that the EMP and EMoP are included in Bill of Quantity and forms part of bid document and civil works contract. The same will be revised if necessary, during project implementation or if there is any change in the project design and with approval of MDBs.

22. This EIA report is structured as following: (i) Introduction of background, methodology of preparation of the report; (ii) Policy and legal framework within which environmental safeguards will be recommended and implemented; (iii) Project description with enumeration of salient features of MDB Corridor 3 which have bearing upon its environmental impacts; (iv) Environmental baseline of MDB Corridor 3 in terms of physical, ambient, and ecological baseline (socioeconomic baseline will be presented in Social Impact Assessment Report); (v) Identification of negative and positive impacts arising from pre-construction, construction and operation and respective measures to mitigate negative impacts and where feasible enhance generate positive impacts; (vi) Analysis of alternatives including its need and alternatives of technology and alignment; (vii) Consultations with stakeholders and plan for disclosure of project information; (viii) Mechanism for stakeholders to communicate grievances and suggestions and for their Redressal; (ix) EMP and institutional arrangement for implementation of environmental impact mitigation measures; and (x) Conclusion.

# 1. INTRODUCTION

## 1.1 Background

1. Chennai Metropolitan Area (CMA) comprises the city of Chennai, 8 Municipalities, 11 Town Panchayats and 179 Village Panchayats in 10 Panchayat Unions. The extent of CMA is 1189 sq.km. The CMA falls in three Districts of Tamil Nadu viz. Chennai District (176 sq.km), part of Thiruvallur District (637 sq.km), and part of Kancheepuram District 376 sq.km). In year 2011, resident population of CMA was 8.0 million.

2. Chennai, the capital city of the state of Tamil Nadu, is part of the Chennai Metropolitan Area (CMA) and plays a vital role in the economy of South India.[1] The Chennai Metropolitan Development Authority (CMDA) devised the Chennai Second Master Plan 2026 and estimated that the population would grow to 12.6 million people with an estimate of daily passenger traffic of 20.8 million in 2026.[2] CMA has emerged as a leading national automotive hub with major manufacturers operating their plants in the area. CMA also houses a growing number of software firms, financial services, and call centers. Like other metropolitan areas in the country, CMA is currently facing the challenges of accelerated urbanization growth that have considerably strained the area's transportation system. The increase in economic activities has boosted the regional economy and job creation, which in turn necessitates improvement in ease of travel and connectivity.

3. The existing transportation system in CMA is marked by high traffic density, carbon emissions, and frequent road incidents. In addition to the high volume of vehicles and already congested roads, inadequate parking space and the encroachment of street space by vendors on major road have exacerbated the traffic congestion. Major roads along the proposed project alignments are forecast to function beyond respective design service volume in year 2035 in absence of the project lines. The accelerating use of private vehicles has put Chennai in the fifth rank in carbon emission from the transport sector among 54 South Asian cities.[3]

4. Inadequate transportation infrastructure and poor service have resulted in an unfavorable decrease in the share of public transport from 54 percent in 1970 to 28 percent in 2014.[4] The Comprehensive Mobility Plan 2018 for CMA identified projects so as to increase public transport share in person trips by motorized vehicular modes in year 2035 to 60% compared to 44% in year 2015 ie., 41% of trips by all modes in year 2035 compared to 30% in 2015.The mass transit transportation, especially an integrated metro system will be essential to achieve this intended split.

5. The city has two mainline railway terminals. Urban Mass Rapid Transit System (MRTS) of 19.35 km from Chennai Beach to Velachery is in operation, land acquisition for balance MRTS section from Velachery to St Thomas Mount is in process. Chennai Metro Phase 1 of 45 km is in operation, work on extension to Thiruvottiyur is in progress. Chennai suburban railway network supplements MRTS. Schematic diagram of urban mass rapid transit network is in Figure 1.1.

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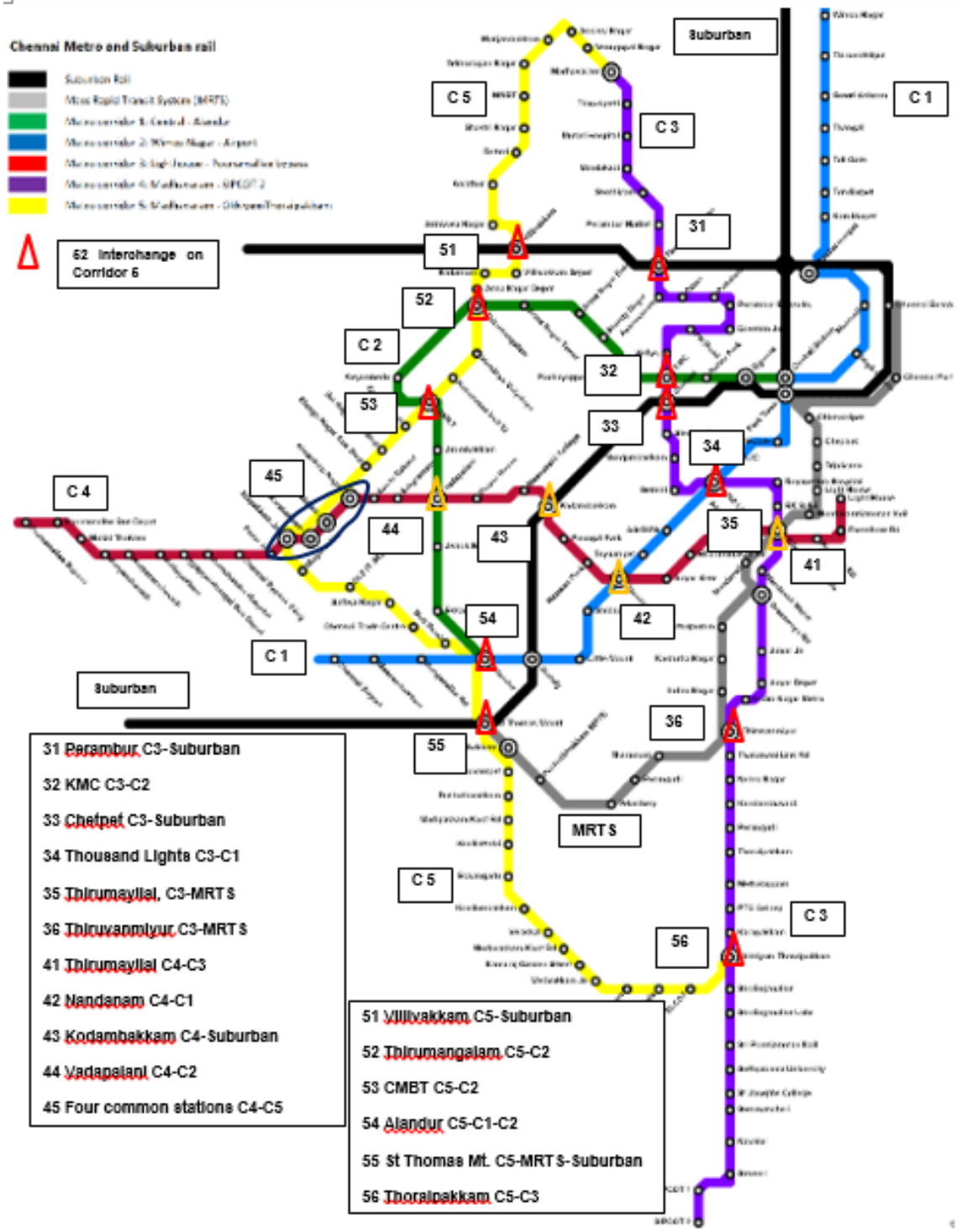
[1] Indian National Census, The Census Organization of India, 2011.

[2] Second Master Plan for Chennai Metropolitan Area 2026, Chennai Metropolitan Development Authority, 2008.

[3] International Council for Local Environmental Initiative Study, 2012.

[4] Comprehensive Detailed Project Report for Chennai Metro Phase-II, Chennai Metro Rail Limited, 2018.

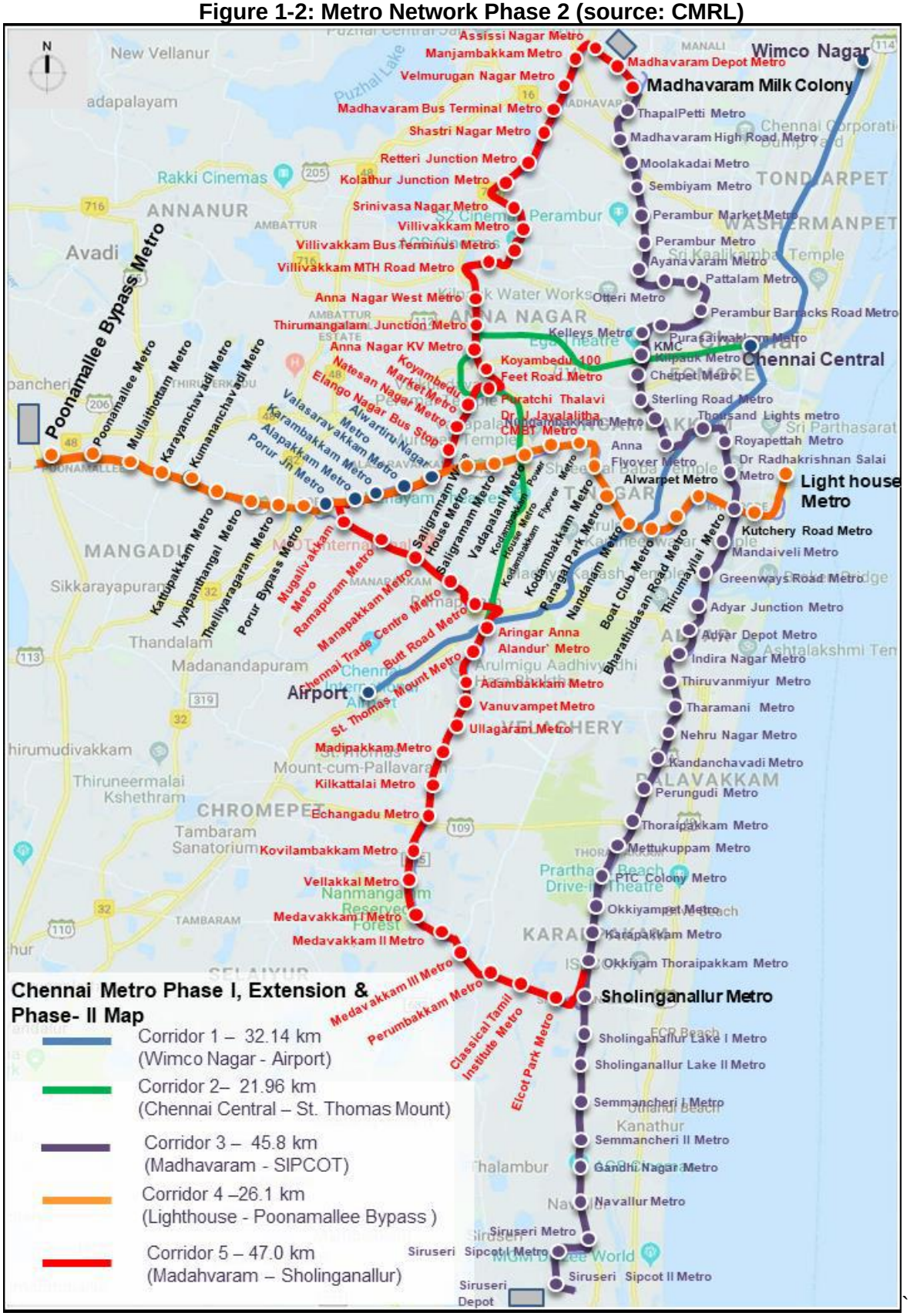
**Figure 1-1: Rail Transport Network in Chennai**




### 1.1.1 Chennai Metro Network

6. **Phase 1** of Chennai metro as shown in Figure 1.2 covers 54.05 km in two corridors - Washermanpet to Airport (23.09 Km), Chennai Central to St. Thomas Mount (21.96 Km) via Koyambedu and extension from Washermanpet to Wimco Nagar (9.00 km) in Thiruvottiyur. As on February 2020, Phase 1 excluding the extension from Washermanpet to Thiruvottiyur is in commercial operation. **Phase 2** includes **Corridor 3, 4 and 5** as shown in Figure 1.2.

**Figure 1-2: Metro Network Phase 2 (source: CMRL)**




*Note: In DPR 2018 the stations Sholinganallur Lake II and Semmancheri I are named Sri Ponniaman Temple and Sathyabama University respectively.*

7. This EIA covers **corridor 3** of phase II of Chennai Metro**.** Corridor 3 runs from Madhavaram in the north to SIPCOT in the south, length of the corridor is 45.813 km comprising 30 underground stations and 20 elevated stations. It provides interchange with Corridor 4 and Corridor 5. It offers interchange with Phase I Metro and MRTS and connects with suburban railway system.

8. The 35.044 km long section from Madhavaram depot to Sholinganallur station via Adyar runs on the Eastern periphery of the city: it is being funded by JICA. This section comprises 30 underground stations and 10 elevated stations. Viaduct and stations 9.627 km long from Sholinganallur to SIPCOT is being financed by ADB; civil construction is scheduled to be commenced by July 2021 and completed by July 2024. Systems works are scheduled to be completed and metro commissioned by November 2025.

9. Corridor 4 and corridor 5 of phase II are covered in separate EIAs, further details on those corridors can be found in the respective documents**.**

### 1.1.2 Nature, Size and Location of MDB Corridor 3

10. MDB Corridor 3 is the 9.627 km line after Sholinganallur station up to SIPCOT 2 station including 9 stations (see figure 1-2). This line forms part of Chennai metro composite Corridor 3. Sholinganallur station forms part of balance Corridor 3 which is being implemented by JICA. The section is proposed for financing by ADB.

11. The Government of Tamil Nadu (GoTN) has created a Special Purpose Vehicle (SPV) for implementing the Chennai Metro Rail Project. This SPV named as “Chennai Metro Rail Limited (CMRL)” was incorporated on 03.12.2007 under the Companies Act. It has now been converted into a Joint Venture of Government of India (GoI) and GoTN with equal equity holding. CMRL as the implementing agency, will be responsible for implementing, operating, and maintaining the city’s metro system. CMRL developed the Comprehensive Mobility Plan for CMA in 2015 to identify the present and future mobility patterns of CMA. The detailed study identified three corridors (corridors 3, 4, and 5) for the second phase of the Chennai Metro Rail to alleviate CMA’s transportation capacity constraints.

## 1.2 Environmental Impact Assessment

### 1.2.1 Categorization

12. The environmental screening has been carried out for MDB Corridor 3 as per MDBs’ policies. Based on preliminary assessment of significance of impacts borne out of field visits and secondary information, MDB Corridor 3 is not expected to have significant adverse impacts other than comprising aesthetics, noise, vibration and likely submergence/degradation of belt of width 5km to 10km of developed area from Thoraipakkam to Siruseri due to climate change. The proposed project will bring in many benefits to the project area.

13. Civil works of MDB corridor 3 will entail construction of viaducts and elevated stations. Construction will take place along existing road corridors in a busy urban area. The civil works may increase congestion and pose safety risks for traffic on the existing roads. Transport of large quantities of construction material and heavy equipment machinery may bring safety risks and inconvenience to the local communities in the project area. Large numbers of construction workers may need to be brought in from other states of India posing health and communicable disease risks. Due to the significant environmental risks described above, the project is categorized as category “A” for environment safeguards.

14. 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 MDB corridor

3 of the metro project is not required to secure prior 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. However on precedent set by Ministry of Environment, Forests and Climate Change, Govt of India prior Environment Clearance will be required for commercial development equal to or above threshold of 20,000 sq.m which is proposed as part of the metro project.

15. **Summary of impacts on JICA project from Madhavaram Milk Colony to Sholinganallur via Adyar of Corridor 3.** At baseline locations air quality was well within upper limits except for CO; daytime noise was found to be exceeding CPCB limits by significant margin; certain quality parameters for drinking water were more than acceptable but less than permissible limit. 212 trees excluding SIPCOT depot will be felled or transplanted; no archaeological or heritage assets will be impacted; projected noise level near alignment during construction will be more than Noise Standards, projected noise level during operation will be marginally higher than baseline; flooding due to climate change between Thoraipakkam and Siruseri, The alignment is located within 10 km from the Guindy National Park and so activities relevant to the project will be regulated. the double elevated section from Nehrunagar to Sholinganallur will impact avifauna during construction and operation of the metro. This section will also adversely impact aesthetics.

### 1.2.2 Purpose of the EIA Report

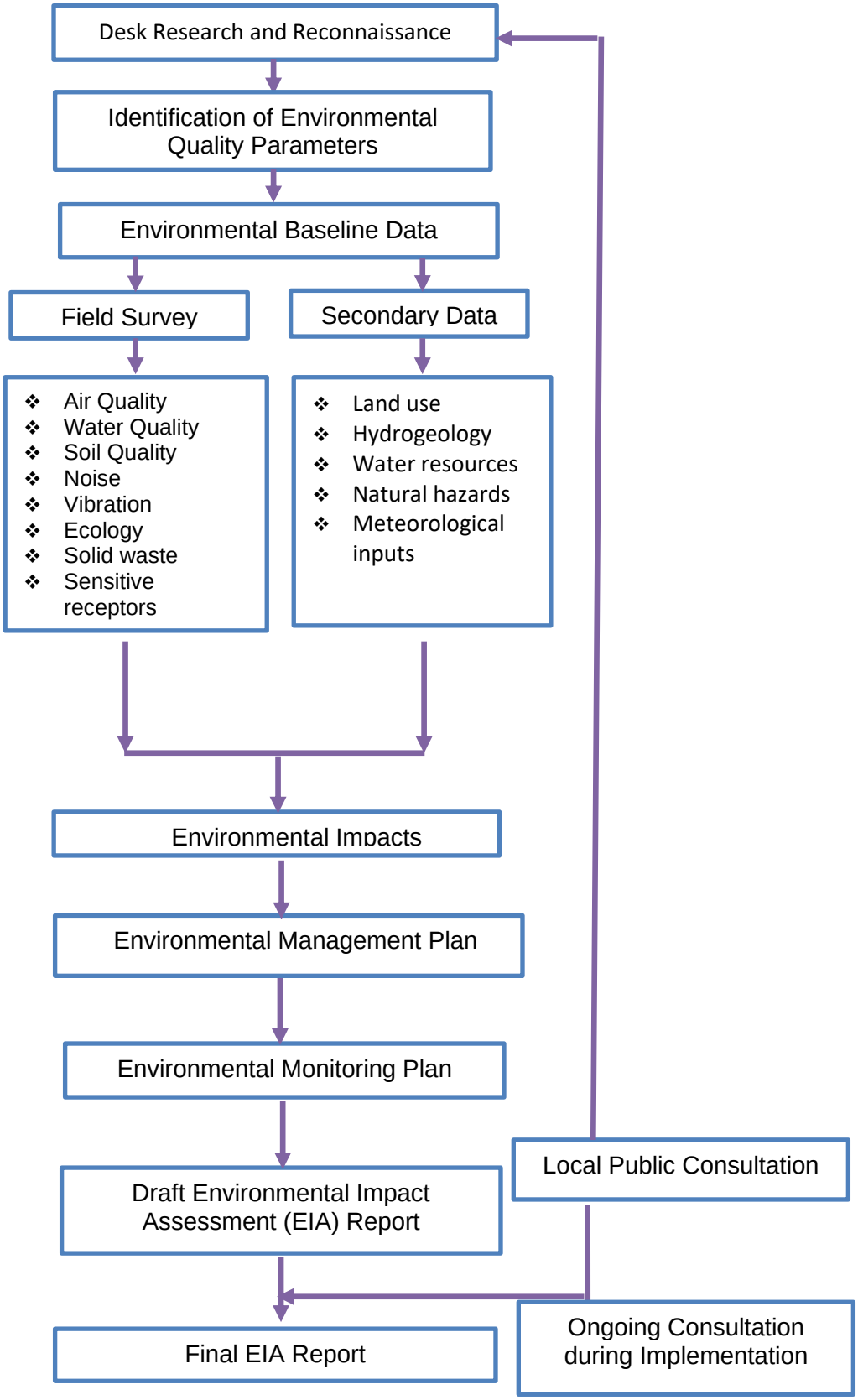
16. This EIA report documents the environmental assessment of MDB Corridor 3. In this report, the different activities that are likely to take place during construction and operation, have been analyzed and the potential impacts that may accompany them have been discussed. The EIA addresses the environmental management requirements of GoI and the MDBs. In general, the EIA Report is outlined as below to address various aspects:

- Provide background of the project in terms of land use, existing Metrorail network and the proposed Metrorail corridors, methodology of preparation of the report and its content;
- Analysis of policy and legal framework within which environmental safeguards for the project will be recommended and implemented;
- Provide information about the baseline environmental settings;
- Provide information on potential environmental impacts of MDB Corridor 3 with its magnitude, distribution, and duration;
- Provide information on required mitigation measures with cost to minimize the impacts;
- Analysis of the alternatives considering alternative locations, designs, management approaches, for selection of most feasible and environmental acceptable options;
- Provide details of stakeholders' consultations;
- Plans for stakeholders to communicate grievances and suggestions and for their Redressal; and
- Formulate environmental management and monitoring plan with institutional measures for effective implementation of mitigation measures proposed.

17. Social Impact Assessment (SIA) with a Resettlement Action Plan (RAP) for implementation is presented as a separate Report. MDB Corridor 3 project will require transfer of 0.616 ha government land and acquisition of 0.203 ha private land; commercial premises of 41 families will be impacted by the MDB project of whom only 4 families will be displaced. No Indigenous People are impacted. Involuntary resettlement categorization is Category B as per ADB Environment and Social Framework and Safeguard Policy as the number of Project Affected Persons is less than 200.

### 1.2.3 Approach and Methodology

**Figure 1-3: Methodology of Environmental Impact Assessment**



18. As shown in Figure 1.3, the EIA followed a number of steps:

- Review of available baseline reports, and technical reports/studies related to Corridor 3;
- Conduct field visits to collect primary or secondary data relevant to MDB Corridor 3 areas to establish the baseline;
- Assess the potential impacts on environmental attributes due to the location, design, installation and operation of MDB Corridor 3 through field investigations and data analysis;
- Explore opportunities for environmental enhancement and identify measures;
- Prepare an environment management plan (EMP) outlining the measures for mitigating the impacts identified including the institutional arrangements;
- Identify critical environmental parameters required to be monitored subsequent to the implementation of MDB Corridor 3 and prepare an environmental monitoring plan;
- Carry out consultation with key stakeholders and administrative authorities to identify their perception on Corridor 3, introduce project components and anticipated impacts; and,
- Disclose the draft EIA at CMRL and MDBs' websites and prepare the Executive Summary in local language to be made publicly available.

19. The Baseline data for air, water and soil quality was collected in width 75m on either side of proposed centre line of alignment, and data for noise and vibration in width 200m on either side of alignment. Sensitive receptors located in width 100m on either side of centre line of alignment were identified according to the silence zone defined by the Central Pollution Control Board.

# 2. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

20. India has well defined institutional and legislative framework. The legislation covers all components of environment viz. air, water, soil, terrestrial and aquatic flora and fauna, natural resources, and sensitive habitats. India is also signatory to various international conventions and protocols. The environmental legislations in India are framed to protect the valued environmental components and comply with its commitment to international community under above conventions and protocols. MDBs have also defined its Environmental and Social Policies. This chapter will describe the applicability of above laws and regulations, conventions, protocols, and safeguards.

21. The laws, regulations, policies and guidelines applicable to this project based on the location, design, construction and operation are summarized in the subsequent sections in following order.

- National (India) Environmental Legislation and Legal Administrative Framework,
- ADB, AIIB and NDB environmental and social policies and standards, and
- Summary of international treaties and applicability to the project.

## 2.1. The National (India) Environmental Laws, Policies And Regulations

22. GoI's environmental legal framework comprises a set of comprehensive acts and regulations aimed at conserving various components of the biological and physical environment including environmental assessment procedures and requirements for public consultation.

### 2.1.2 Metro Rail Policy 2017

23. GoI's Union Cabinet approved a new Metro Rail Policy in 2017 that aims to enable the development and implementation of metro projects in a comprehensive and sustainable manner from the social, economic, and environmental perspectives. The Policy improves the integrated management of Metro development in three main aspects, (i) The new policy proposes that every city should setup a Unified Metropolitan Transport Authority for planning and developing multimodal transportation, which enable the overall planning and development of all modes of transport under the strong lead institutions; (ii) The need to carry out an alternative analysis is a welcome addition in the policy to help in better system selection; and (iii) The requirement to look at the 5-km catchment area for providing feeder services through walking, cycling and para-transit modes is promising.

### 2.1.3 Legislations Relevant to the Project

24. The policies and requirements which are most relevant in the context of this Corridor are provided in Table 2.1 below.

**Table 2-1: Summary of All Relevant Environmental Legislation for MDB Corridor 3**

| Legislation | Objective | Responsible Institution |
|---|---|---|
| Environment (Protection) Act (1986) and Rules (1986);<br>National Conservation Strategy and Policy Statement on Environment and Development of 1992;<br>National Environment Policy of 2006 | To protect and improve the overall environment | Ministry of Environment, Forests, and Climate Change (MoEF&CC) |
| Environmental Impact Assessment (EIA) Notification | To provide guidance on environmental clearance | MoEF&CC |

| Legislation | Objective | Responsible Institution |
|---|---|---|
| under Environmental Protection Rules (2006, 2009, 2011) and relevant Office Memorandums (OM) | requirements and clarification on related specific technical issues | |
| The Noise Pollution (Regulation and Control) Rules, 2000 (Amended 2002) | To provide for the prevention and control of noise pollution and for the establishment of Boards to carry out these purposes | Central Pollution Control Board (CPCB) |
| Metro Rail Transit System, Guidelines for Noise and Vibrations, RDSO, Ministry of Railways, September 2015 | To provide for the prevention and control of vibration | NA |
| The Water (Prevention and Control of Pollution) Act 1972 (Amended 1988) and Rules 1974 | To provide for the prevention and control of water pollution and the maintaining or restoring of wholesomeness of water | CPCB |
| The Tamil Nadu Water (Prevention and Control of Pollution) Rules, 1983 amended May 2009 | | State Pollution Control Board (SPCB) |
| Model Groundwater (Control and Regulation) Bill 1970, amended in 1972, 1996 and 2005 | To provide for the prevention, control and abatement of groundwater pollution | Central Ground Water Authority (CGWA) |
| The Air (Prevention and Control of Pollution) Act, 1981(Amended 1987) and Rules 1982 | To provide for the prevention, control and abatement of air pollution, and for the establishment of Boards to carry out these purposes | CPCB and Road Authorities |
| Policy Statement for Abatement of Pollution of 1992 | To provide for the prevention, control and abatement of pollution | CPCB |
| Municipal Solid Waste (MSW) Rules, 2000;<br>Solid Waste Management Rules, 2016 | Provisions for collection, storage segregation, transportation, processing and disposal of municipal solid wastes | SPCB |
| Hazardous and Other Wastes (Management and Transboundary Movement) Amendment Rules 2019 | To protection the general public against improper handling, storage and disposal of hazardous wastes | SPCB |
| Construction and Demolition Waste Management Rules, 2016 | Large generators (who generate more than 20 tons or more in one day or 300 tons per project in a month) will submit waste management plan and get appropriate approvals from the local authority before starting | SPCB |

| Legislation | Objective | Responsible Institution |
|---|---|---|
| | construction or demolition or remodeling work | |
| Guidelines on Environmental Management of Construction and Demolition (C&D) Waste, March 2017 | Hazardous wastes / toxic wastes streams, including asbestos, should be kept separately from other wastes to avoid further contamination, their disposal to be done in consultation with SPCBs/PCCs under HW Management Rules 2016. The concerned authorities shall examine the DEMOLITION PLAN submitted by the applicant to assess if there are any HW streams. | SPCB |
| The Mines and Minerals (Development and Regulation) Act, 1957 | To protect the environment from quarry operation | State Department of Mines and Geology |
| Central Motor Vehicle Act (1988) and Rules (1988) | To control vehicular air and noise pollution. To regulate development of the transport sector, check and control vehicular air and noise pollution | State Transport Department |
| Indian Treasure Trove Act, 1878 (as modified upto September 1949);<br>Ancient Monuments and Archaeological Sites and Remains Act (1958) | Conservation of Cultural and historical remains found in India<br>Chance find during construction | Archaeological Dept. GoI |
| National Policy on HIV/AIDS and the World of Work<br>National Policy on Safety, Health and Environment at Workplace | To regulate the safety, health and environment at workplace | Ministry of Labour and Employment, |
| A. Tamil Nadu Building and Construction Workers (Conditions of Employment and Miscellaneous Provisions) Act, 1984<br>B. The Contract Labour (Regulation & Abolition) Act, 1970<br>C. Employees State Insurance Act, 1948 (ESI);<br>D. Minimum Wages Act, 1948, The Payment of Wages Act, 1936, amended in 2005; | To regulate the employment and conditions of service of building and other construction workers and to provide for their safety, health and welfare measures | Ministry of Labour and Employment |

| Legislation | Objective | Responsible Institution |
|---|---|---|
| E. The Tamil Nadu Labour Welfare Fund Act, 1972<br>F. The Equal Remuneration Act 1976;<br>G. Workmen's Compensation Act, 1923 | | |
| Interstate Migrant Workmen (Regulation of Employment and conditions of Service) Act 1979 | In case workers and labourers working at the project sites are migrants from other states during construction | Ministry of Labour and Employment |
| Child and Adolescent Labour (Prohibition and Regulation) Act, 1986 | To regulate the employment of children including age limits, type of employment, timing of work, information disclosure and health and safety | Ministry of Labour and Employment |
| Schedule – XIV, (Model Factories Rules 120 (MFR 120) under Section 87) | Handling and processing of Asbestos, manufacture of any article of Asbestos and any other process of manufacture or otherwise in which Asbestos is used in any form. | Ministry of Labour & Employment, GOI, Directorate General Factory Advice Service & Labour Institute. |

**2.1.4 Required Clearances/Permissions**

25. Railway is not listed among activities requiring prior Environmental Clearance in Government of India EIA Notification 2006 and therefore environmental clearance for Corridor 3 is not required. However other milestones which need attention in this context are briefly mentioned here.

- In 1992 in case of Konkan Railway Bombay High Court held that Environment Act 1986 had no application in respect of works undertaken under Railway Act 1989.
- In June 2017 ToR was issued for EC for redevelopment of Anand Vihar railway station under section 8b) of Schedule to EIA Notification 2006.
- In March 2016 in case of Nagpur Metro, MoEFCC clarified that construction of building for commercial purposes having built area equal to or more than 20,000 Sq.m will require prior EC from SEIAA and that the project has to comply the norms such as green building features, rain water harvesting, water conservation etc.
- In May 2016 National Green Tribunal (NGT) held that Metro construction from Noida to Greater Noida is a project covered under Entry 8(b) of the Schedule to the Notification of 2006 as per the area of construction and directed project proponent to obtain Environmental Clearance. In September 2016 Supreme Court stayed NGT order which required prior EC for railway and Metro rail projects.
- In February 2015 in case of Signature road bridge in Delhi, NGT held that construction of a ‘bridge’ or similar activity covering a build up area ≥ 1,50,000 Sq.m and/or covering an area of ≥ 50 hectares, would be covered under Entry 8(b) of Schedule to the Regulations of 2006 and ordered project proponent to obtain Environmental Clearance. The Clearance was applied for and subsequently granted in February 2017.

- In October 2016 NGT directed project proponent to obtain Environmental Clearance from the State Environment Impact Assessment Authority (SEIAA) for construction of a six-lane Hindon elevated road connecting NH-24. The NGT held that the road project was covered under Entry 8(b) of the Schedule to Environmental Clearance Regulations 2006. The Clearance was applied for and subsequently granted in October 2018.

26. In light of the above, prior Environmental Clearance is not required for MDB Corridor 3 if commercial development equal to or above threshold of 20,000 sq.m is not proposed. Since decision on timeline to construct elevated road is not available, elevated metro and elevated road will not be constructed as 1 project. CMRL is therefore not required to apply for Environmental Clearance for the composite metrorail-road project. If and when a decision on construction of elevated road becomes available, the concerned Implementing Agency will apply for pertinent clearances.

27. For reasons explained in section 4.4, wildlife clearance need not be sought.

28. Before the start of civil works for any section of Corridor 3, CMRL must obtain necessary clearances/permissions from statutory authorities. For implementation of Corridor 3, required clearances/ permissions related to environment and labour safeguards have been summarized in Table 2.2.

**Table 2-2: Applicable Permissions and Clearances Required for MDB Corridor 3**

| Sl. No. | Permissions/ Clearances | Acts/Rules/Notifications/ Guidelines | Concerned Agency and Timeframe | Responsibility |
|---|---|---|---|---|
| **A. Pre-construction Stage** | | | | |
| 1. | Building Permissions for stations and depots | Second Master Plan for Chennai Metropolitan Area 2026 amended May 2013 | CMDA, 6 months, to be obtained before start of implementation stage | Contractor and CMRL |
| **B. Implementation Stage** | | | | |
| 2. | Consent to Establish & Operate for Ready Mix Concrete plant & casting yard | Air (Prevention and Control of Pollution) Act 1981 | SPCB, to be obtained before installation | Contractor engaged by CMRL |
| 3. | Permission for withdrawal /dewatering of groundwater[5] | Environment (Protection) Act, 1986<br>Chennai Metropolitan Area Groundwater (Regulation) Act, 1987 as amended till 2008<br>Guidelines/Criteria for evaluation of proposals/requests for ground water abstraction (With effect from 16.11.2015) | CGWA, 3 months, to be obtained before construction | Contractor engaged by CMRL |
| 4. | Consent to recharge groundwater with | Water (Prevention and Control of Pollution) Act 1974 amended 1988, Environment (Protection) | CGWB/PWD, 3 months, to be obtained before construction | Contractor engaged by CMRL |

[5] The Contractor will avoid extraction of groundwater as much as possible. If not avoidable, the permission will be obtained prior to the extraction.

| Sl. No. | Permissions/ Clearances | Acts/Rules/Notifications/ Guidelines | Concerned Agency and Timeframe | Responsibility |
|---|---|---|---|---|
| | dewatering water if any | Amendment Rules, 2017 (Discharge Standard for Sewage Treatment Plants(STPs)), Model Groundwater (Control and Regulation) Bill 1970, amended in 1972, 1996 and 2005 | | |
| 5. | Permission for sand mining from riverbed. (**Currently banned in Tamil Nadu**.) | Environment (Protection) Act, 1986 | Mining Department/ MoEF&CC, currently banned | Contractor engaged by CMRL |
| 6. | Authorization for storage (diesel) and disposal of Hazardous Waste | Petroleum Rules, 2002 and amendments Hazardous and Other Wastes (Management& Transboundary Movement) Amendment Rules, 2019 | SPCB, 3 months, to be obtained before installation | Contractor engaged by CMRL |
| 7. | Consent for disposal of sewage from labour camps. | Water (Prevention and Control of Pollution) Act 1974 amended 1988 Environment (Protection) Amendment Rules, 2017 (Discharge Standard for Sewage Treatment Plants(STPs)) | SPCB, 3 months, to be obtained before installation | Contractor engaged by CMRL |
| 8. | Pollution Under Control Certificate for various vehicles use for construction | Central Motor and Vehicle Act, 1988 | Department of Transport, Govt. of Tamil Nadu authorised testing centres, to be obtained before installation | Contractor engaged by CMRL |
| 9. | Employing Labour/ workers | The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 | District Labour Commissioner, 1 month, to be obtained before installation | Contractor engaged by CMRL |
| 10. | Roof Top Rainwater Harvesting (RWH) | Central Groundwater Authority and Chennai Metro Water Guidelines | CGWA/CMWSSB, 3 months, to be obtained before installation | Contractor engaged by CMRL |
| 11. | Permission for use of fresh water for construction and drinking purpose. | Environment (Protection) Act, 1986 | Municipal Corporation, 3 months, to be obtained before installation | Contractor engaged by CMRL |
| 12. | Permission for Quarry Operation | The Mines and Minerals (Development and Regulation) Act, 1957 | State Department of Mines and Geology, 2-6 months, to be obtained before construction | Contractor engaged by CMRL |

| Sl. No. | Permissions/ Clearances | Acts/Rules/Notifications/ Guidelines | Concerned Agency and Timeframe | Responsibility |
|---|---|---|---|---|
| 13. | Authorization for Disposal of Construction and Demolition (C&D) Waste | Construction and Demolition Waste Management Rules, 2016 | SPCB, 2 months, to be obtained before installation | Contractor engaged by CMRL |
| 14. | Consent to Establish labour camps, pre-casting and material yards, hot mix plant, crushers, batching plant, stations | Air (Prevention and Control of Pollution) Act 1981 and amendments<br>The Noise Pollution (Regulation and Control) Rules, 2000 and amendments<br>Water (Prevention and Control of Pollution) Act 1974 and amendments | SPCB, 3 months, to be obtained before installation | Contractor engaged by CMRL<br><br>The Application forms for seeking Consent are available from the office of SPCB at Chennai. |
| 15. | Consent to C&D waste (muck) disposal | Construction and Demolition Waste Management Rules, 2016<br>Solid Waste Management Rules, 2016 | SPCB, 2 months, to be obtained before disposal | Contractor engaged by CMRL |
| 16. | Installation and operation of DG sets at stations | Air (Prevention and Control of Pollution) Act, 1981 amended 1987; CPCB Notification April 1994 of National Ambient Air Quality Standards | SPCB, 2 months, to be obtained before installation | CMRL |
| 17. | Permission to fell trees | Chennai City Municipal Corporation Act, 1919 | Greater Chennai Corporation, to be obtained before felling | Contractor engaged by CMRL |

### 2.1.5 Institutional Administrative Framework

29. The administrative framework in India for implementation and monitoring of Metro Rail Projects involves following key agencies.

30. **Ministry of Environment, Forests and Climate Change (MoEF&CC):** MoEF&CC is apex body in India responsible for protection and enforcement of laws and regulations. In view of the growing importance of environmental affairs, the Government of India set up a Department in November 1980 under the portfolio of the Prime Minister. The department, later renamed as the MoEF&CC plays a vital role in environmental management for sustained development and for all environmental matters in the country.

31. The major responsibilities of MoEF&CC includes, Environmental resource conservation and protection, Environmental Impact Assessment of developmental projects, Co-ordination with the other ministries and agencies, voluntary organizations and professional bodies on environmental action plans, Policy-planning, Promotion of research and development, manpower planning and training and creation of environmental awareness; Liaison and coordination with international agencies involved in environmental matters.

32. Developmental project proponents are also required to submit Environmental Impact Statements/Assessments to establish that preventive measures are planned by installing adequate pollution control and monitoring equipment, and that effluent discharged into the environment will not exceed permissible levels. The MoEFCC appraises these statements/ assessments and approves the project from the environmental angle.

33. **Tamil Nadu State Pollution Control Board (SPCB):** Tamil Nadu Pollution Control Board was formed under the provisions of section 4 of Water (Prevention & Control of Pollution) Act, 1974. The Board is also functioning as the State Board under section 5 of the Air (Prevention & Control of Pollution) Act, 1981. The prime objective of all these Acts is maintaining, restoring and preserving the wholesomeness of quality of environment and prevention of hazards to human beings and terrestrial flora and fauna.

34. **Central Ground Water Board (CGWB):** The CGWB is responsible for the development, dissemination of technologies, and monitoring of India's groundwater resources, including their exploration, assessment, conservation, augmentation, protection from pollution and distribution. The CGWB, under the Ministry of Water Resources, was established in 1970. Various activities related to regulation and control of ground water development in the country is the responsibility of the Central Ground Water Authority (CGWA) specifically constituted under the Environmental (Protection) Act, 1986. The CGWA has identified over exploited-areas across India where groundwater withdrawal is regulated. To date, 43 critical/ overexploited notified areas have been identified in 10 states. Construction of new ground water structures is prohibited in the notified areas while permission of drilling tube wells is being granted only to the government agencies responsible for drinking water supply.

35. **The National Green Tribunal (NGT):** has been established on 18.10.2010 under the National Green Tribunal Act 2010 for effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources including enforcement of any legal right relating to environment and giving relief and compensation for damages to persons and property and for matters connected therewith or incidental thereto. It is a specialized body equipped with the necessary expertise to handle environmental disputes involving multi-disciplinary issues. The Tribunal shall not be bound by the procedure laid down under the Code of Civil Procedure, 1908, but shall be guided by principles of natural justice.

36. The Tribunal's dedicated jurisdiction in environmental matters shall provide speedy environmental justice and help reduce the burden of litigation in the higher courts. The Tribunal is mandated to make an endeavour for disposal of applications or appeals finally within 6 months of filing of the same. Initially, the NGT is proposed to be set up at five places of sittings and will follow circuit procedure for making itself more accessible. New Delhi is the Principal Place of Sitting of the Tribunal and Bhopal, Pune, Kolkata and Chennai shall be the other four place of sitting of the Tribunal.

## 2.2. International and Regional Agreements and Conventions

37. India is member of almost all major Multilateral Environmental Agreements (MEAs), under four clusters, namely the following:

A. Nature conservation;
B. Hazardous material;
C. Atmospheric emissions; and
D. Marine environment.

38. The Nature conservation and Climate change agreements will be applicable to this Corridor.

**A. Nature conservation**

| Sno. | Nature Conservation |
|---|---|
| 1 | Ramsar Convention on Wetlands |
| 2 | CITES (Convention on International Trade in Endangered Species of Fauna and Flora) |
| 3 | TRAFFIC (The Wildlife Trade Monitoring Network) |
| 4 | CMS (Convention on the Conservation of Migratory Species) |
| 5 | CAWT (Coalition Against Wildlife Trafficking) |
| 6 | CBD (Convention on Biological Diversity) |
| 7 | ITTC (International Tropical Timber Organisation) |
| 8 | UNFF (United Nations Forum on Forests) |
| 9 | IUCN (International Union for Conservation of Nature and Natural Resources) |
| 10 | GTF (Global Tiger Forum) |

**B. Hazardous material**

| Sno. | Hazardous material |
|---|---|
| 1 | Cartagena Protocol on Biosafety |
| 2 | SAICM (Strategic Approach to International Chemicals Management) |
| 3 | Stockholm Convention on Persistent Organic Pollutants (POPs) |
| 4 | Basel Convention on the Control of Trans-boundary Movement of Hazardous Waste and Their Disposal |
| 5 | Rotterdam Convention on Prior Informed Consent (PIC) for certain Hazardous Chemicals and Pesticides in International Trade |

**C. Atmospheric emissions**

| Sno. | Atmospheric emissions |
|---|---|
| 1 | UNFCCC (United Nations Framework Convention on Climate Change) |
| 2 | Kyoto Protocol |
| 3 | UNCCD (United Nations Convention to Combat Desertification) |
| 4 | Montreal Protocol (on Ozone Depleting Substances) |
| 5 | Paris Agreement |

**D. Marine environment**

| Sno. | Marine environment |
|---|---|
| 1 | IWC (International Whaling Commission) |

### 2.3. MDBs' Requirements Applicable to the Project

39. MDBs' project planning activities related to environmental and social safeguards generally comprise: a) screening and categorization by Bank; b) due diligence of the project by Bank; c) environmental and social assessment by Borrower and its review by Bank; d) information disclosure by Borrower and Bank and consultation by Borrower; e) monitoring and reporting by Borrower and Bank; and f) grievance redressal by Borrower.

#### 2.3.1 Safeguard Policy Statement (SPS) 2009 of ADB

40. ADB's SPS sets out the policy objectives, scope and triggers, and principles for three key safeguard areas:

i. Environmental Safeguards,
ii. Involuntary Resettlement Safeguards, and
iii. Indigenous Peoples Safeguards.

41. Pursuant to ADB's Safeguard Policy Statement (2009), ADB funds may not be applied to the activities described on the ADB Prohibited Investment Activities List (PIAL) set forth at

Appendix 5 of the Safeguard Policy Statement (2009). None of the activities included in the PIAL list will be financed under the project.

### 2.4. Applied Standards

42. The project will follow national as well as international best practices and standards related to environment, health and safety. When host country regulations differ from the levels and measures presented in the international Guidelines, projects are expected to achieve whichever is more stringent. Appropriate and less stringent levels or measures than those provided in the international Guidelines can be adopted if they are protective of human health and the environment. (World Bank Group (WBG) Environmental, Health, and Safety (EHS) General Guidelines April 30, 2007). Some international standards for environmental components are listed here:

✓ Air Quality
- WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide *Global Update, 2005.(EHS Guidelines WBG April 2007)*
- Environment (Protection) Seventh Amendment Rules 2009

*Air quality guideline values in terms of PM10, PM2.5 and SO2 are more stringent in WBG guidelines than Indian national standards.*

✓ Water quality
- Water Resources and Environment Technical Note D1, March 2003 WBG and EU standards for discharge from wastewater treatment plant
- Pollution Prevention and Abatement Handbook, WB 1998 / April 1999 for stormwater
- General Standards of discharge for environmental pollutants Part A- Effluents, Schedule VI, Environmental Protection Rules 1986, MoEFCC, Government of India
  *In relation to Indian post-treatment inland surface water standards, WBG effluent discharge guideline values for toxic metals are more stringent; they prescribe coliform levels while Indian standards do not.*
- Designated Best Use Classification of Surface water, CPCB 1978 for propagation of wildlife and fisheries
- WHO Guidelines for Drinking Water Quality 2017
- Drinking Water Specification IS 10500-2012, Bureau of Indian Standards
  *Drinking water standards as per WHO cover fewer substances than Indian standards.*

✓ Soil (in terms of permissible content in foods)
- UK EA Soil Guideline Values cover hydrocarbons and toxic metals;
- EC Regulations 1881/2006, 629/2008 and 835/2011 cover toxic metals, nitrates, Persistent Organic Pollutants (POPs) and Polycyclic Aromatic Hydrocarbons (PAHs)
- In India, Prevention of Food Adulteration Rules 1955 prescribe permissible limits of lead, copper, arsenic, zinc, cadmium, mercury, chromium, nickel.

✓ Noise
- WHO Guidelines for Community Noise ca. 1999
- The Noise Pollution (Regulation and Control) Rules, 2000 (Amended 2002)
- EHS Guidelines WBG April 2007

✓ Vibration
- Transit Noise and Vibration Impact Assessment Manual, Federal Transit Administration, September 2018
- Transit Noise and Vibration Impact Assessment, US FTA, May 2006
- Metro Rail Transit System Guidelines for Noise and Vibrations, RDSO, Sept 2015

✓ Biodiversity **(IFC Performance Standard 6**)

- Consider direct and indirect project related impacts on biodiversity and ecosystem services and identify any significant residual impacts;
- Consider relevant threats to biodiversity and ecosystem services, especially focusing on habitat loss, degradation and fragmentation, invasive alien species, overexploitation, hydrological changes, nutrient loading, and pollution.
- Take into account the differing values attached to biodiversity and ecosystem services by stakeholders;
- Seek to avoid impacts on biodiversity and ecosystem services. When avoidance of impacts is not possible, measures to minimize impacts and restore biodiversity and ecosystem services should be implemented.
- Adopt a practice of adaptive management in which the implementation of mitigation and management measures are responsive to changing conditions and the results of monitoring throughout the project's lifecycle.

✓ Asbestos Handling waste and Management (IFC General EHS Guidelines _ Hazardous Materials Management)

- Use of asbestos containing materials (ACM) should be avoided in new buildings or as a new material in remodeling or renovation activities.

Existing facilities with ACM should develop an asbestos management plan which clearly identifies the locations where the ACM is present, its condition (e.g. whether it is in friable form with the potential to release fibers), procedures for monitoring its condition, procedures to access the locations where ACM is present to avoid damage, and training of staff who can potentially come into contact with the material to avoid damage and prevent exposure.

-

✓ **Climate Change** (Asian Development Bank)

- Expanding the use of clean energy;
- Encouraging sustainable transport and urban development;
- Managing land use and forests for carbon sequestration;
- Promoting climate-resilient development;
- Strengthening policies, governance and capacities.

✓ **Occupational Health and Safety** (World Bank Group and European Investment Bank)

✓ **Community Health and Safety** (World Bank Group and European Investment Bank)

# 3. PROJECT DESCRIPTION

## 3.1. Rationale

43. India has experienced rapid growth in urbanization over several decades, with the share of the urban population from 17.9 percent in 1960 to 34.0 percent in 2018.[6] By 2030, Indian cities are projected to be home to another 250 million people.[7] The metropolitan areas are facing extremely high population densities and traffic congestion.

44. To create safe, affordable, quick, comfortable, reliable, and sustainable urban transport systems for Indian cities, the Ministry of Urban Development (MoUD) formulated the National Urban Transport Policy (NUTP) in 2006. The NUTP proposes the development of a metro rail system in every city of India with a population of more than two million people. GoI's Union Cabinet approved a new Metro Rail Policy in 2017 that aims to enable the development and implementation of metro projects in a comprehensive and sustainable manner from the social, economic, and environmental perspectives. As of February 2019, metro line services with a total length of 585 km are operational in India.[8]

45. Chennai, the capital city of the state of Tamil Nadu, is part of the Chennai Metropolitan Area (CMA) and plays a vital role in the economy of South India.

46. The existing transportation system in CMA is marked by high traffic density and carbon emissions.

47. CMRL, a joint venture of the GoI and the Government of Tamil Nadu (GoTN) with equal equity ownership, is responsible for implementing, operating, and maintaining the city's metro system. CMRL developed The Comprehensive Mobility Plan for CMA in 2015 to identify the present and future mobility patterns of CMA. The detailed study identified three corridors (corridors 3, 4, and 5) for the second phase of the Chennai Metro Rail to alleviate CMA's transportation capacity constraints.

## 3.2. Description of MDB Corridor 3

48. The first phase of the Chennai Metro Rail covers 54 km in two corridors, with 45 km currently already in operations since 2015 and another 9 km to be operational in 2020. GoI, GoTN, and the Japan International Cooperation Agency (JICA) funded the first phase that provides direct connection between northern and southern parts of Chennai.

49. MDB Corridor 3 is the 10.1 km line after Sholinganallur station upto SIPCOT 2 Station including 9 stations. This line forms part of Chennai metro corridor 3. Sholinganallur station forms part of balance Corridor 3 which is being implemented by JICA. The MDB Corridor 3 provides passenger interchange with balance Corridor 3 at Sholinganallur. This section is proposed for financing by ADB. GOTN decided to construct the elevated road along median of NH 49A (Old Mahabalipuram Road or OMR) to cater to intercity road traffic leading out of Chennai as well as share load of local traffic. Implementing Agency for elevated road will be different from CMRL: the Government will suitably decide in due course. Timeline for construction of elevated road is not decided. In the initial phase this road could land on existing NH 49A at Siruseri.

50. MDB Corridor 3 metro line is proposed to run elevated along NH 49A in the first level above existing road and the elevated expressway as an independent structure runs parallel to metro alignment. This will help conserve right of way of NH 49A up to Siruseri (44.2m at Sholinganallur to 44.7m at Siruseri and 30.9m to 23.9m inside SIPCOT IT Park) thereby

[6] https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=IN

[7] Urbanization Beyond Municipal Borders, The World Bank, 2013.

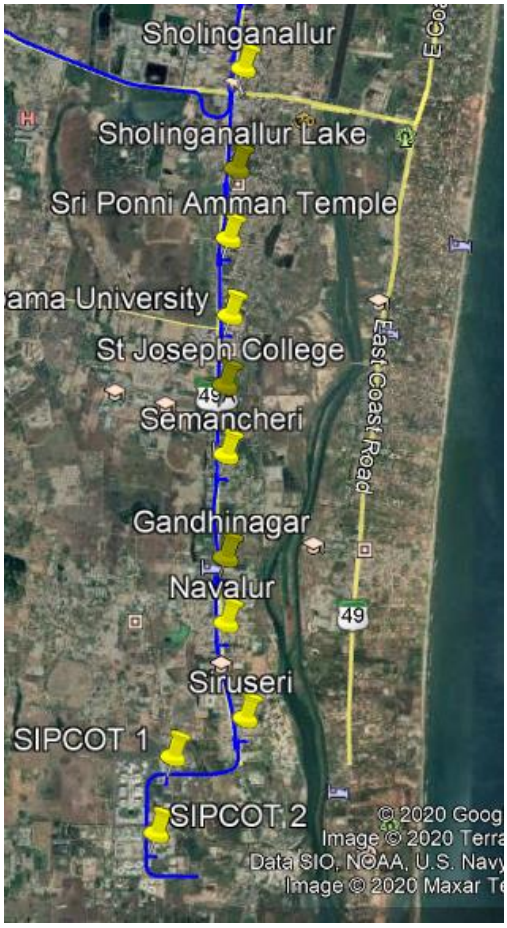
[8] Press Information Bureau, Ministry of Housing and Urban Affairs, Government of India,

minimizing reduction in its capacity (traffic forecast in CMP by year 2035 on NH 49A will be 39% above its design service volume). Moreover, it will facilitate local pedestrian and vehicular road traffic. The spans, columns and foundations of the metro viaduct and stations will be aligned with but structurally independent of the elevated road. Construction of metro will be done independent of the elevated road with independent environmental permit.

51. The MDB corridor 3 alignment will take off from Sholinganallur metro station which will be constructed as part of Corridor 3 segment from Madhavaram to Sholinganallur being financed by JICA. It will run along the OMR till Siruseri, thereafter turning right to enter SIPCOT IT Park and terminate at SIPCOT 2 station. A minor depot which includes elevated stabling beyond SIPCOT 2 station was proposed in the DPR, however this will be replaced by stabling sidings only.

52. Stations of MDB Corridor 3 as per the DPR are depicted in Figure 3.1. Since the preparation of the DPR in 2018 St. Joseph College station has been dropped. A list of stations is presented in table 3.1.

**Figure 3-1: MDB Corridor 3**




(Source: DPR of Chennai Metro Phase 2, Dec 2018)

**Table 3-1: List of stations MDB Corridor 3**

| N | Station Name | Inter station distance (m) | Chainage (m) (as part of composite corridor 3 |
|---|---|---|---|
| 1 | Sholinganallur Lake | 1191 | 36235 |
| 2 | Sri Ponniamman Temple | 818 | 37053 |
| 3 | Sathyabama University | 866 | 37919 |
| | *St. Joseph's College* | dropped | |
| 4 | Semmancheri | 1632 | 39551 |
| 5 | Gandhi Nagar | 1151 | 40702 |
| 6 | Navallur | 733 | 41435 |
| 7 | Siruseri | 1102 | 42537 |
| 8 | SIPCOT 1 | 1069 | 43606 |
| 9 | SIPCOT 2 | 1065 | 44671 |

53. Topographical survey was carried out in detail using modern surveying instruments. The geotechnical investigations determined the required strength characteristics of the underlying soil/rock strata to design the foundation of the proposed structure. A total of 18 bore holes were drilled all along the proposed MDB Corridor 3 alignment. More boreholes will be drilled as necessary for detailed design. Also, since the proposed site is located in seismic Zone III of India, suitable seismic measures such as isolation devices such as bearings which decouple superstructure and sub-structure thereby increasing flexible behavior of the bridge and enable dissipation of energy thus increasing safety will be adopted in the design of the structures.

### 3.2.2 Salient Design Features

54. The salient features of MDB Corridor 3 Project are summarized in Table 3.2.

**Table 3-2: Salient Features of Chennai Metro MDB Corridor 3**

**Gauge (Nominal):** 1435 MM
**Route Length:** 10.13 km fully elevated
**Number of Stations:** 10 all elevated
**Speed:**
1. Design Speed 80 kmph
2. Maximum Design Speed 90 kmph
3. Schedule (Booked) Speed 32 kmph

**Train Operation Plan :**

| Particulars | 2025 | 2035 | 2045 | 2055 |
|---|---|---|---|---|
| Trains/hour (3 Car, 6 Car) | 15 (6,0) | 15 (6,0) | 15 (6,0) | 17 (0,6) |
| Head Way (Second) | 600 | 600 | 600 | 600 |
| Capacity (6p/m$^2$;8p/m$^2$) | 4596, 5850 | 4596 5850 | 4596 5850 | 9456 12024 |
| Max. PHPDT Demand | 2213 | 3566 | 4050 | 4500 |
| Total Coach Requirement @ | 63 | 63 | 63 | 126 |

Added.@ Table 8.6 DPR Dec 2018 MMC-Adyar-SIPCOT, others Table 8.4 DPR Dec 2018 SLR-SIPCOT

**Traction Power Supply:**
1. Traction System Voltage 25 kV AC
2. Current Collection Overhead Electric Traction
3. Receiving Substations (RSSs) Siruseri RSS

**Power Demand (MVA) :**

| Load | 2025 | | 2035 | | 2045 | | 2055 | |
|---|---|---|---|---|---|---|---|---|
| | Normal | Emergency | Normal | Emergency | Normal | Emergency | Normal | Emergency |
| Siruseri GSS-Siruseri RSS (Ch 32393 to Ch 44671) 12.278km | | | | | | | | |
| Traction | 2.20 | 6.35 | 2.33 | 7.02 | 2.44 | 7.65 | 4.05 | 10.84 |
| Auxiliary | 3.85 | 13.42 | 4.42 | 16.28 | 5.08 | 18.43 | 5.48 | 19.83 |
| Total | 6.05 | 19.77 | 6.75 | 23.30 | 7.52 | 26.08 | 9.53 | 30.67 |

For composite ToP Table 12.5 DPR Dec 2018

**Rolling Stock:**

1. Rolling Stock with light weight Stainless Steel/Aluminum Body
2. Max. Axle Load 16 T
3. Dimensions L22.6 x W2.9m x H3.9m

**Facilities:** Depot at SIPCOT for stabling, washing and inspection of rakes has now been dropped. Separate stabling area has been provided.

**Signalling, Telecommunication and Train Control:**

1. Type of signaling — Communication based Train Control System (CBTC) with unattended train operation permitting an operational headway of 90 seconds.
2. Telecommunication — Integrated System with Optic Fiber cable, Supervisory Control and Data Acquisition (SCADA), Close Circuit Television (CCTV), Central Voice Recording System (CVRS) etc.

**Fare Collection:**

Automatic Fare Collection (AFC) System with smart card/token etc.

55. As per travel demand forecast on revised network in DPR 2018, composite Corridor 3 will cater to daily boarding of 6.6 lakh in 2025 and 13.6 lakh in 2055; maximum sectional PHPDT will correspondingly increase from 16,289 to 27,361. Consequently, on MDB Corridor 3, PHPDT across sections will vary between 2,213 and 101 (between SIPCOT 1 and SIPCOT 2 stations) in year 2025; 4,500 and 219 in year 2055.

56. After elevated metro cum elevated road are implemented, at grade NH 49A will operate as 4 lane divided road with other cross section elements: it can carry 7000 trips in peak direction in year 2035 leaving excess of 7500. This excess will be shared by metro (as per DPR, peak direction metro section load between Sholinganallur and Siruseri varies from 3200 to 500) and elevated road (est. from CMP 4500 and 7000). Elevated road 4 lane divided is adequate to carry its share of traffic.

57. Requirement of rolling stock for the forecast ridership may need to be updated after confirmed distancing guidelines for **permanent** implementation in contagious diseases such as Covid-19 are issued by the government. Funding toward any consequent increase in number of rolling stock will be known in course of time.

58. Stations impose significant demands on energy. In addition, traction, rolling stock and train control systems also require reliable sources of grid and standby power, high intensity energy, as well as efficient equipment. Table 3.3 presents the power demand of alignment during operation.

**Table 3-3: Power Demand**

| Load | 2025 | | 2035 | | 2045 | | 2055 | |
|---|---|---|---|---|---|---|---|---|
| | Normal | Emergency | Normal | Emergency | Normal | Emergency | Normal | Emergency |
| Siruseri GSS-Siruseri RSS (Ch 32393 to Ch 44671) 12.278km | | | | | | | | |
| Traction | 2.20 | 6.35 | 2.33 | 7.02 | 2.44 | 7.65 | 4.05 | 10.84 |
| Auxiliary | 3.85 | 13.42 | 4.42 | 16.28 | 5.08 | 18.43 | 5.48 | 19.83 |
| Total | 6.05 | 19.77 | 6.75 | 23.30 | 7.52 | 26.08 | 9.53 | 30.67 |

*For composite ToP Table 12.5 DPR Dec 2018*

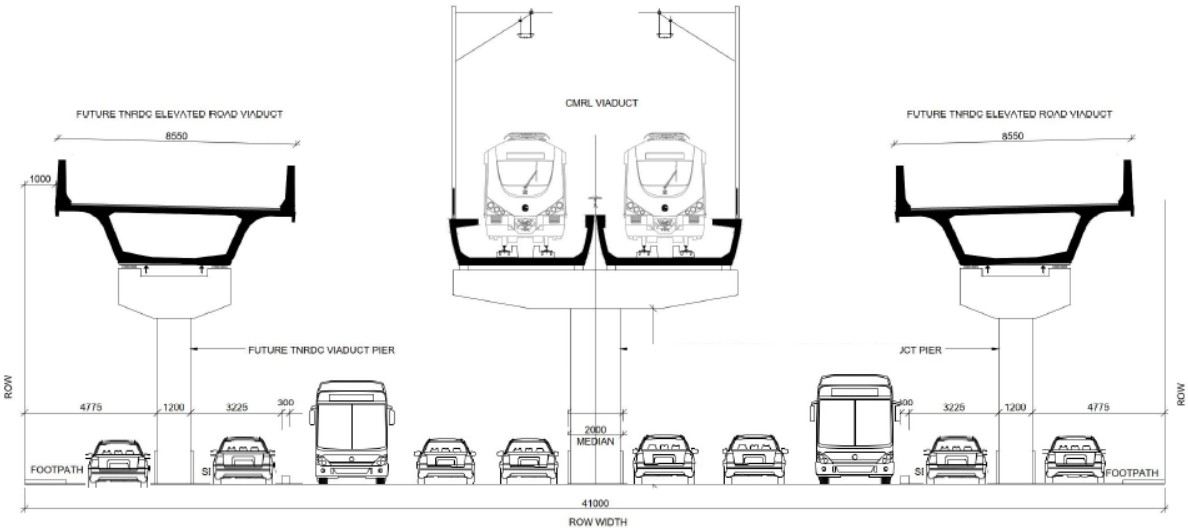
### 3.2.3 Station and Viaduct Arrangement

59. Bicycle sharing and pick/drop zones for autorickshaw, taxi and bus with un-conflicting pedestrian connectivity are planned at stations. Certain stations are identified for feeder bus services. Off street parking for park and ride and commercial development are not proposed on this Corridor. As ridership builds up, private vehicle parking to facilitate park-ride will be planned at stations accessible to residential nodes. At grade pedestrian crossings are planned: subways will be planned subsequently.

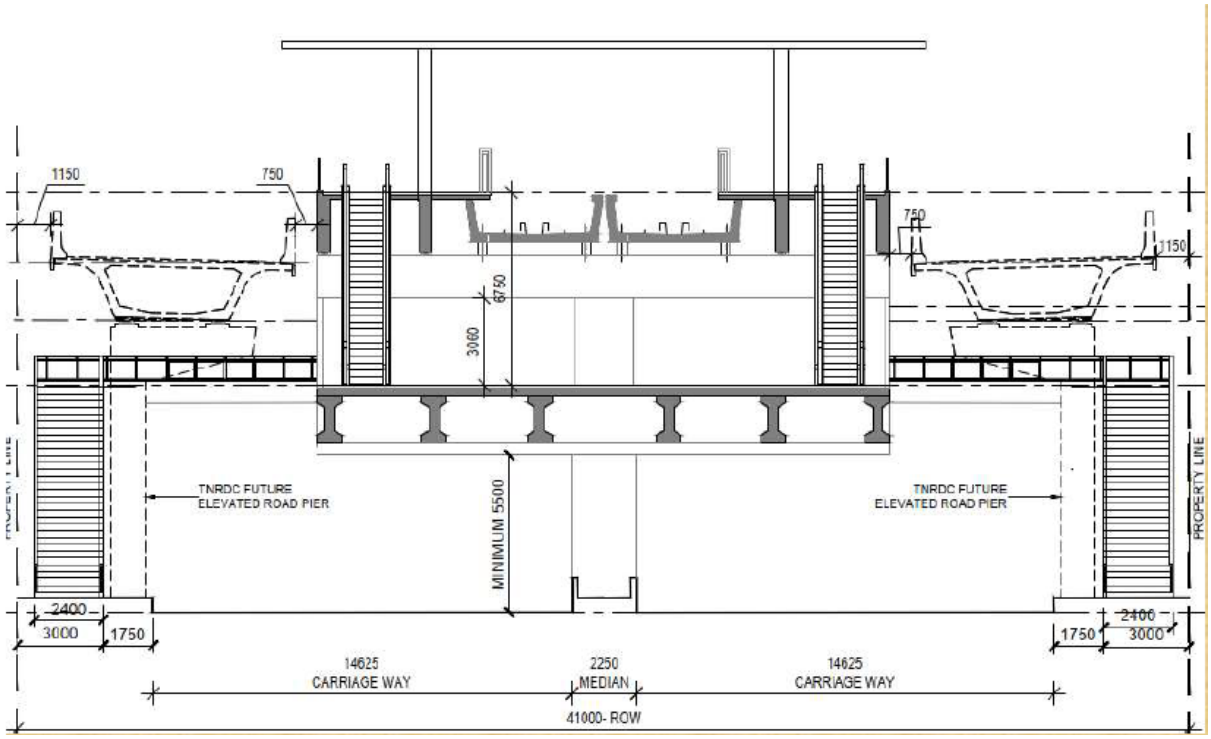
60. Elevated stations located at the median of existing roads will be 140 m long and 24 m wide. In view of adequate right of way of road, the stations will be constructed on portal frames. The typical elevated station consists of three levels: ground, concourse and platform. Passenger facilities, operational and commercial areas are provided at the concourse level. The viaduct is 2-level comprising space for the future construction of an elevated road at lower level with a minimum vertical clearance of 5.50 m above road level and metro at the higher level. As per DPR 2018, rail level varies between viaduct mid section and stations from 28m to 18m above ground level. As per SoD 2013 of Chennai metro, minimum height between rail level and underside of live conductor in open is 5.0m; typical height of catenary on elevated section is 7m. To reduce physical and visual impact, stations will be transparent with minimum walls on the sides. Figure 3.2 shows the typical structural arrangement and Figure 3.3 depicts typical elevated station at the SIPCOT IT park section.

**Figure 3-2: Typical Structural Arrangement**

**Road Cross Section with CMRL Viaduct and Elevated Expressway**

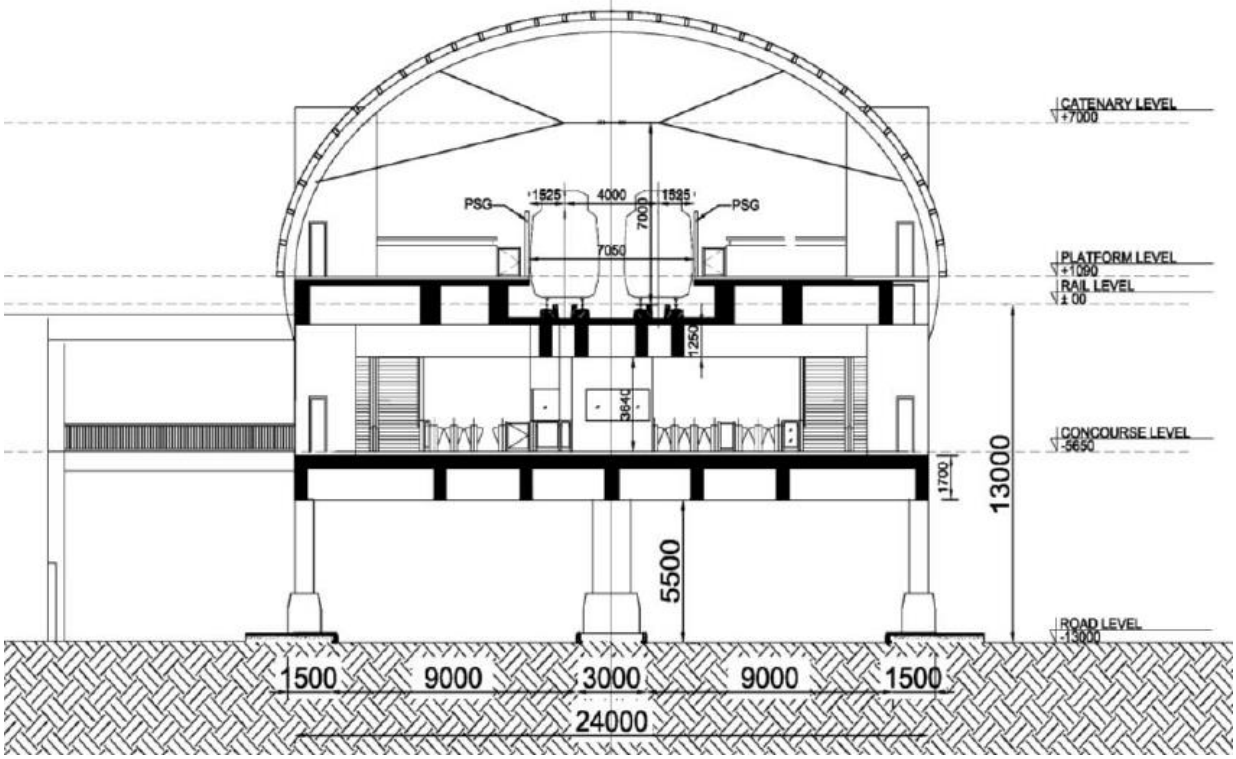



**Road Cross Section with CMRL Station and Elevated Expressway**




*Source: CMRL*

**Figure 3-3: Typical Elevated Station**




### 3.2.6 Labour Camp

61. The Contractor during the progress of work, will provide, erect and maintain necessary (temporary) living accommodation and ancillary facilities for labour. Contractor will establish construction camps as part of the project. Emphasis will be given to use existing facilities (established under ongoing lines). However, locations of the camps will be finalized after mobilization of contractor and in consultation with CMRL. The Contractor engaged by CMRL will also coordinate with the development authority for land use clearance, SPCB and Municipal Corporation to establish the labour camps before construction. Selection of sites for labour camp must follow the guidelines for site selection as included in annexure 10 of this EIA. The contractor has to provide a plan with camp layout first, including sewage and drainage system, access road, primary medical facilities, temporary residential buildings etc, to be approved by CMRL before establishment. He will implement provisions of the following statutes:

- Tamil Nadu Building and Construction Workers (Conditions of Employment and Miscellaneous Provisions) Act, 1984
- The Contract Labour (Regulation & Abolition) Act, 1970
- Employees State Insurance Act, 1948 (ESI);
- Minimum Wages Act, 1948, The Payment of Wages Act, 1936, amended in 2005;
- The Tamil Nadu Labour Welfare Fund Act, 1972
- The Equal Remuneration Act 1976;
- Workmen's Compensation Act, 1923
- Interstate Migrant Workmen (Regulation of Employment and conditions of Service) Act 1979
- Child and Adolescent Labour (Prohibition and Regulation) Act, 1986

### 3.2.7 Construction Activities and Methodology

62. Main construction activities include demolition of 4 semi-engineered structures used for commercial purpose (see Resettlement Plan) and ground clearing; Excavation and fill; Transport of construction materials, C&D waste (muck); Casting of concrete elements and preparation of concrete and their transportation; Pile driving where cast-in-situ is not feasible, blasting in rock etc.

63. Substructure - open foundation, pile, pile caps, columns; station structure; earth retaining structures will be cast-in-situ. The structural elements for superstructure i.e. box segments, I-Girders, U-girders and sometimes pile caps are pre-cast. Pre-cast construction may be segmental or non-segmental type. In case of segmental method, structural segments are pre-casted in casting yards, pre-stressed and then transported to the location of use and launched by means of suitable launching arrangement. The construction yard has arrangement for casting beds, curing and stacking area, batching plant with storage facilities for aggregates and cement, site testing laboratories, reinforcement steel yard and fabrication yard etc. An area of about 3 ha is required for each construction yard. The contractor has to provide a plan with yard layout, including sewage and drainage system, access road, first aid facilities etc, to be approved by CMRL before establishment.

## 3.3. Associated Facilities

64. Associated facilities are those that are not included or funded by the Project but are: (i) directly and materially related to the Project; (ii) carried out or planned to be carried out, contemporaneously with the Project; (iii) whose viability and existence depend exclusively on the project and; (iv) whose goods and services are essential for successful operation of the project and would not be constructed or expanded if the Project did not exist.

65. Balance Corridor 3 from Madhavaram to Sholinganallur via Adyar which is being financed by JICA constitutes one of the Associated Facilities to MDB Corridor 3. The other Associated Facilities which are required for passenger trips forecast on MDB Corridor 3 to materialise are a) MDB Corridor 5 b) Phase 1 under operation, c) Phase 1A under construction d) MRTS and suburban railway.

66. The construction and operation of MDB Corridor 3 will require power and water from existing electricity grid and water supply system. Electricity is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, signalling & telecom, firefighting etc. and workshops, depots within premises of metro system). The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications. These existing grid substations and water supply network are being operated and managed by respective agencies under full compliance with state and local policies and regulatory frameworks.

67. Chennai City has 230kV, 110kV, 33kV power transmission and distribution network to cater to various types of demand in the vicinity of proposed corridor. Keeping in view of reliability requirements of the corridor, one Receiving Substation (RSS) is proposed to avail power supply for traction as well as auxiliary services from Tamil Nadu Transmission Corporation Limited grid sub-stations at 110kV voltage through transmission lines or cable feeders. M/s TANGEDCO has confirmed the availability of supply.

68. Gas Insulated Substation (GIS) type substations, which offer the advantage of considerable saving in space requirement as well as reduced maintenance, are proposed for each Receiving cum Traction Substation and Auxiliary Substations of MDB Corridor 3. Each elevated station will be provided with an Auxiliary Substation with two 33kV/415V, 3-phase, 500 kVA dry type cast resin transformers and the associated HT & LT switchgear. In addition,

provision will be made for one DG set at each station for emergency loads. In addition, it is proposed to provide standby DG set of 250 kVA at all elevated stations to cater to all emergency loads. Power Demand is estimated in Table 3.3.

69. During construction, water consumption will be of the order of 148 KLD for construction and 231 KLD for labour camps. During operation, the water demand at stations for cleaning is 166 KLD. The water requirement for construction will be met as follows: a) dust control: surface runoff, wastewater, seawater b) casting of concrete elements: treated municipal water c) curing of concrete: surface runoff, water from dewatering during piling, treated municipal water d) labour camps: treated municipal water.

70. Water for stations will be met through public water supply system, supplemented by rainwater harvesting.

### 3.4. Description of Balance Corridor 3 from MMC to Sholinganallur

71. Chennai metro Phase-II corridor 3 runs from Madhavaram Milk Colony (MMC) to SIPCOT II via Sholinganallur, the construction of the section from MMC to Sholinganallur will be financed by JICA (called Balance corridor 3 in this EIA). 40 stations have been proposed in Balance corridor 3 consisting of 30 underground stations (MMC station to Taramani Link Road station) and 10 elevated stations (Nehru Nagar station to Sholinganallur station). Total length for Balance corridor 3 is 35.3 km. A major depot of 27.8 Ha is planned at MMC.

72. Balance corridor is part of the “EIA for Chennai Metro Rail Phase-II Priority Corridors” as prepared for JICA by RITES in November 2017. Information relevant for Balance corridor 3 is summarized in this paragraph.

73. The EIA does not provide specific information on the height of the elevated section, the exact location of the stations, stacked or parallel tunnels, linkages to existing transportation systems, etc. Furthermore the EIA does not provide information on Public Consultations nor on the Grievance Redress Mechanism (GRM). The EIA does describe the baseline data, the expected impacts and possible mitigation measures.

74. Environmental baseline data for air, noise, water and soil has been collected at 6 sampling locations:

- 24 hour air quality monitoring results indicate that SO2, NO2, PM10 and PM2.5 are within the NAAQ limits for residential, Industrial and rural areas (WBG limits were not used in the EIA, when compared to these standards the guidelines for PM2.5 and PM 10 are exceeded). The level of CO exceeds the NAAQ limits at all locations.
- 24 hour ambient noise level monitoring indicates that noise levels are exceeding the noise level standards prescribed by CPCB at all locations, either during day or night time, for Residential Zone, Commercial Zone and Silence Zone as well.
- Water samples were collected from wells (4), tap water (1) and surface water (1, Sholinganallur). Analysis of water sample depicts that all parameters are in acceptable limit except some parameters viz turbidity, calcium, chloride, hardness, magnesium, mercury and lead. Biological oxygen Demand (BOD) in the surface water sample at Sholinganallur renders the water unsuitable for use other than for irrigation, industrial cooling or controlled waste disposal (class E of CPCB Best Designated Use).
- The soils are slightly alkaline in nature. Organic matter content in soils varies from 1.02% to 1.29%.

75. Baseline ecological data indicates the construction of Balance corridor 3 will likely lead to a loss of 816 trees, of which 275 are located along the alignment on the sides and median of the existing roads. 541 trees will need to be removed for construction of the depot at MMC. No rare or endangered species of trees were noticed during field studies. Pallikaranai Marsh, the last remaining wetland of Chennai city and located near the elevated section of Balance corridor 3, has not been mentioned in the EIA.

76. No known archaeological monuments or sites are located on or along the proposed corridor.

77. The following environmental impacts are expected due to construction of Balance corridor 3:

- Change of Land Use: Land will be required permanently for stations, Depot, Ramp and running sections.
- Loss of Forests/Trees: There are 816 trees that are likely to be cut during construction along the corridor and on the depot site.
- Utilities/Drainage: The alignment will cross drains, large number of subsurface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, traffic signals etc.
- Soil Erosion: Run off from unprotected excavated areas can result in excessive soil erosion, especially when the erodibility of soil is high. In general, construction works are stopped during monsoon season.
- Air Pollution due to construction: Particulate pollution occurs due to excavation, loading and unloading of construction materials, vehicular and construction equipment emission and emission from the DG sets etc.
- Noise Pollution: Based on limited modeling the construction noise is predicted to be 90dB(A) at 125 meters distance from the construction site.
- Vibration: Pile driving for piers and tunnel driving generate vibrations. Vibration is pronounced in section of hard rock. TBM operation generates vibrations which are transmitted in all directions.
- Land Subsidence: Land subsidence is anticipated at stations which will be constructed by cut and cover method. Subsidence due to tunneling is not considered in the EIA.
- Risk to Existing Buildings: Construction involves cut and cover, tunneling and piling. As part of pre-construction/construction activities building condition survey will have to be conducted, cost of which is not included in EMP.
- Labour Camp: Improper disposal of municipal solid waste generated by labour camps can pollute surface water bodies and groundwater. Burning of waste can cause air pollution. The labour camps will require water from municipal water supply. Construction workers are more prone to infectious diseases. Problems could arise due to cultural differences between workers from outside and local residents.
- Traffic Diversions: During construction period, complete/partial traffic diversions on road will be required, as most of the construction activities are on the road.
- Muck Disposal: Construction activities will generate about 4.06 Mm3 of soil. Out of this, about 1.37 Mm3 is likely to be reutilized in backfilling in underground stations and depots. The balance 2.69 Mm3 must be disposed of in environmental friendly manner.

- Increased Water and Energy Demand: The demand for water and energy will increase during construction phase. Water consumption during construction is of the order of 1657 KLD.
- Ground and Surface Water: Ground water contamination can take place if chemical substances get leached by precipitation of water and percolate to the ground water table. Dumping of construction materials which could result in hazardous leachate percolating into ground water; dumping of used water from the RMC plant; oils and greases from construction sites and labour camp are sources of water pollution.
- Source of construction material: Poor choice of source and quarrying operations cause dust pollution and wastage of natural resources.

78. During project operation, the following impacts are expected:

- Noise Pollution: Effect of predicted day-time noise level is expected to have low impact with respect to the existing ambient noise environment. The EIA does not specify which model is used to determine this. 5 out of 6 receptors used for the noise prediction are located along the underground section of the Balance corridor 3, only the receptor at Sholinganallur is located along the elevated section. The model assumes trains will only operate during daytime hours, between 7AM and 10PM.
- Vibration: Passing of trains on elevated section as well as underground section causes vibrations. The dominant component of vibration due to passing on elevated section is horizontal while in tunnel vertical component is dominant. Impact is more in solid rock.
- Water Supply and Sanitation at Stations: The water demand at station comprising drinking, toilet, cleaning and air conditioning in Chennai will be of the order of 3024 KLD at underground stations and 224 KLD at elevated stations. The water requirement for the stations will be met through the public water supply system. Solid waste generation from operational staff at stations is likely to be 15 ton per month. Sewage at stations is estimated to be 70 KLD. This will be led into the municipal network.
- Pedestrian and Traffic Congestion around Stations: Commencement of metro services results in passenger rush at stations which in turn results in congestion around stations.

79. The likely impacts due to the proposed depot are:

- Water Supply: The water demand at Madhavaram depot would be about 59 KLD for train washing and 42 KLD for domestic purpose including staff quarters.
- Sewage and Effluent: About 37 KLD sewage from domestic activities and 53 KLD effluent from train washing will be generated at Madhavaram Depot.
- Oil Pollution: Oil spillage during change of lubricants, cleaning and repair processes, in the maintenance Depot cum workshop for maintenance of rolling stock, is very common. If discharged it can contaminate water sources.
- Noise Pollution: The main source of noise from depot is the operation of workshop. The roughness of the contact surfaces of rail and wheel and train speed is the factors, which influence the magnitude of rail - wheel noise.
- Surface Drainage: Due to the filling of the low-lying area for the construction of depots, the surface drainage pattern may change specially during monsoon.
- Solid Waste: It is estimated that municipal solid waste of about 3.6 ton per month will be generated from Madhavaram Depot.

80. Various positive environmental impacts have been identified:

- Reduced air pollution: The reduction in PM, CO, HC and NOx is expected to be 98.17 tons/year, 1550.91tons/year, 606.14 tones/year and 3715.89 tons/year respectively in year 2021.
- Traffic Noise Reduction: Reduction in traffic volume of 10% & 50% reduces noise at the tune of 0.5 dB & 3.0 dB respectively.
- Direct Benefits to Passengers: The project will result in direct benefits to users of Metro and other modes: reduction in vehicle operating costs, savings in travel time, improvement in quality of life, reduction in loss of productivity due to health disorders resulting from pollution and reduction in road accidents.
- Employment Opportunities: In post-construction phase, about 1715 people will be employed for operation and maintenance of the system. Thus, the project would provide substantial direct employment and consequent indirect employment.
- Benefits to Economy: These corridors will yield benefits in terms of growth in economic activity due to better accessibility, reduction in cost of road construction and maintenance and reduction in loss of productivity due to health disorders resulting from pollution and accidents.

81. The impacts will be mitigated or reduced by incorporating mitigation measures into the project cycle i.e. during design, construction and operation phases:

- Loss of Forests/Trees: Compensatory afforestation will take place in the form of planting 12 saplings for every tree cut. Native plant species and miscellaneous indigenous tree species are recommended for afforestation. Survival rate of the saplings has not been specified in the EIA.
- Utilities/Drainage: Prior to the execution of work at site, detailed investigation of all utilities will be undertaken and plans for their retention in situ with precautions or temporary/permanent diversions prepared and got approved by respective agencies.
- Soil Erosion: Excavation shall be limited; temporary berms and use of temporary mulches, fabrics, mats, seeding, or other control devices or methods shall be implemented.
- Air pollution due to construction: Mitigation measures as per SH&E manual shall be adopted during the construction period. Capital and operating cost are included in engineering cost and therefore is not included in EMP.
- Noise Pollution: Mitigation measures as per SH&E manual shall be adopted during the construction period. Construction work is prohibited between 10PM and 6AM within 150 meter of sensitive receptors (however the EIA does not provide a list of sensitive receptors). Capital and operating cost are included in engineering cost and therefore is not included in EMP. In addition to track-related measures, parabolic noise barriers are proposed on each side of the track. Noise barriers shall be placed along the curved portion of the viaduct and at stations during operation (The EIA does not provide specifics on height and length of these noise barriers nor on the exact location of the sensitive receptors. Model-based substantiation is lacking).
- Vibration and risk to existing buildings: Vibration can be reduced by system maintenance, improving track geometry, elastic fastenings, and separation pads. At locations where the alignment is close to sensitive structures, the contractor shall

prepare a monitoring scheme prior to construction at such locations. Threshold limits as per CMRL SHE Manual.

- Labour Camp: The following facilities shall be provided by the Contractor: Water supply, waste water and sewage treatment, Solid Waste Management Shelter at Workplace, Canteen Facilities, First aid facilities, Day Crèche Facilities, Health care awareness and clinics. Construction works shall be executed as laid down in the Safety Health and Environment (SH&E) Manual prepared by the Contractor and approved by the Implementing Agency.
- Traffic Diversions: Measures such as road widening, traffic segregation, one-way movements, traffic diversions, acquisition of service lanes, etc. will be employed. Although the EIA does not specify this, it is advised to comply with the IRC:SP:55-2014 “Guidelines on Traffic Management in Work Zones” for any traffic diversion.
- Muck Disposal: Disposal will take place in pre-identified pits, to be identified by CMRL/CMDA such that displacement of persons is not involved. Mitigation measure proposed are cleaning of disposal sites and then treated so that leached water does not contaminate the groundwater, controlling the height from which soil will be dropped, stockpiling of earth in the designated locations with suitable slope, filling of muck in layers and compact mechanically. Sufficient equipment, water and personnel shall be available on dumping sites at all times to suppress dust. Before excavation, the Contractor will be required to test the soil quality including heavy metals. If the soil is contaminated, the polluter will be responsible for treatment and disposal (The EIA does not describe how the polluter will be identified nor what has to be done when it remains inconclusive who the polluter is).
- Increased Water and Energy Demand: Water supply for drinking, washing of stations, air conditioning and other uses will be procured from municipal authorities. Wastewater from station will be discharged to the existing sewage network. Requirement of electrical energy for climate control, lighting and other facilities at stations shall be optimized by proper use of natural day/night light and design of passenger flow inside stations and on streets outside stations. Rain water harvesting and installations for solar power shall be implemented in stations and depot where feasible. Solar energy generation per year is estimated to be 8.97 Giga-watt-hr for Balance corridor 3 (no calculation provided in the EIA).
- Ground and Surface Water: Water from dewatering must be led to sewers or used to recharge groundwater (method is not described in the EIA). Procedures for storage, handling and transport of construction material shall be prescribed in SH&E method statement approved for construction. Hazardous waste shall be stored and disposed of by the Contractor as per Hazardous and Other Wastes (Management, Handling & Trans-boundary movement) Rules 2016. Depot will be equipped with Sewage Treatment Plant (STP) and Effluent Treatment Plant (ETP). Sludge is to be used as fertilizer on site, waste water is to be treated in the ETP. Oil spilled in depot will be trapped in oil and grease trap and disposed of to authorized collectors so as to avoid any underground/ surface water contamination. Oil that is mixed in water shall be removed in the ETP. Surface runoff is to be collected and led to rainwater harvesting pits. Misuse of water has to be avoided (The EIA does not specify how).
- Source of construction material: Segregation and temporary storage of reusable and recyclable materials at identified locations. Transport recyclable materials to

construction sites. C&D waste generated from metro construction has potential use after processing and grading.

- Pedestrian and Traffic Congestion around Stations: adequate and well-laid out space shall be designed for concourses and platforms, escalators, elevators and staircases, lighting, turnstiles for normal and abnormal operating conditions; optimal height / depth of the stations, forced ventilation shall be provided. Physical and operational integration of metro with other modes shall be planned.

82. TheEIA for Chennai Metro Rail Phase-II Priority Corridors" as prepared for JICA by RITES in November 2017 does not describe if any residual impacts are to be expected after mitigation, however it can be expected that some residual impacts will remain.

83. The training for engineers and managers will be imparted by CMRL on regular basis to implement the environmental protection clauses of the tender document and to implement the best environmental practices during the construction phase and ensure preparedness for disaster prevention.

84. Disaster management and emergency plans will be prepared by the Contractor and approved by the IA. To ensure proper disaster management, an Emergency Action Committee shall be constituted, consisting of Station Master concerned, Police Officer of the area, Home Guard representative, Fire Brigade representative, Health Department representative, Department of Information and Publicity, and Non-Governmental Organization of the area. Emergency measures will include: Emergency Lighting, Fire Protection, Ventilation Shafts, Emergency doors.

85. During construction stage environmental monitoring will be carried out for air quality ((M2.5, PM10, SO2, NOx, CO and HC), noise levels, vibration, water quality (parameters as per BIS: 10500), ecology (status of ecology/trees) and workers Health and Safety (inspection and medical checkups). Lumpsum provision has been made in the cost estimate.

86. The parameters monitored during operation will be PM2.5, PM10, SO2, NOx, CO and HC for ambient air quality and parameters as per BIS 10500 for water quality. Lumpsum provision has been made in the cost estimate. The EMoP does not provide for monitoring the effluent from the ETP.

87. It is recommended to establish an Environment Division at the initial stage of the project itself. This division should have an Environmental Officer and an Environment Engineer. The task of the division would be to supervise and coordinate studies, environmental monitoring and implementation of environmental mitigation measures, and it should report directly to Chief Engineer of the Project Authority.

### 3.5. Implementation Plan, Schedule and Cost

88. MDB Corridor 3 will be implemented under design consultant and civil work contracts. There will be several packages for different components such as civil works contracts, detailed design, system contracts, supply and installations, rolling stocks etc. It is estimated that project will be constructed over a period of 53 months from award of civil construction contracts. The operation is expected to start by 2026. Table 3.4 shows the detailed schedule.

89. The total capital cost of MDB Corridor 3 for December 2018 including taxes and duties, excluding SIPCOT depot, is estimated at USD 290 million.

**Table 3-4: Implementation Schedule- CMRL Phase 2- MDB Corridor C3**

| | | Updated | 11/23/2020 |
|---|---|---|---|
| **DESCRIPTION** | **START** | **FINISH** | **REMARKS** |
| **LAND ACQUISITION** | Jan/19 | Dec-20 | WIP |
| **GEO TECH INVESTIGATION** | | | |
| Inviting the Tender for Geo tech Investigation, Evaluation & Awarding work | Jan-19 | Jun-19 | COMPLETED |
| Geo Tech. & Survey Works | Jun-19 | Jan-20 | COMPLETED |
| **DETAILED DESIGN CONSULTANT** | | | |
| Invite & Awarding tender for Detail Design Consultant Works | Aug-18 | Mar-19 | COMPLETED |
| DDC -Execution of wok | Mar-19 | Mar-25 | WIP |
| **GENERAL CONSULTANCY** | | | |
| Invite & Awarding tender for General Consultancy | Jan-20 | Dec-20 | |
| GC works | Jan-21 | Dec-26 | |
| **CONSTRUCTION VIADUCT** | | | |
| Inviting & Awarding Tender for Viaduct Construction | Dec-20 | Jun-21 | |
| Construction of Viaduct | Jul-21 | Jul-24 | |
| **CONSTRUCTION OF ELEVATED STATION** | | | |
| Inviting & Awarding Tender for Elevated Station Construction with Arch. Finishes | **Dec-20** | Jun-21 | |
| Construction of Elevated Station with Arch. Finishes | Jul-21 | Jul-24 | |
| **TRACK CONTRACT** | | | |
| **Supply of rails for tracks** | | | |
| Iniviting & Awarding tender for supply of rails - tracks | **Apr-21** | Aug-21 | |
| Execution of work | Aug-21 | Sep-22 | |
| **Installation of Rails, turnout, fasterning etc** | | | |
| Inviting & Awarding tender for track work laying | Aug-22 | Dec-22 | |
| Execution of work | Jan-23 | Jan-25 | |
| **CMRS INSPECTION & COMMISSIONING** | Sep-25 | Nov-25 | |

*Source: CMRL Nov. 2020*

# 4. ENVIRONMENTAL BASELINE

90. The collection of current baseline information on physical, ambient, ecological and socioeconomic environment of the project area of influence, provides an important reference for conducting an EIA. The description of environmental settings include the characteristic of area in which the project activities would occur and likely to be affected by project related impacts. Compiled existing baseline conditions include primary data on air quality, water quality, noise, vibration, soil, ecology and biodiversity, and socioeconomic aspects. Secondary data were also collected from published source and various government agencies.

## 4.1. Data Collection Methodology

91. The data on water, air, and noise were collected through field monitoring conducted in Nov/Dec 2019. Vibration measurements were done at identified sensitive receptors in March 2020. Data on biodiversity was collected through the field studies in May 2018. Meteorological data was collected from India Meteorological Department. Efforts have been made to compile the available data from literature, books, maps and reports. The methodology adopted for data collection is highlighted wherever necessary. Environmental attributes and samplings of baseline surveys are presented in Table 4.1 and monitoring locations are presented in Table 4.2, Table 4.16, Figure 4.2, Figure 4.7 and Figure 4.8. The detailed analysis reports received from the monitoring laboratory are provided in Annexure 1, whereas summary from the reports are discussed in respective sections.

**Table 4-1: Environmental Attributes and Data Source**

| Sl. No | Attribute | Parameter | No. of Samples | Source |
|---|---|---|---|---|
| **Physical Environment** | | | | |
| 1. | Geology | Geological Status | --- | Literature review |
| 2. | Seismology | Seismic Hazard | --- | Literature review |
| 3. | Climate | Climate Parameters | --- | Literature review |
| 4. | Soil Quality | Physio-chemical parameters | 3 | Sampling/ Monitoring locations |
| **Ambient Environment** | | | | |
| 5. | Water Quality | Physical, Chemical and Biological parameters | 2 (Groundwater) 1 (Surface) | Sampling/ Monitoring locations |
| 6. | Ambient Air Quality | PM, $SO_2$, $NO_2$, CO, | 3 | Sampling/ Monitoring locations |
| 7. | Noise | Noise levels in dB (A) Lmax, Lmin, Leq, L10, L50, L90 | 6 (Sample Sensitive Receptors) | Sampling/ Monitoring locations |
| 8. | Vibration | Peak Particle Velocity in mm/s | 4 (Sample Sensitive Receptors) | Sampling/ Monitoring locations |
| **Ecological Environment** | | | | |
| 9. | Flora and Fauna | Number | Once | Field Studies, Literature review |
| **Socio-Economic Environment** | | | | |
| 10. | Socio-economic aspects | Socio-economic profile | Once | Field Studies by Social Team, Literature review. |

**Table 4-2: Details of Sampling / Monitoring Locations***

| S. No | Distance from Sampling Location to Alignment | Land Use** |
|---|---|---|
| 3I | Sholinganallur Lake, 8m, A,W,S | Surface water body |
| 3J | Navallur Bus Stop, 10m, A,W,S | Residential+ Industrial; groundwater |
| 3K | SIPCOT, 2m, A,W,S | Industrial/institutional; groundwater |
| 1C3 | Corner Stone Revival Church, 24m N | Silence zone in Residential+ Industrial area |
| 2C3 | Veerasakthi Vinayagar Temple, 24m N | |
| 3C3 | Sri Bala Vinayagar Temple, 35m N | |
| 4C3 | St Joseph College of Engineering, 45m N | |
| 5C3 | Jamia Masjid Islamic Centre , 50m N | |
| 6C3 | Madhura hospital, 88m N | |

*A: Air, W: Water; S: Soil, N: Noise*
**Locations for vibration at sensitive receptors are listed under Table 4.16, Figure 4.8*
***As per CPCB guideline which is presented under Noise Section*

92. The environmental baseline monitoring were conducted by NABL accredited Pollucare Engineers India Private Limited during the period of 10.12.2019 to 15.12.2019 for Air, water and noise. The ecological survey was conducted by Dr Arivazhagan during 16th November 2020 to 15th December 2020.

93. Sampling locations were selected to represent land uses along the alignment namely silence zone under religious and educational use in industrial, institutional and residential areas. The baseline information is categorized as physical, ambient, ecological and socioeconomic environment with depiction in following sections.

94. Further 38 environmentally sensitive receptors located within 200m on either side of alignment as listed in Annexure 2 have been identified from site reconnaissance, comprising educational centres, religious places and hospitals. To elaborate the baseline, a full set of baseline of air, water (surface and ground), soil, noise and vibration will be collected by the contractor prior to the construction commencement.

**Criteria for choice of parameters of pollution**:

95. The criteria are mentioned separately under heads of soil, water and noise measurements in subsequent paragraphs. They are summarized here. Concentration of nitrogen dioxide is strongly correlated with those of other toxic pollutants, and being the easier to measure, is often used as a surrogate for the pollutant mixture as a whole. Wide adverse effects of particulate matter are observed in both short-term and long-term exposures; it is possible to derive a quantitative relationship between particulate matter and specific health outcomes.. The biggest source of lead in air is petrol and mining: neither of them are present in Chennai and so lead was not measured. Ammonia was not measured because it is highly reactive making it difficult for monitoring instruments to capture it; uncertainty surrounding sources; the gas can have a very short life span. Ozone is a secondary pollutant resulting from action of nitrogen oxides and VOCs; nitrogen oxides are measured as dioxide and therefore ozone was not measured.

96. Quality parameters for drinking water quality which also cover general effluent discharge were measured.

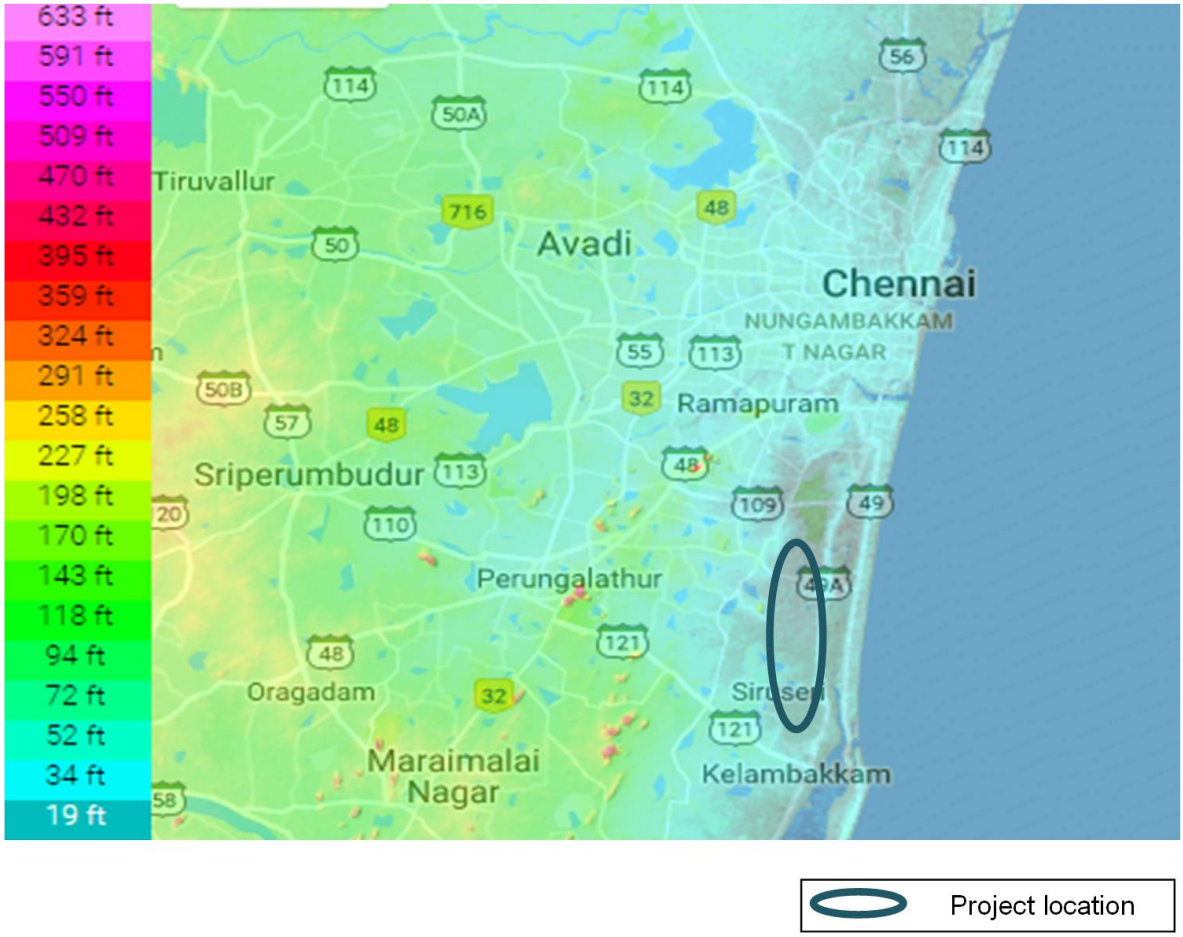
97. Contamination of soil by hydrocarbons and pesticides is not observed in the project area and therefore other parameters including metals were measured. Soil sampling depth was 20cm to 30cm subject to depth of top filled up soil.

## 4.2. Physical Environment

### 4.2.1 Physiography

98. Chennai is located on the South–Eastern coast of India in the North–Eastern part of Tamil Nadu. It is situated on a flat coastal plain that's why it is also known as the Eastern Coastal Plains. The study area is lies between Latitude of 13° 10' N to 12° 49' N and Longitude of 80° 10' E to 80° 14' E. Chennai is a low-lying area and the land surface is almost flat. It rises slightly as the distance from the sea-shore increases but the average elevation of the city is not more than 3 m above mean sea-level, while most of the localities are just at sea-level and drainage in such areas remains a serious problem. The topographical setting of project area is shown in Figure 4.1.

**Figure 4-1: Topographical setting of Project Area**




### 4.2.2 Soil

99. Locations of monitoring quality of soil, water and air are depicted in Figure 4.2. The laboratory analysis results for soil are reported in Table 4.3. Organic matter content in soils remained below 2%. Geotechnical investigations in 2016 during preparation of DPR 2018 showed that from Satyabama to SIPCOT 1 (app. 5.7km long) weathered rock was found at

depth 5m below ground level but hard rock was not found upto depth 30m; from Sholinganallur to Sri Ponni Amman Temple and SIPCOT 1 to stabling area (total app. 3.5km), weathered rock was found at depth 1m to 5m and hard rock was found at depth 12.5m to 25m. In the 7.5km long section from Sholinganallur to Siruseri, rock is overlaid by sandy soils of thickness 6m to 18.5m; from SIPCOT 1 to stabling area (app. 1.5km) by clayey soils 6.5m to 11m thick. Cross section based on boreholes is at Figure 4.4. As per CMDA Masterplan section from Sholinganallur to Semmancheri is sandy in nature, as depicted in Figure 4.3.

100. Contamination of soil by hydrocarbons and pesticides is not observed in the project area and therefore other parameters including metals were measured.

**Figure 4-2: Monitoring Locations - Soil, Air, Water by Landuse**


*3 locations 3I,3J,3K; Field Survey: Nov/Dec 2019*

**Table 4-3: Results of Laboratory Analysis of Soil Sample**

| SN | Parameter | Unit | 3I | 3J | 3K | Soil standards |
|---|---|---|---|---|---|---|
| 1 | pH (at 250C) | | 6.42 | 7.8 | 6.66 | 6.0* |
| 2 | Conductivity (1:2 soil water sus.) | mS/cm | 82 | 88 | 42 | 1* |
| 3 | Chloride | mg/kg | 14.5 | 34.5 | 72.6 | - |
| 4 | Available Nitrogen | Kg/hec | 1.1 | 0.18 | 0.41 | - |
| 5 | Total Zinc as Zn | mg/kg | 48.2 | 5.6 | 6.2 | - |
| 6 | Manganese as Mn | mg/kg | 8.2 | 6.2 | 1.8 | - |
| 7 | Total Lead as Pb @ | mg/kg | <0.1 | <0.1 | <0.1 | - |
| 8 | Total Copper as Cu | mg/kg | 2.3 | 5.8 | 38.3 | - |
| 9 | Organic Carbon | % | 0.93 | 0.68 | 0.62 | - |
| 10 | Water Soluble Sulphate | mg/kg | 18.6 | 24.3 | 52.3 | - |
| 11 | Boron | mg/kg | 32 | 8.1 | 7688 | - |
| 12 | Iron | mg/kg | 675 | 426 | 515 | - |
| 13 | Nickel | mg/kg | <0.1 | <0.1 | <0.1 | 130 |
| 14 | Bicarbonate | mg/kg | 12 | 36 | 32 | - |
| 15 | Calcium | mg/kg | 5.8 | 13.8 | 29.1 | - |
| 16 | Magnesium | mg/kg | 84.3 | 32.3 | 18.3 | - |
| 17 | Sand | % | 37.8 | 48.1 | 55.7 | - |
| 18 | Silt | % | 38.2 | 36 | 28 | - |
| 19 | Clay | % | 24 | 15.9 | 16.3 | - |
| 20 | Sodium | mg/kg | 1210 | 958 | 813 | - |
| 21 | Potassium | kg/hec | 52.4 | 107 | 138 | - |
| 22 | Sulphur | mg/kg | 6.2 | 8.1 | 17.5 | - |
| 23 | Organic Matter | % | 1.61 | 0.78 | 1.38 | - |
| 24 | Orthophosphate | mg/kg | 794 | 21 | 0.36 | - |
| 25 | Carbonate | mg/kg | 8 | 18 | 21 | - |
| 26 | Arsenic | mg/kg | <0.1 | <0.1 | <0.1 | 32 |
| 27 | Mercury | mg/kg | <0.1 | <0.1 | <0.1 | 1 |
| 28 | Cadmium as Cd | mg/kg | <0.1 | <0.1 | <0.1 | 10 |
| 29 | Molybdenum | mg/kg | <0.1 | <0.1 | <0.1 | - |
| 30 | Available Nitrogen | Kg/hec | 20625 | 3375 | 11 | - |

** As per Bureau of Indian Standards. The rest are as per UK Soil Guideline Values (SGV) for residential area (http://www.environmentagency.gov.uk/clea))*
*3 locations 3I to 3K Nov/Dec 2019, @ EPA screening limit soil residential 1200ppm eq to 1200mg/kg Source: https://www.atsdr.cdc.gov*

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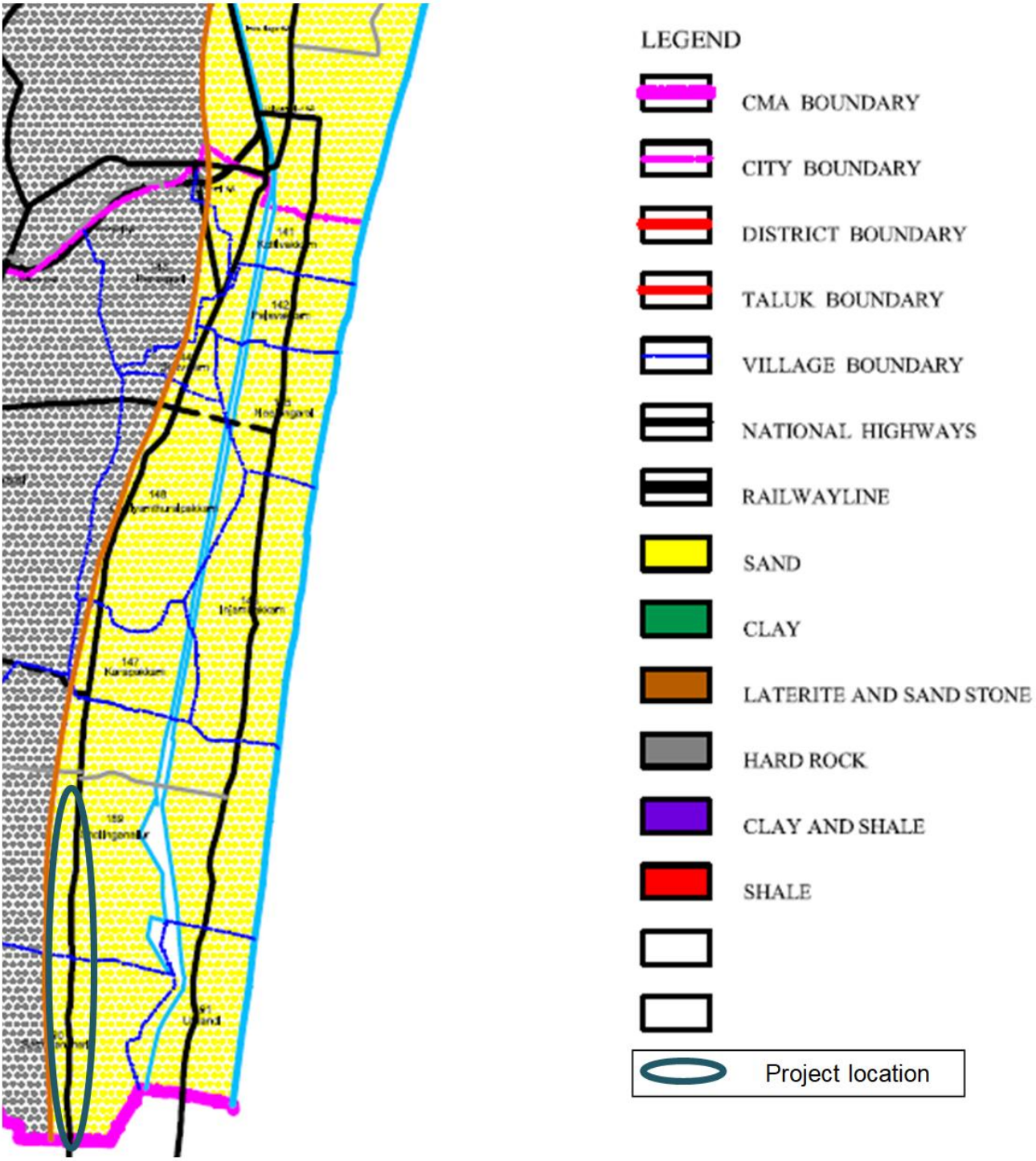
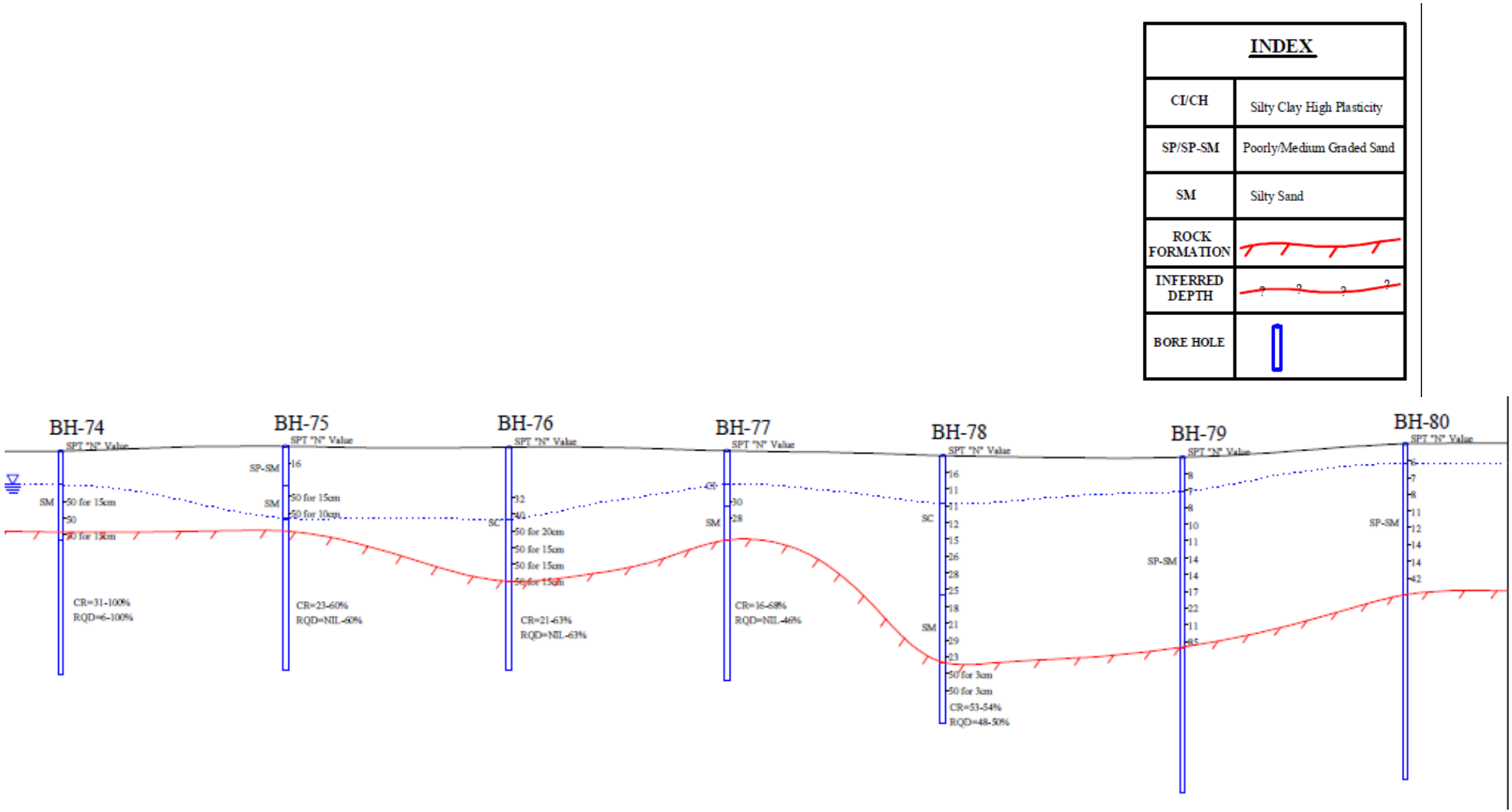
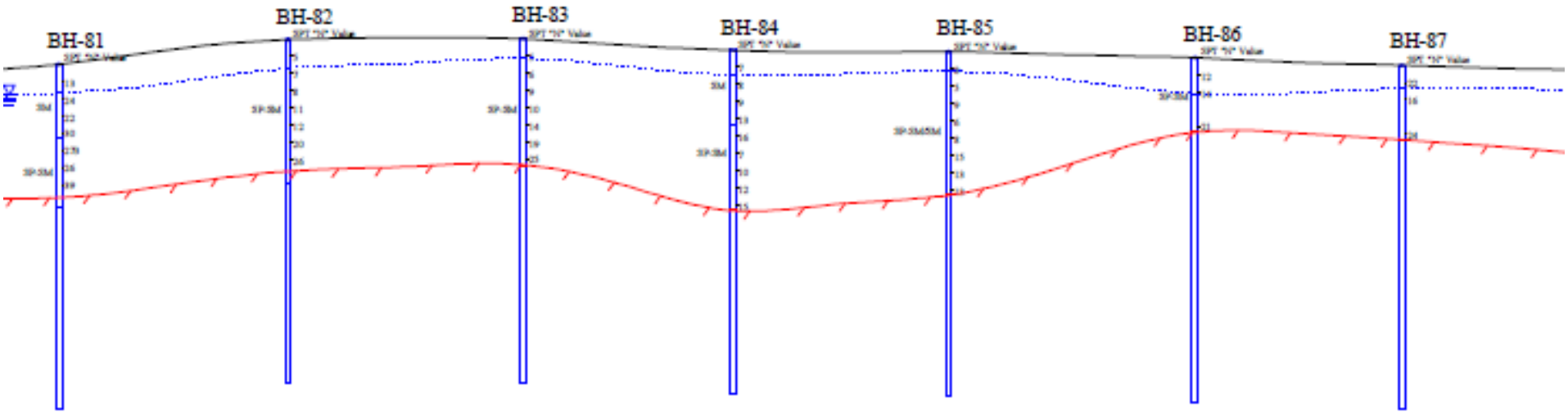
**Figure 4-3: Soil Types in CMA**

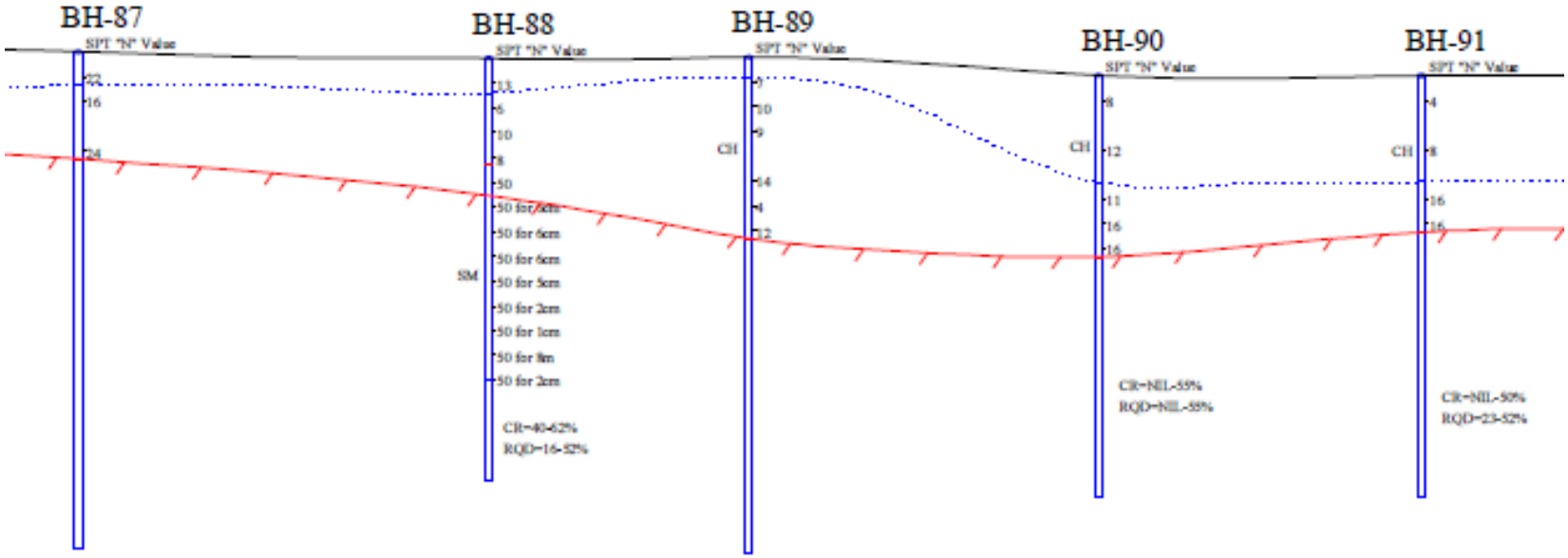



*Second Master Plan for Chennai Metropolitan Area 2026, CMDA*

**Figure 4-4: Soil cross section from boreholes**




BH-81
BH-82
BH-83
BH-84
BH-85
BH-86
BH-87


BH-87
BH-88
BH-89
BH-90
BH-91
SPT "N" Value
CH
SM
50 for 6cm
50 for 5cm
50 for 2cm
50 for 1cm
50 for 8m
50 for 2cm
CR=40-62%
RQD=16-52%
CR=NIL-55%
RQD=NIL-55%
CR=NIL-50%
RQD=23-52%

### 4.2.3 Geology and Minerals

101. The geological formations in the region are from the Archaeans to the recent Alluvium (Table 4.4). The geological formations can be grouped into three units, namely (i) the Archaean crystalline rocks, (ii) consolidated Gondwana with Tertiary sediments and (iii) the recent Alluvium. Most of the geological formations are concealed by the alluvial materials, except for a few exposures of crystalline rocks like charnockites along the railway track in Guindy area. The thickness of Gondwana shales is highly variable in the city.

**Table 4-4: Geological Formation in the Project Area**

| Geological succession in Chennai district Group | System | Age | Lithology | Aquifer Characteristics |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| Quarternary | Recent | Sub-Recent | Soils, Alluvium (sand & silt) | Moderate to good porous aquifer system |
| Tertiary | (Cuddalore Sandstone equivalents) | Eocene to Piliocene | Sandstone & and shale (fossiliferous) | Moderately Porous Aquifer |
| ---UNCONFIRMITY--- | | | | |
| Mesozic | Upper Gondwana (Sri Perumbudur Beds) | Lower Cretaceous to Lower Jurassic | Brown Sandstone and siltstone; Grey shale; Black shale | Less Porous aquifer with minor fractures |
| ---UNCONFIRMITY--- | | | | |
| Azoic | Archaean | -- | Charnockites, Granites, Gneisses | Fractured Aquifer |

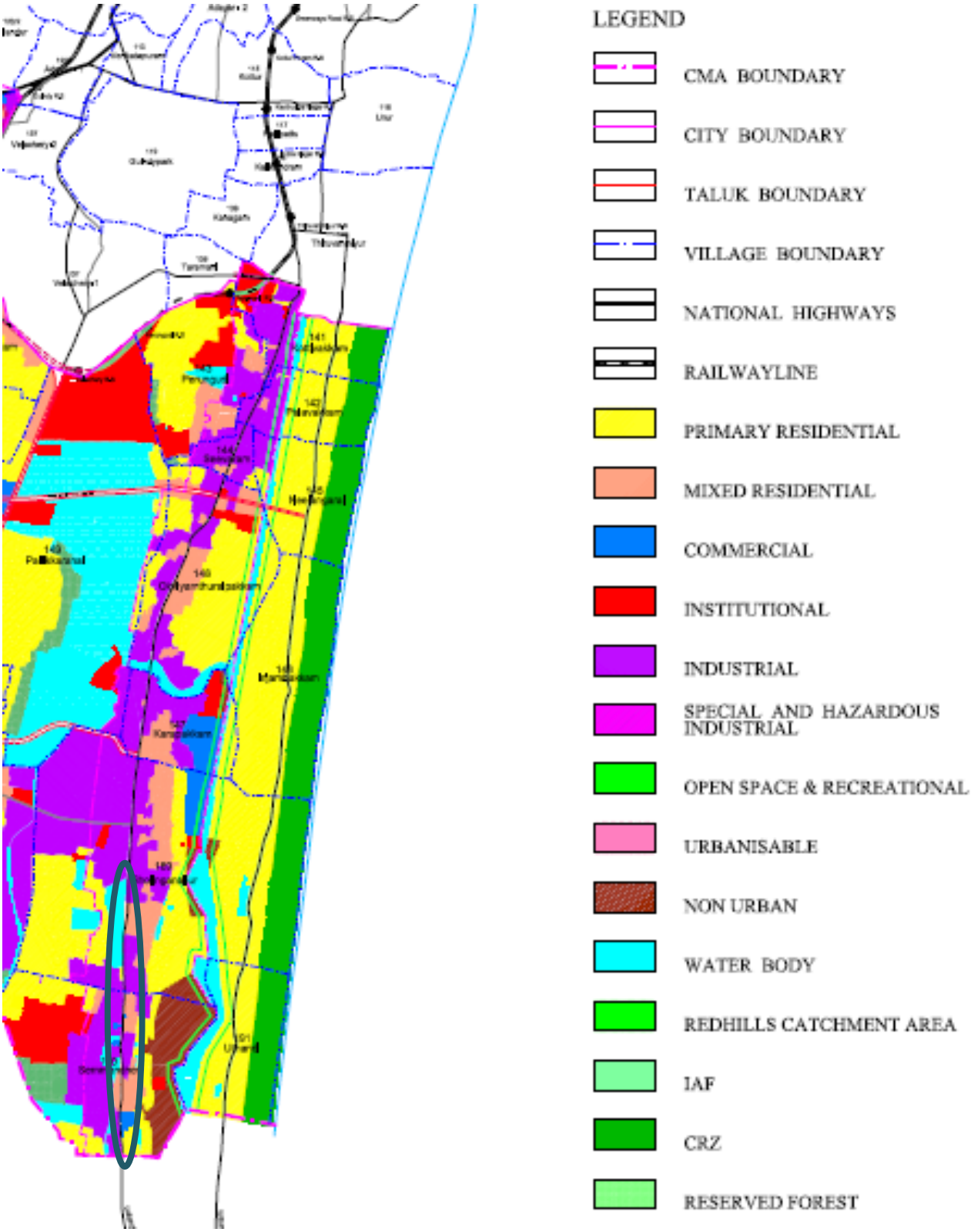
*Source: cpheeo.nic.in*

### 4.2.4 Land Use

102. Land use along the alignment of MDB Corridor 3 is residential cum industrial upto Siruseri and industrial thereafter. Land use along the project corridor is depicted in Figure 4.5.

103. The highlights of land use in CMA and along the project corridor are listed in Table 4.5. It can be seen that Chennai Masterplan 2026 planned 14.5% decrease in area under residential and employment activities in Chennai City from 2006 to 2026 while projecting 26.5% increase in population of Chennai city (from est. 46.28 lakh by year 2006 to est. 58.56 lakh by 2026). This means increase in densities translating into improved utilization of high capacity system like metro rail. Maps with planned landuse for 2026 can be found at CMDA's website (***http://cmdalayout.com/landusemaps/landusemaps.aspx***).

**Figure 4-5: Land Use in Chennai Metropolitan Area**




*Source: Second Master Plan for Chennai Metropolitan Area, 2026*

**Table 4-5: Land use in CMA**

| | Land use 2006 | | Land use 2026 | |
|---|---|---|---|---|
| | Area (ha)* | | | |
| **Land use** | **Chennai City** | **Rest of CMA** | **Chennai City** | **Rest of CMA** |
| Residential | 9523 | 22877 | 8342 | 45593 |
| Commercial | 1245 | 390 | 714 | 880 |
| Industrial | 908 | 6563 | 822 | 10690 |
| Institutional | 3243 | 3144 | 2868 | 3888 |
| Open Space and Recreational | 366 | 200 | 1000 | 392 |
| Agricultural | 99 | 12470 | Nil | 7295 |
| Non-urban | 82 | 2433 | 113 | 2333 |
| Others | 2087 | 56507 | 3754 | 28147 |
| Urbanisable | Nil | Nil | Nil | 2075 |
| Total | 17553 | 104584 | 17613 | 101293 |

** Rounded off* *Source: Second Master Plan for Chennai Metropolitan Area, 2026*

104. Land use along the alignment is summarized below.

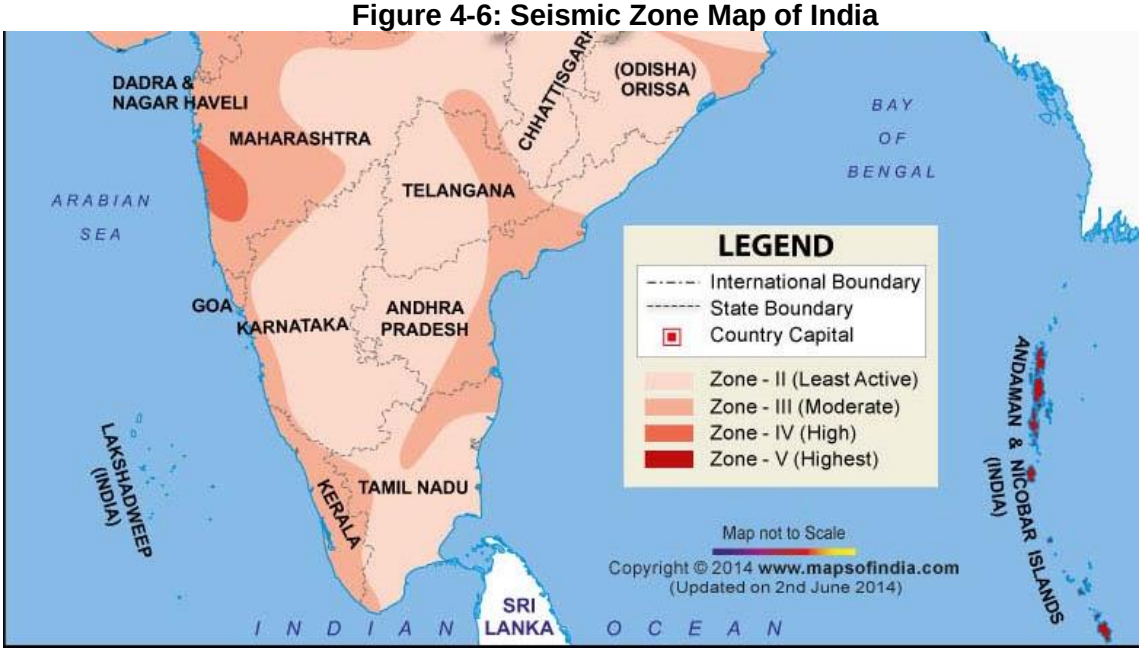
**Table 4-6: Land use abutting the Alignment**

| Section / station | Landuse |
|---|---|
| Sholinganallur | Industrial & Residential |
| Sholinganallur Lake to Semmancheri | Industrial & Residential |
| Semmancheri to Siruseri | Industrial & Residential |
| Siruseri to SIPCOT 2 | Industrial |

### 4.2.5 Seismicity

105. As per seismic zoning map of India shown at Figure 4.6, Tamil Nadu and Chennai are located in Moderate Seismic Zone (Zone III–BIS: 1893 (2001)).

**Figure 4-6: Seismic Zone Map of India**




106. Last reported tremor in Chennai was on 12 February 2019 due to earthquake measuring 5.1 Richter (Source: IMD) with epicenter 10 km deep in Bay of Bengal.

### 4.2.6 Meteorology

#### 4.2.6.1 Temperature

107. Chennai has a tropical wet and dry climate. The city lies on the thermal equator and is also on the coast, which prevents extreme variation in seasonal temperature. Meteorological data like monthly total rainfall, maximum & minimum temperature, wind rose and relative humidity of the Chennai for a period of Jan 2011 to Dec 2017 collected from Indian Meteorological Department (IMD). Table 4.7 and Table 4.8 depicts that the hottest part of the year is May with maximum temperature varies 41.0°C to 43.0°C. The coolest part of the year is January, with minimum temperature varies 17.7°C to 20.3°C.

**Table 4-7: Monthly Highest Maximum Temperature (Deg C)**

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2011** | 31.1 | 32.6 | 37.7 | 35.7 | 41.7 | 38.6 | 38.0 | 36.9 | 36.4 | 35.4 | 32.6 | 31.6 |
| **2012** | 31.2 | 33.6 | 36.3 | 35.6 | 42.5 | 42.4 | 38.8 | 37.3 | 36.8 | 36.0 | 33.6 | 31.0 |
| **2013** | 30.9 | 32.5 | 35.1 | 37.4 | 42.7 | 39.7 | 38.3 | 36.9 | 35.7 | 35.6 | 33.6 | 32.1 |
| **2014** | 30.6 | 32.3 | 36.6 | 38.6 | 42.8 | 41.8 | 39.2 | 38.5 | 36.7 | 36.2 | 32.5 | 31.8 |
| **2015** | 31.3 | 33.1 | 35.1 | 36.8 | 42.2 | 39.6 | 41.0 | 37.6 | 36.9 | 35.7 | 32.6 | 32.4 |
| **2016** | 33.0 | 34.0 | 39.0 | 41.0 | 41.0 | 39.0 | 37.0 | 38.0 | 37.0 | 37.0 | 34.0 | 31.0 |
| **2017** | 31.0 | 36.0 | 36.0 | 41.0 | 43.0 | 41.0 | 39.0 | 37.0 | 36.0 | 36.0 | 34.0 | 33 |

*Source: Regional Meteorological Centre, Chennai*

**Table 4-8: Monthly Lowest Minimum Temperature (Deg C)**

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2011** | 18.7 | 17.7 | 20.1 | 23.5 | 23.1 | 22.7 | 23.1 | 20.5 | 21.6 | 22.6 | 18.7 | 19.0 |
| **2012** | 17.7 | 19.2 | 22.4 | 25.7 | 27.1 | 24.2 | 22.6 | 23.7 | 22.0 | 22.2 | 17.6 | 20.7 |
| **2013** | 19.0 | 19.5 | 20.4 | 25.3 | 24.8 | 24.7 | 23.2 | 23.6 | 23.0 | 23.8 | 22.0 | 19.1 |
| **2014** | 20.3 | 19.0 | 22.1 | 25.6 | 24.3 | 23.0 | 23.6 | 22.9 | 23.7 | 23.4 | 21.3 | 21.0 |

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2015** | 19.0 | 20.8 | 23.2 | 23.5 | 25.6 | 24.6 | 23.9 | 23.1 | 23.5 | 24.3 | 22.4 | 21.5 |
| **2016** | 19.0 | 20.0 | 23.0 | 25.0 | 25.0 | 24.0 | 24.0 | 24.0 | 23.0 | 22.0 | 19.0 | 19.0 |
| **2017** | 19.0 | 19.0 | 22.0 | 26.0 | 27.0 | 25.0 | 24.0 | 24.0 | 24.0 | 23.0 | 23.0 | 21 |

*Source: Regional Meteorological Centre, Chennai*

#### 4.2.6.2 Rainfall

108. The city gets most of its seasonal rainfall from the North–East monsoon, from October to December. South-West monsoon prevails from June to September. Cyclones in the Bay of Bengal sometimes hit the city. 1,049.3mm recorded in November 2015 was due to an extreme weather event which resulted in widespread flooding. The highest recorded monthly rainfall was 1,088 mm in November 1918. The monthly rainfall is given in Table 4.9.

**Table 4-9: Monthly Rainfall (mm)**

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2011** | 10.8 | 88.9 | 0.0 | 18.5 | 12.6 | 130.2 | 67.4 | 368.9 | 286.2 | 260 | 457.2 | 134.8 |
| **2012** | 16.3 | 0.0 | 1.6 | 0.2 | 0.0 | 24.7 | 79.9 | 89.5 | 214.1 | 422.6 | 47.0 | 125.5 |
| **2013** | Trace | 14.3 | 11.9 | 3.6 | 3.6 | 34.0 | 146.6 | 195.1 | 240.1 | 157.2 | 193.7 | 85.9 |
| **2014** | 0.1 | 9.9 | 0.0 | 0.0 | 13.5 | 96.2 | 69.7 | 222.6 | 130.8 | 405.5 | 196.9 | 149.9 |
| **2015** | 2.8 | 0.0 | 0.0 | 12.3 | 7.9 | 20.3 | 205.9 | 106.5 | 75.0 | 159.9 | 1,049.3 | 454.7 |
| **2017*** | 0.0 | 5.0 | 2.5 | 0.0 | 0.5 | 60.0 | 55.0 | 90.0 | 65.0 | 160.0 | 155.0 | 9.0 |

*Source: Regional Meteorological Centre, Chennai, *www.meteoblue.com*

#### 4.2.6.3 Humidity

109. Mean Relative Humidity is presented in Table 4.10 and Table 4.11. It varies 56% to 88% at 08:30 hrs and 57% to 81% at 17:30 hrs. 2016 and 2017 data were collected at different time slots.

**Table 4-10: Monthly Mean Relative Humidity at 08:30 hrs (%)**

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2011** | 82 | 81 | 77 | 75 | 64 | 60 | 70 | 79 | 80 | 84 | 85 | 88 |
| **2012** | 83 | 77 | 76 | 72 | 65 | 56 | 68 | 73 | 76 | 83 | 80 | 84 |
| **2013** | 88 | 84 | 80 | 77 | 73 | 61 | 80 | 83 | 82 | 86 | 86 | 80 |
| **2014** | 78 | 79 | 72 | 72 | 67 | 64 | 70 | 78 | 77 | 82 | 82 | 83 |
| **2015** | 83 | 81 | 74 | 72 | 69 | 66 | 70 | 77 | 77 | 83 | 91 | 86 |
| **2016*** | 94 | 100 | 94 | 94 | 100 | 100 | 100 | 100 | 100 | 94 | 100 | 100 |
| **2017*** | 100 | 94 | 94 | 94 | 89 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

*Source: Regional Meteorological Centre, Chennai, * at 05.30 hrs (www.timeanddate.com)*

**Table 4-11: Monthly Mean Relative Humidity at 17:30 hrs (%)**

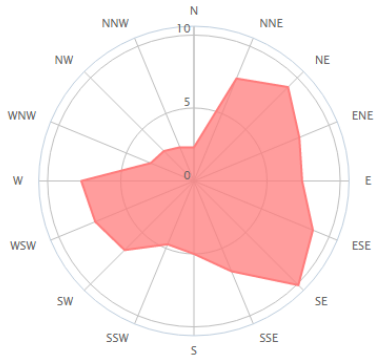
| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2011** | 60 | 61 | 59 | 67 | 65 | 58 | 57 | 69 | 74 | 80 | 76 | 67 |
| **2012** | 68 | 61 | 68 | 70 | 65 | 59 | 61 | 70 | 73 | 77 | 73 | 78 |
| **2013** | 75 | 72 | 69 | 77 | 74 | 60 | 76 | 76 | 78 | 81 | 81 | 73 |
| **2014** | 69 | 67 | 64 | 68 | 68 | 66 | 65 | 74 | 75 | 80 | 77 | 76 |
| **2015** | 73 | 71 | 67 | 69 | 69 | 65 | 70 | 71 | 75 | 78 | 87 | 78 |
| **2016*** | 38 | 30 | 29 | 30 | 30 | 37 | 37 | 33 | 37 | 30 | 27 | 27 |
| **2017*** | 35 | 24 | 38 | 23 | 25 | 16 | 33 | 42 | 47 | 36 | 43 | 40 |

*Source: Regional Meteorological Centre, Chennai, *at 14.30 hrs (www.timeanddate.com)*

#### 4.2.6.4 Wind

110. The wind rose diagram has been prepared based on the daily data for the period of 10/2009 to 08/2016. The prominent direction is NE, ESE and SE. Wind rose diagram for the Chennai is shown in Figure 4.7.

**Figure 4-7: Wind Rose Diagram for Chennai**




### 4.3. Ambient Environment

111. In order to assess the impact on existing ambient environment it is necessary to have baseline status of ambient environmental parameters.

#### 4.3.1 Water Resources

112. As the city lacks a perennial water source, catering the water requirements of the population has remained an arduous task. Ground water levels from 2013 to 2016 were up to 10m below ground in pre-monsoon as well as post-monsoon seasons and rise in water level of up to 4m in 80% to 90% of observation wells in Chennai district between pre-monsoon and post-monsoon months. From May 2016 and January 2017, the ground water levels were up to 4m in 46% of observation wells (Groundwater Yearbook of Tamil Nadu and UT Puducherry, Central Groundwater Board).

113. As per data provided by Chennai water authority, in 2017 quantity of water stored in the four reservoirs namely Red Hills, Cholavaram, Chembarambakkam and Poondi lakes was total of 4,365 mcft or 330 Million Liter per Day (MLD). In May 2019 the combined storage of these reservoirs was about 160 mcft or 8 MLD. On 19 June 2019, Chennai city officials declared that "Day Zero", or the day when almost no water is left, had been reached, as all the four main reservoirs supplying water to the city had run dry. Two years of deficient monsoon rainfall, particularly in late 2017 and throughout much of 2018 had led to this crisis (India Today 20 June 2019).

114. Chennai receives about 985 MLD from various sources against the required amount of 1,200 MLD. As of year 2018, 300 million litres of water was estimated to have been be sourced from the four reservoirs in Chennai with their storage standing at 40% of their capacity; 180 MLD from the desalination plants in Minjur and Nemmeli and 70 MLD (against the usual 180 MLD) from Veeranam tank. Krishna water of about 400 MLD supplements these sources; and other water sources, including abandoned stone quarries, agriculture wells and Neyveli Corporation mines. (Down to Earth 22 May 2019).

115. Table 4.12 shows ground water levels upto 10 m below ground in pre-monsoon as well as post-monsoon seasons and rise in water level of upto 4 m in 80% to 90% of observation wells in Chennai district between pre-monsoon and post-monsoon months upto January 2017. During geotechnical investigations conducted in August 2016, groundwater level was found to be w at 1.2m to 6.5m below ground level.

116. From Satyabama to SIPCOT 1 (app. 5.7km long) weathered rock was found at depth 5m below ground level but hard rock was not found upto depth 30m; from Sholinganallur to Sri Ponni Amman Temple and SIPCOT 1 to stabling area (total app. 3.5km), weathered rock was found at depth 1m to 5m and hard rock was found at depth 12.5m to 25m. In the 7.5km long section from Sholinganallur to Siruseri, rock is overlaid by sandy soils of thickness 6m to 18.5m; from SIPCOT 1 to stabling area (app. 1.5km) by clayey soils 6.5m to 11m thick. In spite of high water table and porous sandy soil, the use of cast in situ piles with liner could result in dewatering of moderate magnitude.

**Table 4-12: Ground water level in Chennai District**

| **Month/year** | **% of observation wells in each range of water level (m) below ground level** | | | **Rise (m) in water level** | **Fall (m) in water level** |
|---|---|---|---|---|---|
| | **0 to 2** | **2 to 5** | **5 to10** | | |
| May 2013 | *8* | 54 | 38 | 60% wells <2m, 30% wells 2m to 4m | 100% wells <2m |
| January 2014 | *36* | 36 | 29 | | |
| May 2014 | *14* | 33 | 53 | 50% wells <2m, 30% wells 2m to 4m, 20% wells >4m | Zero |
| January 2015 | *56* | 25 | 19 | | |
| May 2015 | *14* | 50 | 36 | 60% wells <2m, 30% wells 2m to 4m, 10% wells >4m | Nil |
| January 2016 | *41* | 47 | 12 | | |
| May 2016 | 24 | *59* | 17 | 83% wells <2m | 86% wells <2m |
| January 2017 | 14 | *79* | 7 | | |

*Source: CGWB Yearbooks for Tamil Nadu and Puduchery*

### 4.3.2 Drainage

117. Adyar River originates at the confluence (Thiruneermalai) of two streams that drains the upstream area of Chembarambakkam tank. It is a small river of 42 km length and a catchment of 800 Sq. km. The river carries flow all through 365 days of a year with an average discharge of 89.43 MCM/Year at Kathipara cause way. It drains the southern part of the district and remains flooded during monsoon. During the high tides, the backwater from the Bay of Bengal enters inland up to 3 – 4 km.

118. Cooum is the other main river flowing through the central part of the district and carries only drainage water, which is highly polluted. It originates from the surplus waters from the Cooum tank in Tiruvallore taluk and the tanks, which are in enroute, discharge their surplus water into the river during flood season. The flow of Cooum River at Korattur is 40.2 MCM/year for an average duration of 31 days in a year.

119. Otteri Nulla is another small stream flowing in the northern part of the city. Buckingham canal is the man made one for navigation purposes earlier, but now it act as sewerage carrier in the city.

### 4.3.3 Water Quality

120. The analysis of water samples is presented in Table 4.13. Laboratory analysis of water sample depicts that the parameters in groundwater samples are well within the prescribed permissible limits for drinking water as per IS 10500-2012 except in pH, chlorides and coliforms.

121. However the measured values for Sholinganallur lake (surface water), except for Nitrate Nitrogen, were within General Quality Standards of Schedule VI Environment Protection Rules (EPR) 1986 for discharge of pollutant effluents in surface water: these standards are applicable for industries, operations or processes other than those industries, operations or process for which standards have been specified (104 industries) in Schedule I of EPR.

122. 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**.** Sholinganallur lake values meet the criteria for propagation of wildlife and fisheries in surface water.

123. The measured values were not compared with CPCB 1978 criteria for irrigation & industrial cooling nor with EPR guide for effluent discharge into irrigation land as the sites are not meant for use in irrigation.

124. Quality parameters for drinking water quality which also cover general effluent discharge were measured.

## Table 4-13: Results of Laboratory Analysis of Water Sample

| S.N | Parameters | Unit | Corridor 3 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | **3I (surface)** | **3J (ground)** | **3K (ground)** | **Acceptable/Permissible Limit for drinking water IS 10500 mg/l** | **Effluent standards – inland surface water EPR 1986 max. mg/l** | Effluent standards IFC/WBG for treated sanitary effluent in mg/l | Wildlife & fisheries - surface water CPCB 1978 Primary criteria mg/l | Drinking water - CPCB 1978 Primary criteria mg/l |
| 1 | pH @ 25ºC | - | 6.91 | 7.84 | 7.61 | 6.5-8.5/no relaxation | 5.5 to 9.0 | 6.0 to 9.0 | 6.5 to 8.5 | 6.5 to 8.5 |
| 2 | Turbidity | NTU | <0.1 | <0.1 | <0.1 | 1/5 max | - | | - | - |
| 3 | Total Dissolved Solids (TDS) @ 180ºC | mg/L | 135 | 375 | 580 | 500/2000 max | - | | - | - |
| 4 | Dissolved Oxygen | mg/L | 6.4 | 2.0 | 1.9 | - | - | | 4 or more | 6 and more |
| 5 | Aluminium (as Al) | mg/L | <0.01 | <0.01 | <0.01 | 0.03/0.2 | - | | - | - |
| 6 | Total Ammonia | mg/L | 3.8 | <1.0 | <1.0 | Total ammonia 0.5 / no relaxation | Free ammonia 5.0 | | Free ammonia. 1.2 or less | - |
| 7 | Total Suspended Solids @ 105ºC | mg/L | <2.0 | <2.0 | <2.0 | 0.5/1 | 100 | 50 | - | - |
| 8 | Barium (as Ba) | mg/L | <0.01 | <0.01 | <0.01 | 0.7/ none | - | | - | - |
| 9 | Boron (as B) | mg/L | <0.01 | <0.01 | <0.01 | 0.5/1.0 | - | | - | - |
| 10 | **Calcium** (as Ca) | mg/L | 15.4 | 29.4 | 57.2 | 75/200 | - | | - | - |
| 11 | **Chloride** (as Cl) | mg/L | 33.5 | 187 | 243 | 4/ none | - | | - | - |
| 12 | Copper (as Cu) | mg/L | 0.12 | <0.01 | <0.01 | 0.3/ no relaxation | 3.0 | | - | - |
| 13 | Fluoride (as F) | mg/L | 0.84 | 0.59 | 0.64 | 1/1.5 | 2.0 | | - | - |
| 14 | Iron (as Fe) | mg/L | 0.18 | 0.41 | 0.28 | 0.3/1.0 | 3.0 | | - | - |
| 15 | Magnesium (Mg) | mg/L | 5.9 | 7.9 | 9.9 | 30/100 | - | | - | - |
| 16 | Manganese (as Mn) | mg/L | 0.14 | <0.01 | <0.01 | 0.1/0.3 | 2.0 | | - | - |
| 17 | Nitrate Nitrogen | mg/L | 16 | <1.0 | <1.0 | 0.01/ no relaxation | 10.0 | | - | - |
| 18 | Total Nitrogen | mg/L | 22.4 | 19.6 | 18.7 | 0.01/ no relaxation | - | 10 | - | - |
| 19 | Oil & Grease | mg/L | <5.0 | <5.0 | <5.0 | - | 10.0 | 10 | - | - |
| 20 | Hexavalent Chromium (as $Cr^{+6}$) | mg/L | <0.01 | <0.01 | <0.01 | 0.05/ no relaxation | - | | - | - |
| 21 | Biochemical Oxygen Demand (BOD)(3 days at 27ºC) | mg/L | 8.6 | <2.0 | <2.0 | 200/600 | 30 | 30 | - | 2 or less |
| 22 | Chemical Oxygen Demand (COD) | mg/L | 32 | <4.0 | <4.0 | 200/600 | 250 | 125 | - | - |
| 23 | Organic Phosphorous | mg/L | 0.18 | 0.15 | 0.11 | 5/15 | 5.0 | 2 | - | - |

| S.N | Parameters | Unit | Corridor 3 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | **3I (surface)** | **3J (ground)** | **3K (ground)** | **Acceptable/Permissible Limit for drinking water IS 10500 mg/l** | **Effluent standards – inland surface water EPR 1986 max. mg/l** | Effluent standards IFC/WBG for treated sanitary effluent in mg/l | Wildlife & fisheries - surface water CPCB 1978 Primary criteria mg/l | Drinking water - CPCB 1978 Primary criteria mg/l |
| 24 | Vanadium (as | mg/L | <0.01 | <0.01 | <0.01 | 0.003/ no relaxation | 0.2 | | - | - |
| 25 | Nitrate (as $NO_3$) | mg/L | 0.16 | 0.12 | 0.19 | 45/ none | - | | - | - |
| 26 | Phenolic Compounds ($C_6H_5OH$) | mg/L | <0.001 | <0.001 | <0.001 | 0.001/ 0.002 | 1.0 | | - | - |
| 27 | Selenium (as Se) | mg/L | <0.002 | <0.002 | <0.002 | 0.1/ no relaxation | 0.05 | | - | - |
| 28 | Silver (as Ag) | mg/L | <0.001 | <0.001 | <0.001 | 0.1/ no relaxation | - | | - | - |
| 29 | Sulphates (as $SO_4$) | mg/L | 1.3 | 38.6 | 44.4 | 200/400 | - | | - | - |
| 30 | Sulphide (as $H_2S$) | mg/L | <1.0 | <1.0 | <1.0 | 0.05/no relaxation | 2.0 | | - | - |
| 31 | Ammonical Nitrogen (as N) | mg/L | <1.0 | <1.0 | <1.0 | - | 50 | | - | - |
| 32 | Total Kjehdahl Nitrogen (as N) | mg/L | <1.0 | <1.0 | <1.0 | - | 100 | | - | - |
| 33 | Zinc (as Zn) | mg/L | 2.6 | 2.1 | 3.5 | 5/15. | 5.0 | | - | - |
| 34 | Cadmium (as Cd) | mg/L | <0.01 | <0.01 | <0.01 | 0.003/ no relaxation | 2.0 | | - | - |
| 35 | Cyanide (as CN) | mg/L | <0.01 | <0.01 | <0.01 | 0.05/ no relaxation | 0.2 | | - | - |
| 36 | Lead (as Pb) | mg/L | <0.01 | <0.01 | <0.01 | 0.01/ no relaxation | 0.1 | | - | - |
| 37 | Mercury (as Hg) | mg/L | <0.0001 | <0.0001 | <0.0001 | 0.001/ no relaxation | 0.01 | | - | - |
| 38 | Nickel (as Ni) | mg/L | <0.01 | <0.01 | <0.01 | 0.02/ no relaxation | 3.0 | | - | - |
| 39 | Total Phosphate | mg/L | 1.3 | 1.6 | 1.3 | - | - | | - | - |
| 40 | Dissolved Phosphate (as $PO_4$) | mg/L | 0.86 | 0.91 | 0.72 | - | 5.0 | | - | - |
| 41 | Arsenic (as As) | mg/L | <0.5 | <0.5 | <0.5 | 0.01/0.05 | 0.2 | | - | - |
| 42 | Chromium (as Cr) | mg/L | <0.5 | <0.5 | <0.5 | 0.05/ no relaxation | Total 2.0 | | - | - |
| 43 | **Total Hardness** (as $CaCO_3$) | mg/L | 62.5 | 106 | 184 | 200/600 | - | | - | - |
| 44 | **Sodium (as Na)** | mg/L | 28 | 35 | 23 | - | - | | - | - |
| 45 | **Potassium (as K)** | mg/L | 6.9 | 8.1 | 9.3 | - | - | | - | - |
| 46 | **Total Alkalinity** (as $CaCO_3$) | mg/L | 56 | 128 | 174 | 200/600 | - | | - | - |
| 47 | Escherichia coli (MPN) | MPN/100ml | 2 | 2 | 4 | Absent | - | | - | - |
| 48 | Total coliform (MPN) | MPN/100ml | 12 | 12 | 13 | Absent | - | *400* | | 50 or less |

| S.N | Parameters | Unit | Corridor 3 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | **3I (surface)** | **3J (ground)** | **3K (ground)** | **Acceptable/Permissible Limit for drinking water IS 10500 mg/l** | **Effluent standards – inland surface water EPR 1986 max. mg/l** | Effluent standards IFC/WBG for treated sanitary effluent in mg/l | Wildlife & fisheries - surface water CPCB 1978 Primary criteria mg/l | Drinking water - CPCB 1978 Primary criteria mg/l |
| 49 | Fecal Coliform | MPN/100ml | 2 | 9 | 4 | Absent | - | | - | - |

3 locations 3I to 3K Nov/Dec 2019

### 4.3.4 Air Quality

125. The air pollutants emitted by point and non-point sources are transported, dispersed or concentrated by meteorological and topographical conditions. The monitoring results for ambient air quality are presented in Table 4.14. 24-hour air quality monitoring results indicates that all parameters were within the permissible level of National Ambient Air Quality Standards (NAAQS). However Particulate Matter (both $PM_{10}$ and $PM_{2.5}$) exceeded WHO guideline. The NAAQS laid down by CPCB and WHO guideline are given in Table 4.15.

126. **Criteria for choice of parameters of pollution**: Particulate matter, carbon monoxide, sulphur dioxide, nitrogen dioxide, ammonia, lead and ozone comprise the Air Quality Index monitored in India. US EPA list of criteria pollutants comprises the above except ammonia. WHO concluded that concentrations of nitrogen dioxide are often strongly correlated with those of other toxic pollutants, and being the easier to measure, is often used as a surrogate for the pollutant mixture as a whole. Wide adverse effects of particulate matter are observed in both short-term and long-term exposures; it is possible to derive a quantitative relationship between the concentration of the pollutant as monitored in ambient air and specific health outcomes (usually mortality). The biggest source of lead in air is petrol and mining: neither of them are present in Chennai and so lead was not measured. Ammonia was not measured because it is highly reactive making it difficult for monitoring instruments to capture it; uncertainty surrounding sources; the gas can have a very short life span. Ozone is a secondary pollutant resulting from action of nitrogen oxides and VOCs; nitrogen oxides are measured as dioxide and therefore ozone was not measured.

**Table 4-14: Ambient Air Quality (24hr Time weighted Average)**

| SN | Parameter | Unit | Corridor – 3 | | |
|---|---|---|---|---|---|
| | | | 3I | 3J | 3K |
| 1 | Sulphur Dioxide ($SO_2$) | µg/m$^3$ | 16.4 | 14.3 | 18.9 |
| 2 | Nitrogen Dioxide ($NO_2$) | µg/m$^3$ | 28.1 | 29.6 | 25.7 |
| 3 | Particulate matter ($PM_{10}$) | µg/m$^3$ | *61.6* | *63.2* | *61.1* |
| 4 | Particulate Matter ($PM_{2.5}$) | µg/m$^3$ | 34.9 | 31.9 | 35.3 |
| 5 | Carbon Monoxide (CO) | mg/m$^3$ | BDL | BDL | BDL |

**Table 4-15: National and International Ambient Air Quality Standards**

| Pollutant | Time weighted Average | Concentration in Ambient Air* | | WHO Guideline |
|---|---|---|---|---|
| | | Industrial, Residential, Rural &Other Area | Ecological Sensitive Area | |
| Sulphur Dioxide ($SO_2$) □g/ m$^3$ | Annual | 50 | 20 | - |
| | 24 Hours | 80 | 80 | - |
| Oxides of Nitrogen ($NO_2$) □g/ m$^3$ | Annual | 40 | 30 | 40 |
| | 24 Hours | 80 | 80 | - |
| Particulate Matter (size less than 10□m) or $PM_{10}$ □g/ m$^3$ | Annual | 60 | 60 | 20 |
| | 24 Hours | 100 | 100 | 50 |
| Particular Matter (size less than 2.5□m) or $PM_{2.5}$□g/m$^3$ | Annual | 40 | 40 | 10 |
| | 24 Hours | 60 | 60 | 25 |
| Carbon Monoxide (CO) mg/ m$^3$ | 24 Hours | - | - | 7 |
| | 8 Hours | 02 | 02 | 10 |

| Pollutant | Time weighted Average | Concentration in Ambient Air* | | WHO Guideline |
|---|---|---|---|---|
| | | Industrial, Residential, Rural &Other Area | Ecological Sensitive Area | |
| | 1 Hour | 04 | 04 | 30 |
| Ozone ($O_3$) □g/m$^3$ | 8 Hours | 100 | 100 | 100 |
| | 1 Hour | 180 | 180 | - |
| Lead (Pb) □g/m$^3$ | Annual | 0.5 | 0.5 | - |
| | 24 Hours | 1.0 | 1.0 | - |
| Ammonia ($NH_3$) □g/m$^3$ | Annual | 100 | 100 | - |
| | 24 Hours | 400 | 400 | - |

**Source: CPCB guidelines for AAQM*

### 4.3.5 Noise

127. The noise data was collected at 6 selected sensitive receptors in year 2019 which are located within 200 m on either side of the alignment (Annexure 2). The noise levels observed are listed in Table 4.16, locations are depicted in Figure 4.8.

**Figure 4-8: Locations of noise and vibration monitoring at sensitive receptors on MDB Corridor 3**


*Noise 6 locs 1C3 to 6C3; Vibration 4 locs C3 F to C3 I; Field Survey: Dec 2019*

**Table 4-16: Ambient Noise Level Monitoring Results dBA (by receptors)**

| S.No | Name of the Sensitive Receptor** | Locations on Corridor 3 | Type of Sensitive Receptor* | Distance from the outer most proposed tracks (m) | Leq (Day) 50 dB(A) | Leq (Night) 40 dB(A) |
|---|---|---|---|---|---|---|
| 1 | Corner Stone Revival Church | Sholinganalur Lake-Poniyamman Temple | Church | 23.84 | 44.4 | 36.6 |
| 2 | Veerasakthi Vinayagar Temple | Ponniyamman Temple - Satyabhama University | Temple | 23.78 | 52.1 | 38.2 |
| 3 | Sri Bala Vinayagar Temple | St Joseph College – Semmanchari | Temple | 34.76 | 43.5 | 36.5 |
| 4 | St Joseph College of Engineering | Satyabhama University - St Joseph College | College | 44.84 | 43.5 | 36.5 |
| 5 | Jamia Masjid Islamic Centre | Gandhinagar – Navallur | Mosque | 49.94 | 47.9 | 37.9 |
| 6 | Madhura hospital | Navallur – Siruseri | Hospital | 88.09 | 43.6 | 35.5 |

*6 locations 1C3 to 6C3 Field Survey Nov/Dec 2019*

** Standards for silence zone as presented in table 4-17 are applicable to hospitals, educational institutions and religious places*

*** A full ist of sensitive receptors along the alignment, including high-rise residential buildings and high-rise hotels, can be found in Annexure 2*

128. The Ambient Noise limits laid down by CPCB and WBG have been given in Table 4.17. The noise level measured at 1 of the 6 receptors (Veerasakthi Vinayagar Temple) along the alignment was above the national daytime permissible limit.

**Tarble 4-17: Ambient Noise Limits**

| Area Code | Category of Area | CPCB Limits dB (A) Leq | | WBG Guideline **(LA eq dB)** | |
|---|---|---|---|---|---|
| | | Day time* | Night time | Day time | Night time |
| A | Industrial | 75 | 70 | 70 | 70 |
| B | Commercial | 65 | 55 | 70 | 70 |
| C | Residential | 55 | 45 | 55 | 45 |
| D | Silence Zone** | 50 | 40 | - | - |

*Source: CPCB guideline (as per The Noise Pollution (Regulation and Control) Rules, 2000) * CPCB day time is from 6.00 AM to 10.00 PM, WHO defines day time as 7.00 AM to 10 PM. Presented data in table 4-17 are based on a day time from 6.00 AM to 10.00 PM. Hourly data can be found in Annex 1*

*; *****Silence Zone*** *is defined as an area up to 100m around premises of Hospitals, Educational Institutions, Courts of law and religious places or any others declared as such.*

*World Bank Group EHS guidelines*

### 4.3.6 Vibration

129. Vibration consists of rapidly fluctuating motions of the particles without any net movement. Objects can vibrate differently in three mutually independent directions which are vertical, horizontal and lateral. It is common to describe vibration levels in terms of velocity, which represents the instantaneous speed at a point on the object that is displaced. Vibrations are transmitted from the source to the ground and propagate through the ground to the receiver. Vibration amplitudes are usually expressed as either peak particle velocity (PPV) or the root mean square (RMS) velocity. PPV is used to evaluate the potential for building damage. It is defined as the maximum instantaneous peak of the vibration signal. PPV is not considered the appropriate measurement for evaluating the human response to vibration as it is typically used for construction noise monitoring. RMS is used to evaluate human response, since it takes some time for the human body to respond to vibration signals.

130. The triaxial transducers are placed at proposed survey location. The signals obtained from all three axes are in horizontal, transverse and vertical directions viz. X- Easting, Y-Northing and Z-Vertical direction. The standard measurable units for velocity are in mm/s. Measuring the peak particle velocity (PPV) is mostly used for representation of vibration when the pressure wave passes through the particles. PPV are expressed in terms of mm/s. Decibel notation acts to compress the range of numbers required to describe vibration; it is also therefore used in vibration reporting.

131. The dynamic analysis and seismic response have been studied for 4 identified sensitive receptors comprising religious, educational institutions and hospitals which are located near by the alignment as shown in Figure 4.8.

132. The induced ground vibration level is summarized in Table 4.18 and monitoring schedule is shown in Table 4.19. All the measurements were done at 100 Hz frequency.

133. Vibration level at 3 (Vinayagar Temple, St Joseph College and Madhura Hospital) out of 4 monitored locations is found to exceed acceptable human annoyance impact criteria for operation of this project. This implies that vibration levels during operation of the metro will certainly be higher than the acceptable values: benefit of attenuation due to mitigating measures will be known upon vibration forecast.

134. The observed levels at all 4 locations are well below the building vibration damage criteria for construction relevant to structures existing at those location: level of PPV 5 mm/sec has been mentioned in EMP as the permissible upper level to be maintained by the contractor during construction. The measured levels are also below limits set by Indian authorities Directorate General of Mines Safety (DGMS) and Central Institute of Mining and Fuel Research (CMFRI or CMRI) which are more relevant for blasting during construction. Need for mitigating measures during construction and their benefit will be known upon vibration forecast. All these standards are placed in Table 4.20.

**Table 4-18: Baseline Vibration**

| SN | Location | Surface | PPV (Maximum) | | | VdB (Maximum) | | | VdB (Average) | | | VdB RMS | | Vd * | PPV # / PPV @ mm/s |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | East | North | Up | East | North | Up | East | North | Up | Max. | Time | | |
| **Part 2** | | | | | | | | | | | | | | | |
| C3-F | Shivalayam Temple | Marble | 0.099 | 0.100 | 0.119 | 71.79 | 71.90 | 73.41 | 58.36 | 67.79 | 67.75 | **70.40 (UP)** | 5:23 PM | **72** | **7.50 / 7.50** |
| C3-G | Vinayagar Temple | Marble | 0.190 | 0.711 | 0.195 | 77.48 | 88.94 | 77.70 | 62.04 | 68.58 | 69.85 | **85.93 (North)** | 2:57 PM | **72** | **7.50 / 7.50** |
| C3-H | St. Joseph College of Engg. | Tiles | 0.148 | 0.096 | 0.447 | 75.31 | 71.56 | 84.91 | 64.07 | 67.78 | 74.93 | **81.90 (UP)** | 11:09 AM | **72** | **7.50 / 7.50** |
| C3-I | Madhura Hospital | Tiles | 0.141 | 0.130 | 0.607 | 74.89 | 74.18 | 87.57 | 63.73 | 68.97 | 68.16 | **84.56 (UP)** | 12:55 PM | **72** | **7.50 / 7.50** |

** Limit derived from table 8-1 (cat 2, frequent events) Transit Noise and Vibration Impact Assessment Manual, Federal Transit Administration, Sept 2018 & Table 3.7 Metro Rail Transit System Guidelines for Noise and Vibrations, RDSO India, Sept 2015: Human annoyance criteria relevant to operation of metro;*

*# Limit converted from Table 7-5 (engineered C&M) Transit Noise and Vibration Impact Assessment Manual, Federal Transit Administration, Sept 2018: Building Damage criteria relevant during construction;*

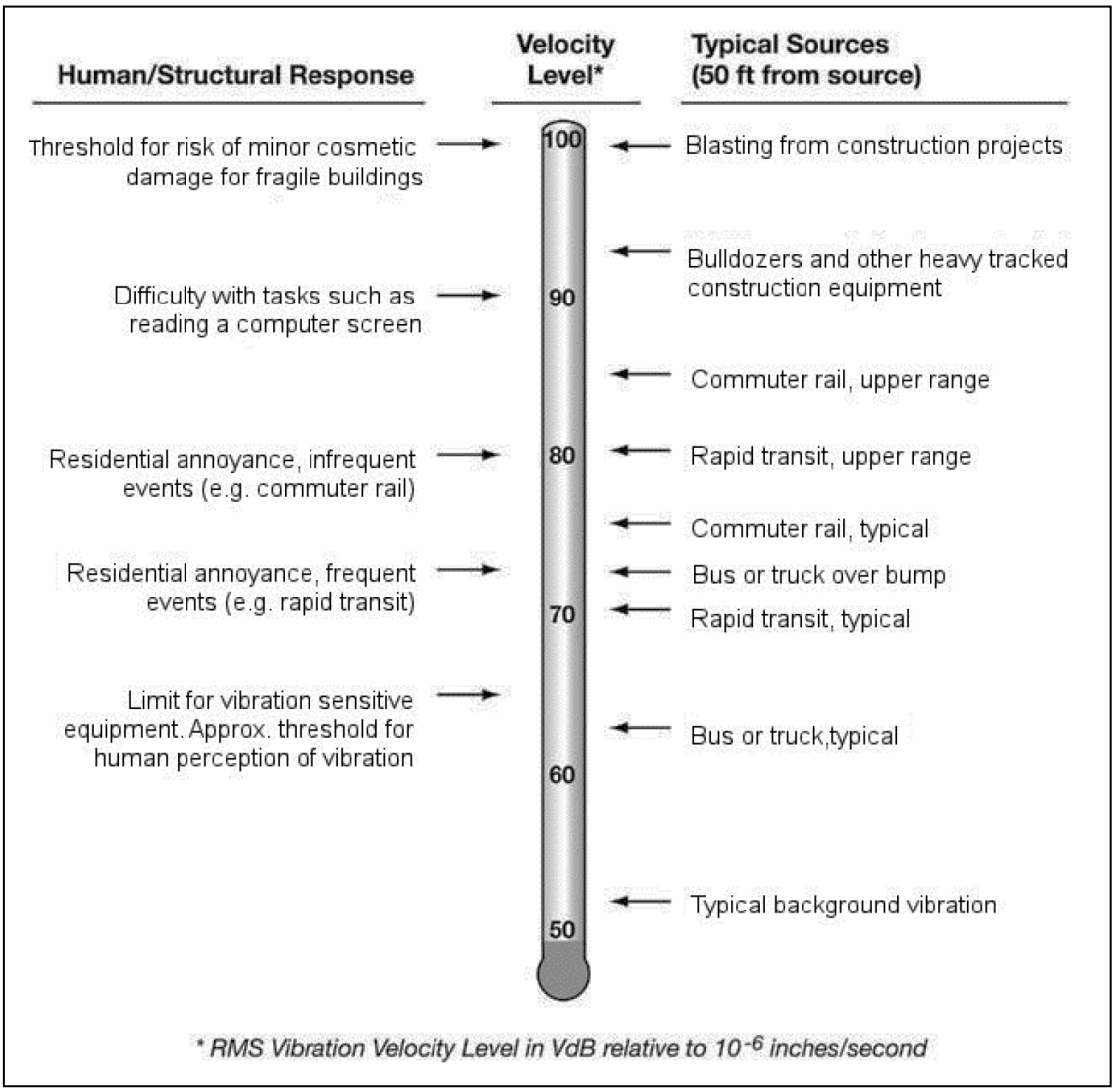
*@ Limit converted from Table 19 (older residential, continuous/fr. Inter.) Transportation and Construction Vibration Guidance Manual, Caltrans, Sept 2013: Building Damage criteria relevant during construction*

*4 locations C3-F to C3-I Field Survey March 2020*

**Table 4-19: Monitoring Schedule**

| S.No | Location | Monitoring schedule | Duration (hrs) | Date of Commencement |
|---|---|---|---|---|
| C3-F | Shivalayam Temple | 09:57 AM – 6:04 PM | 08 | 03/03/2020 |
| C3-G | Vinayagar Temple | 09:50 AM -6:00 PM | 08 | 02/03/2020 |
| C3-H | St. Joseph College of Engineering | 09:56 AM - 5:55 PM | 08 | 01/03/2020 |
| C3-I | Madhura Hospital | 8:43 AM – 4:59 PM | 08 | 04/03/2020 |

**Table 4-20: Standards for Vibration**
**Human Response to typical levels of ground-borne vibration**




*Source: FTA Transit Noise and Vibration Impact Manual, September 2018*

## US FTA

**Table 8-1. Ground-Borne Vibration (GBV) and Ground-Borne Noise (GBN) Impact Criteria for General Assessment**

| Land Use Category | GBV Impact Levels (VdB re 1 micro-inch /sec) | | | GBN Impact Levels (dB re 20 micro Pascals) | | |
|---|---|---|---|---|---|---|
| | Frequent Events[1] | Occasional Events[2] | Infrequent Events[3] | Frequent Events[1] | Occasional Events[2] | Infrequent Events[3] |
| **Category 1**: Buildings where vibration would interfere with interior operations. | 65 VdB[4] | 65 VdB[4] | 65 VdB[4] | N/A[4] | N/A[4] | N/A[4] |
| **Category 2**: Residences and buildings where people normally sleep. | 72 VdB | 75 VdB | 80 VdB | 35 dBA | 38 dBA | 43 dBA |
| **Category 3**: Institutional land uses with primarily daytime use. | 75 VdB | 78 VdB | 83 VdB | 40 dBA | 43 dBA | 48 dBA |

**Notes:**

1. "Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.
2. "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.
3. "Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.
4. This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.
5. Vibration-sensitive equipment is generally not sensitive to ground-borne noise.

***Vibration Category 3 - Institutional:*** *Vibration Category 3 includes schools, churches, other institutions, and quiet offices that do not have vibration-sensitive equipment, but still have the potential for activity interference.*
*Source: Transit Noise and Vibration Impact Assessment, US FTA, May 2006 and*
*Transit Noise and Vibration Impact Assessment Manual, Federal Transit Administration, September 2018*

| Building/ Structural Category | PPV, in/sec | Approximate $L_v$* |
|---|---|---|
| I. Reinforced-concrete, steel or timber (no plaster) | 0.5 | 102 |
| II. Engineered concrete and masonry (no plaster) | 0.3 | 98 |
| III. Non-engineered timber and masonry buildings | 0.2 | 94 |
| IV. Buildings extremely susceptible to vibration damage | 0.12 | 90 |

*RMS velocity in decibels, VdB re 1 micro-in/sec

**RDSO**

| Table 3.7. Ground-Borne Vibration (GBV) and Ground-Borne Noise (GBN) Impact Criteria for General Assessment | | | | | | |
|---|---|---|---|---|---|---|
| Land Use Category | GBV Impact Levels (VdB ref 25.4 micro-mm /sec) | | | GBN Impact Levels (dB ref 20 micro Pascals) | | |
| | Frequent Events[1] | Occasional Events[2] | Infrequent Events[3] | Frequent Events[1] | Occasional Events[2] | Infrequent Events[3] |
| Category 1: Buildings where vibration would interfere with interior operations. | 65 VdB4 | 65 VdB4 | 65 VdB4 | N/A4 | N/A4 | N/A4 |
| Category 2: Residences and buildings where people normally sleep | 72 VdB | 75 VdB | 80 VdB | 35 dBA | 38 dBA | 43 dBA |
| Category 3: Institutional land uses with primarily daytime use. | 75 VdB | 78 VdB | 83 VdB | 40 dBA | 43 dBA | 48 dBA |

**Notes:**

1. " Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.
2. "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.
3. "Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.
4. This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.
5. Vibration sensitive equipment is generally not sensitive to ground-borne noise. DIN 4150-2 can also be referred for guidelines values for evaluating human exposure to vibration in dwellings and similar spaces.

*Source: Metro Rail Transit System Guidelines for Noise and Vibrations, RDSO India, Sept 2015*

## Caltrans

Table 19. Guideline Vibration Damage Potential Threshold Criteria

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

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

*Source: Transportation and Construction Vibration Guidance Manual, Caltrans, Sept 2013*

## Directorate General of Mines Safety (DGMS)

| Type of structure | Vibration (mm/s) for dominant excitation frequency, Hz* | | |
|---|---|---|---|
| | < 8Hz | 8-25Hz | >25Hz |
| | | | |
| (A) Buildings/structures not belonging to the owner | | | |
| Domestic houses/structures (kuccha, bricks & cement) | 5 | 10 | 15 |
| Industrial building | 10 | 20 | 25 |
| Objects of historical importance & sensitive Structures | 2 | 5 | 10 |
| (B) Buildings belonging to the owner with limited span of life | | | |
| Domestic houses/structures | 10 | 15 | 20 |
| Industrial buildings | 15 | 25 | 50 |

*Source: DGMS (Tech) (S&T) Circular No. 7 of 1997*

** PPV = 2πfA, in which f = frequency (Hz) and A = displacement (mm)*

## Central Institute of Mining and Fuel Research (CMFRI)

| Type of structures | PPV (mm/s) | |
|---|---|---|
| | <24 Hz | >24 Hz |
| Domestic houses, dry well interior, construction Structures with Cemented, bridge | 5.0 | 10.0 |
| Industrial buildings, steel or reinforced concrete Structures | 12.5 | 25.5 |
| Object of historical importance, very sensitive Structures, more than 50 years old construction and Structures in poor state condition | 2.0 | 5.0 |
| **IS 14881:2001** | | |
| Soil, weathered or soft conditions mm/s | 70 | |
| Hard rock conditions mm/s | 100 | |

*Dhar et al, 1993*

## 4.4. Ecological Environment

### 4.4.1 Ecologically Sensitive Areas

135. The ecologically sensitive areas near MDB Corridor 3 are depicted in Figure 4.9. The alignment of MDB Corridor 3 does not pass near any protected ecologically sensitive area, nor is it located within the CRZ. Nanmangalam Reserve Forest is located at 5.5 km and Pallikaranai marsh is located at 3 km from the alignment, neither is a protected ecosensitive area (*wiienvis.nic.in*). The first section on MDB Corridor 3 between Sholinganallur and Sholinganallur Lake falls within distance of 10km from edge of Guindy National Park which is a protected ecologically sensitive area.

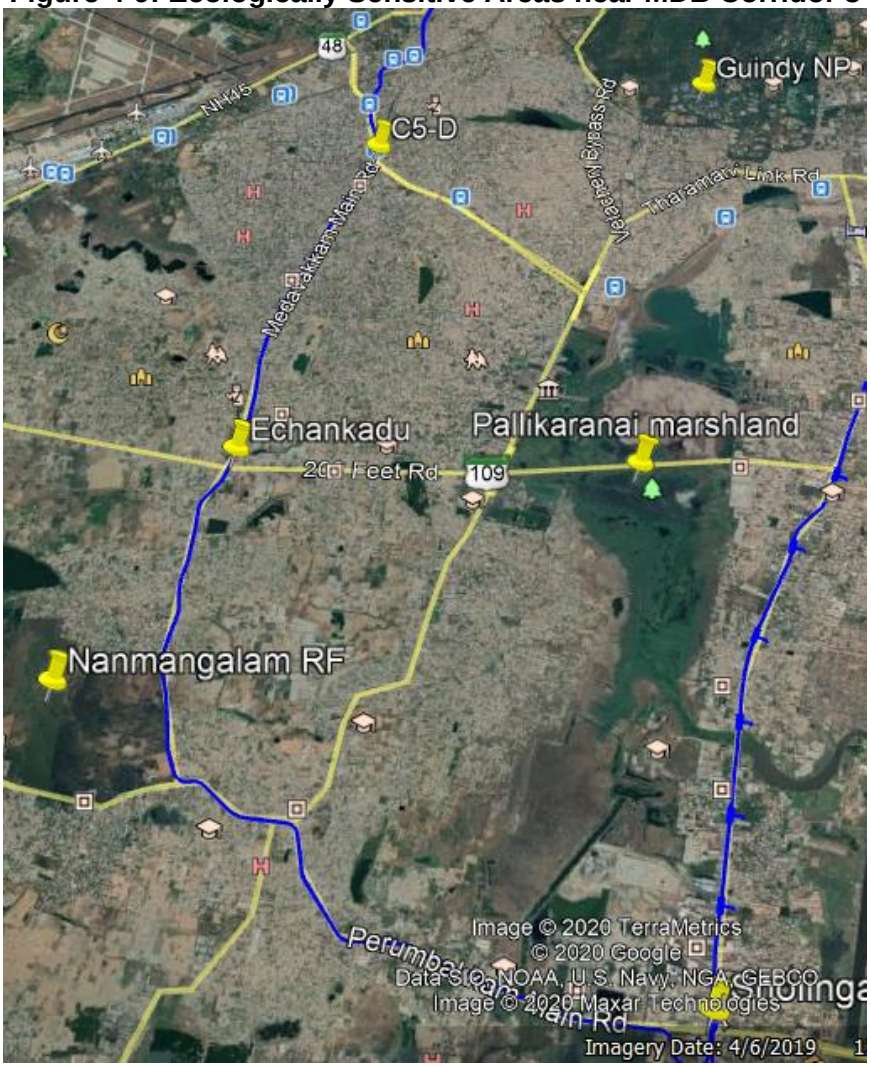
136. Vide letter dated 31 July 2013, MoEF&CC informed States that a default area of 10 km from the boundary will be the Eco-Sensitive Zone (ESZ) of such protected areas for which proposals identifying ESZs were not forwarded by the States to MoEF&CC. Vide MoEFCC clarification dated 2 July 2012, projects falling in ESZs which are not covered under Notification 2006 and which do not require Environmental Clearance (EC) do not require prior approval of National Board of Wildlife (NBWL). As commercial development equal to or above threshold of 20,000 sqm is not proposed, prior EC need not be sought and hence prior approval of NBWL need not be sought.

137. In accordance with 2011 Guidelines for declaration of ESZ around national parks and wildlife sanctuaries, activities relevant to the project are categorized in Table 4.21.

**Table 4-21: Guidelines for ESZ Activities**

| Activity | Prohibited | Regulated | To be promoted |
|---|---|---|---|
| Discharge of effluents and solid waste in natural water bodies or terrestrial area | Yes | -- | -- |
| Felling of trees | --- | Yes | --- |
| Commercial use of natural water resources including ground water harvesting | --- | Yes | --- |
| Erection of electrical cables | --- | Yes | --- |
| Widening of roads | --- | Yes | --- |
| Movement of vehicular traffic at night | --- | Yes | --- |
| Air and vehicular pollution | --- | Yes | --- |
| Sign boards and hoardings | --- | Yes | --- |
| Underground cabling | --- | --- | Yes |
| Rain water harvesting | --- | --- | Yes |
| Renewable energy | --- | --- | Yes |
| Green technology for all activities | --- | --- | Yes |

**Figure 4-9: Ecologically Sensitive Areas near MDB Corridor 3**




138. A biodiversity assessment of the Nanmangalam Reserve Forest (NRF) was conducted in December 2020. The vegetation of NRF is strictly a scrub with plantations. Eucalyptus plantations (117 ha) dominate the forest. The assessment enumerated 449 different species and 4 varieties of flowering plants (angiosperms), including the rare ground orchids *Habenaria viridiflora* and *Eulophia epidendraea* and the carnivorous *Utricularia spp.* and *Drosera burmanii.* Five species namely *Drosera indica, Gloriosa superba, Madhuca longifolia, Pseudarthria viscida* and *Santalum album* that are found within NRF are redlisted medicinal plants for South India. NRF is rich in faunal diversity too, there are about 70 species of birds, around 37 species of butterflies, 7 species of mammals, 14 species of dragonflies and damselflies and 19 species of herpto fauna were recorded during the study period. The Reserve Forest's most famous inhabitant and star attraction is the Eurasian Eagle-Owl (*Bubo Bubo*). All of the faunal species observed during the assessment are least-concern (LC) species as categorized by the International Union for Conservation of Nature (IUCN).

139. The biodiversity of Pallikaranai Marsh has also been assessed in December 2020. This freshwater swamp is one of the three wetlands in the state of Tamil Nadu which are included in wetlands identified under National Wetland Conservation and Management Programme. (MoEF&CC Annual report 2006-2007). During this assessment a total of 124 species of flora consisting of herbs (grass, herbs, creepers and climbers), shrubs and trees were recorded. Among the floral community the herbasious layer was most dominant category followed by trees and shrubs. Earlier study in Pallikaranai recorded 164 species (unpublished data) which includes domestic and garden plants. The dominant tree species observed was *Prosophis juliflora*, which is an exotic species predominantly proliferated along the marsh. The wetland is rich in faunal species, a total of 196 species of fauna consists of 25 invertebrates and 171 vertebrates were

recorded during the study period survey. Among the species recorded the avifauna diversity was significantly high compared to other species observed (n=127), followed by Herptofauna (n=22), Insects (n=19), Mammals (n=10), Fishes (n=12). Crustaceans (n=3) and Mollusks (n=3). Most of the faunal species observed during the assessment are least-concern (LC) species as categorized by the International Union for Conservation of Nature (IUCN), however with few exceptions like the Indian River Tern, the Woolly-necked Stork and the Greater Spotted Eagle, which have the status Vulnerable (VU), and the Spot-billed Pelican, the Black-tailed Gotwit, the Black-headed Ibis, the Oriental White Ibis, the Painted Stork and the Eurasian Curlew which have the status Near Threatened (NT). Earlier studies conducted in Pallikaranai show a significant variation of number of species observed between the studies, indicating a seasonal variation of species. These studies also indicated the presence of the Black-bellied Tern, a faunal species with IUCN status Endangered (EN). The results of the assessment indicate that the Pallikaranai Marshland harbors a notable diversity of flora and fauna, with the potential of functioning as an in situ conservation area for birds. The merit of the marshland is further enhanced by the presence of a sizeable number of migratory birds that visit the marshland during the season.

140. Although not regarded as an ecologically sensitive area, Sholinganallur Lake is positioned right alongside the OMR and therefore close to the alignment of MDB corridor 3. Though the lake is one of the largest water bodies in the southern suburbs, it was pushed into oblivion because of incessant garbage dumping and pollution by inflow of sewage. In July 2018, the Environmentalist Foundation of India (EFI) took up the task of restoring the lake with help of the local community. After two months of removing garbage, debris, plugging sewage outfalls, desilting and strengthening the bunds, the lake was given a new lease of life. Since then the water quality has improved and faunal species like the Spot-billed Pelican, Pheasant-tailed Jacana, Lesser Whistling Duck and Pond Heron have started to return.

### 4.4.2 Flora and Fauna

141. The number of trees on public land in right of way of viaduct, stations and depot likely to be cut is 164. Their number on private land is to be ascertained from the field. No rare or endangered species of trees were noticed during field studies. The predominant tree species along the project corridor are listed below in Table 4.22.

**Table 4-22: Predominant Tree Species along the Corridor (Local name- Botanical name)**

| Species | IUCN status |
|---|---|
| 1. Vembu- *Azadirachta indica* | *LC* |
| 2. Vadam- *Terminalia catapa* | *LC* |
| 3. Nirkadambai - *Neonauclea purpurea* | *NE* |
| 4. Thoongu moonji - *Albizia saman* | - |
| 5. Panei - *Borassus flabellifer* | *NE* |
| 6. Pungam - *Pongamia pinnata* | *LC* |
| 7. Mayir Konnai - *Delonix regia* | *LC* |
| 8. Nettilingam- *Polyalthia longifolia* | *NE* |
| 9.Vagai - *Albizia lebbeck* | *NE* |
| 10.Thennai - *Cocos nucifera* | *NE* |
| 11. Shevaga - *Morinda tinctoria* | - |
| 12. Nuna - *Bombax malabarica* | *NE* |
| 13. Arasu - *Ficus religiosa* | *NE* |
| 14.Al - *Ficus benghalensis* | *NE* |
| 15. Ma - *Mangifera indica* | *DD* |

*LC Least Concern; NE Not evaluated; DD Data Deficient; - Not known*

142. No rare or endangered species of trees were noticed during field studies. To minimize tree cutting it is proposed to transplant young trees to the extent possible. Local forestry officials will be consulted to transplant the trees at suitable locations.

143. Common birds observed in the project area are pigeons, parrot, crows, and doves. The predominant mammals observed in the project area are mongoose, bat, Squirrel, monkey and mice etc. No rare or endangered species were noticed during the field survey along the alignment.

## 4.5. Socioeconomic Environment

### 4.5.1 Utilities

144. MDB Corridor 3 will run through the urban area elevated. The alignment will need to negotiate underground water pipelines, sewage pipelines, underground telecommunication cables, elevated power lines: all perpendicular as well as parallel to the alignment except sewage pipelines which are only perpendicular (*Draft DPR January 2017*). Utility information is placed in **Annexure 3**. It will also cross storm water drains.

145. These utility services are essential and have to be maintained in working order during different stages of construction, by temporary/permanent diversions and relocation or by supporting in position. Any interruption to these will have serious repercussions on the most sensitive services and direct impact on the public besides setback to construction and project implementation schedule & costs. Therefore, detailed survey and planning will be required to protect/divert the utility services.

146. The 9.6 km elevated section from Sholinganallur station to SIPCOT-II station passes 1 college, 1 school, 1 hospital and 32 religious buildings, all located within 200 meter from the center of the alignment. Exact details of these sensitive receptors including their coordinates and distance to the alignment can be found in **Annexure 2**. Based on the Resettlement plan (RP) for the project none of the sensitive receptors will be directly impacted by this section of corridor 3 since the piers and viaducts are all planned on the median of the road/ or on the service road. There will be no adverse impact on the adjoining property.

147. MDB Corridor 3 will impact 41 households engaged in commercial activity (11 owners, 22 tenants, 8 squatters & kiosk) leading to loss of business premises, business income and rental income. Of these only 4 squatter families are fully impacted requiring their relocation. Affected households will be duly compensated following the Entitlement Matrix which is part of the RP. No residential households are impacted.

### 4.5.2 Physical Cultural Resources

148. No known protected archaeological monuments/sites nor heritage assets are located on or along the proposed alignment (http://www.cmdachennai.gov.in/HeritageBuildings.html). 35 other resources of educational, religious, cultural, medical nature are located within 200m from the alignment: of these 27 are located within screening distance (100m) for noise and 18 within screening distance for vibration (62m). None are located in project zone of direct impact.

### 4.5.3 Demographic Features

149. The Project will improve passenger transportation in Chennai Metropolitan Area which is projected to support resident population of 125.82 lakh in year 2026. As in year 2014, almost all households in the urban parts of the 3 districts contributing to CMA are supported by at least one employed person. In the project affected households, about 50% of are working on salary or daily wages or contract or job works, 40% are business owners; 17% of households are in vulnerable category comprising those below income poverty line (about 4%), socially weak communities and women headed households.

150. MDB corridor 3 will acquire 2,033 sqm of private land and will impact 110 people from 41 households. Hindus account for 73 percent of the surveyed population whereas Muslims account for 15 percent and Christians for 12 percent. Education levels for males and females are similar,

an average of 7.7% of the surveyed population is illiterate. About 79% of the affected people is aged between 18 and 60. More demographic details can be found in the RP for the project.

# 5. ANTICIPATED IMPACTS AND MITIGATION MEASURES

## 5.1. Methodology

151. 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 residual impacts are minimized to the extent possible.

## 5.2. Identification of environmental components

152. 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.

153. **Type of impact on the VECs.** 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.

154. **Area of impact assessment**. The area covered for assessing direct project impacts includes:

- An average of 15 meter corridor on either side along the existing road;
- Sensitive receptors in an area of 200 meter on either side of the alignment.

155. In addition, a 10 km strip throughout the project alignment was studied for **indirect impacts**.

156. **Significance of impacts**. The assessment of the significance of the impacts on the VECs requires understanding the sensitivity of each VEC within the project context; the duration of impact; the extent of impact, the intensity of impact and the likelihood of impact. The following sections elaborate these.

157. **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.

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 moderate due to high levels of organic matter. Sholinganallur lake is within direct impact zone. |
| 1.4 Surface water quantity | High | Chennai is facing major water shortages. |
| 1.5 Ground water quality | Medium | Water quality of the groundwater in the project area is moderate due to high levels of chloride and calcium. |
| 1.6 Ground water quantity | High | Chennai is facing major water shortages. |
| 1.7 Land degradation and pollution | Low | The project alignment is following the median of the IT expressway which passes mainly through residential and commercial areas |
| 2. Biological environment | | |
| 2.1 Trees, terrestrial and aquatic vegetation | Medium | Nanmangalam Reserve Forest is located at 5.5 km and Pallikaranai marsh is located at 3 km from the alignment. Furthermore the alignment passes Sholinganallur lake, where ecological restoration efforts are ongoing. Approx. 164 trees have to be removed from the project alignment. |
| 2.2 Terrestrial fauna (mammals, birds, insects) | Low | |
| 2.3 Ecologically important areas | Medium | |
| 3. Social environment | | |
| 3.1 Private land and buildings | Medium | Approximately 41 families will be affected, approx. 2030 $m^2$ of private land needs to be acquired. |

| VEC | Sensitivity level | Remarks |
|---|---|---|
| 3.2 Public property/ infrastructure/ utility structures | High | The alignment will cross sub-surface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, traffic signals, roadside lights, footbridges etc |
| 3.3 Noise | High | The ambient noise levels in general meet the CPCB and WHO limits. However some residential high-rise buildings are close to the proposed alignment. |
| 3.4 Vibration | High | There are several structures located near the proposed alignment. Regular traffic such as buses and trucks on the IT expressway add to vibration levels |
| 3.5 Occupational health and safety | Medium | The project area already experiences some road safety issues due to the traffic on the highway |
| 3.6 Public health and safety | Medium | |
| 3.7 Physical cultural resources (PCR) | Medium | There are several religious places located close to the alignment. |

158. **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.

159. **Extent of impact**. The extent of impact entails the spatial scale of impact on one or more of the VECs. The terms CMA (Chennai Metropolitan Area, regional), local and on-site are used to describe the area of impact:

- On-site: The impact is felt within the direct impact zone;
- Local: The impact is felt within the indirect impact zone;
- CMA: The impact is felt beyond the indirect impact zone.

160. **Intensity of impact**. The intensity 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.

161. Based on the sensitivity of the VEC and the rating of duration, extent, intensity of impact as described above and bearing in mind the likelihood of occurrence of the impact, the overall significance of each impact was classified as major, moderate or minor as demonstrated in Table 5.2.

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

| Significance | VEC Sensitivity | Duration | Extent | Intensity |
|---|---|---|---|---|
| **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 |

## 5.3. Screening of impacts

162. Based on the rating criteria provided in table 5.2, environmental impacts anticipated during the project design and pre-construction stage (D), construction (C) stage and operation (O) stage were screened for their level of significance as demonstrated in table 5.3 below. If for example, the sensitivity of a VEC is considered high, (table 5-1) and a large number of people will be permanently affected on a regional scale, the impact will be considered highly significant. On the other hand if a VEC is medium sensitive and only a few receptors will be temporarily affected on a localized scale, the significance of the impact will be minor. 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.

163. The significance of each environmental impact or project activity is indicated in the cells in the second to last column of table 5.3, the last column shows the anticipated residual impacts after mitigation. Red indicates a major negative impact, orange indicates a moderate negative impact; purple indicates a minor negative impact and green indicates a 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 residual impacts are minimized to the extent possible.

**Table 5-3: Screening of environmental impacts**

| S.N. | Parameter | Adverse Impacts | | | | | | | | | | | | Significance before mitigation | Residual impacts after mitigation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Duration | | | Extent | | | Intensity/Risk | | | Likelihood | | | | |
| | | S | T | P | O | L | C | L | M | H | U | L | D | | |
| **A.** | **Impacts due to Location and Design (Pre-Construction)** | | | | | | | | | | | | | | |
| 1 | Degradation of surface water quality due to sewage discharge | | | * | * | | | * | | | | * | | Moderate | Minimal -ve |
| 2 | Use of surface water for stations | | | * | | * | | * | | | * | | | Moderate | Minimal -ve |
| 3 | Degradation of groundwater quality due to location of stations and inclusion of sewage treatment | | | * | | * | | | * | | | | | Minor | None |
| 4 | Location of construction yards | | * | | * | | | | * | | | | * | Minor | Minimal –ve |
| 5 | Location of muck disposal sites | | | * | * | | | * | | | | | * | Moderate | Minimal –ve |
| 6 | Location of project alignment in areas with vegetation and trees. | | | * | * | | | | * | | | | * | Moderate | Minimal –ve |
| 7 | Impact of height of viaduct and lighting on birds | | | * | | * | | * | | | | * | | Moderate | Minimal –ve |
| 8 | Transfer of 0.615 ha government land and acquisition of 0.203 ha private land | | | * | | * | | | * | | | | * | Minor | Minmal –ve |
| 9 | Aesthetic impact. Limited reduction with proposed sleek structures | | | * | | * | | | | * | | * | | Major | Moderate -ve |
| 10 | Metro noise adds to baseline noise which is already high. Significant reduction with proposed design features | | | * | * | | | | | * | | * | | Major | Moderate –ve |
| 11 | Metro vibration adds to baseline vibration level. Limited reduction with proposed design features | | | * | * | | | | * | | | * | | Major | Moderate –ve |
| 12 | Design of Health and Safety features in stations and trains for construction workers and operating staff | | | * | * | | | | * | | | | * | Moderate | Moderate –ve |

| S.N. | Parameter | Adverse Impacts | | | | | | | | | | | | Significance before mitigation | Residual impacts after mitigation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Duration | | | Extent | | | Intensity/Risk | | | Likelihood | | | | |
| | | S | T | P | O | L | C | L | M | H | U | L | D | | |
| 13 | Safety risks due to flooding and earthquakes | | | * | * | | | | * | | * | | | Moderate | Minimal –ve |
| 14 | Transmission of communicable diseases including Covid-19 | | | * | * | | | | | * | | * | | Major | Moderate –ve |
| 15 | Possible impact on religious or cultural buildings / structures within 200 meter of the alignment | | | * | * | | | | * | | * | | | Minor | None |
| 16 | Increased energy demand from grid, causing additional GHG emissions | | | * | | | * | * | | | | | * | Moderate | Minimal –ve |
| **B.** | **Impacts due to Project Construction** | | | | | | | | | | | | | | |
| 1 | Sourcing of construction material; Emissions from machinery and vehicles; site operations; operations in construction yard; dumping at excavate and waste disposal sites | | * | | | * | | | * | | | | * | Major | Minimal –ve |
| 2 | Degradation of surface and ground water quality due to run-off and waste water from construction sites, construction yards, waste disposal sites, labour camps, drainage changes of excavate and C&D waste disposal sites, siltation of water bodies | | * | | | * | | * | | | | * | | Moderate | Minimal –ve |
| 3 | Use of surface water for construction purposes | | * | | | * | | | * | | * | | | Moderate | None |
| 4 | Reduction of ground water quantity due to dewatering activities | | * | | * | | | * | | | | | * | Moderate | None |
| 5 | Soil erosion due to site clearing and levelling | | * | | | * | | * | | | | * | | Minor | Minimal –ve |

| S.N. | Parameter | Adverse Impacts | | | | | | | | | | | | Significance before mitigation | Residual impacts after mitigation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Duration | | | Extent | | | Intensity/Risk | | | Likelihood | | | | |
| | | S | T | P | O | L | C | L | M | H | U | L | D | | |
| 6 | Soil pollution due to operations at construction yards, C&D and hazardous waste disposal sites | | * | | | * | | * | | | | * | | Moderate | Minimal –ve |
| 7 | Removal of 164 trees, damage to maintained trees and bushes | | * | | * | | | * | | | | | * | Minor | Minimal –ve |
| 8 | Impact on birds due to height of viaduct, construction noise and vibration and lighting | | * | | * | | | * | | | | | * | Moderate | None |
| 9 | Diversions of utility services and possible outages | | * | | | * | | | * | | | * | | Moderate | None |
| 10 | Traffic diversions | | * | | | * | | | | * | | | * | Major | None |
| 11 | Temporary use of land for construction, labour camps and traffic detours | | * | | * | | | | * | | | | * | Moderate | None |
| 12 | Noise and Vibration due to operation of construction equipment and vehicular movement | | * | | | * | | | * | | | | * | Major | None |
| 13 | Impacts due to possible poor conditions in labour camp, working at height and with heavy machinery, risk of transmission of communicable diseases including Covid-19 | | * | | * | | | | * | | | * | | Moderate | Moderate –ve |
| 14 | Public exposure to traffic, noise, vibrations, dust and communicable diseases including Covid-19 | | * | | * | | | | * | | | * | | Moderate | None |
| 15 | Chance finds of objects of physical or cultural value | * | | | * | | | * | | | * | | | Minor | None |
| **C.** | **Impacts due to Project Operation** | | | | | | | | | | | | | | |
| 1 | Degradation of water quality due to sewerage discharge | | | * | | * | | * | | | | * | | Minor | Minimal -ve |

| S.N. | Parameter | Adverse Impacts | | | | | | | | | | | | Significance before mitigation | Residual impacts after mitigation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Duration | | | Extent | | | Intensity/Risk | | | Likelihood | | | | |
| | | S | T | P | O | L | C | L | M | H | U | L | D | | |
| 2 | Increased water demand from public water supply | | | * | | * | | | * | | | | * | Moderate | Minimal -ve |
| 3 | Land degradation due to insufficient waste management | | | * | * | | | | * | | | * | | Moderate | None |
| 4 | Noise due to metro operations | | | * | | * | | | * | | | | * | Major | Minimal -ve |
| 5 | Vibration due to metro operations | | | * | | * | | | * | | | | * | Major | Minimal -ve |
| 6 | Accidents, electromagnetic interference, exposure to electromagnetic radiation and communicable diseases | | | * | * | | | | * | | | | * | Moderate | Moderate -ve |
| | **POSITIVE IMPACTS** | | | | | | | | | | | | | | |
| 1 | Reduced air pollution due to modal shift towards public transport | | | * | | * | | | | * | | | * | | High +ve |
| 2 | More efficient and environmentally friendly movement of people | | | * | | * | | | | * | | | * | | High +ve |
| 3 | Groundwater recharge due to rainwater harvesting | | | * | | * | | | | * | | | * | | High +ve |
| 4 | Growth of compensated trees | | | * | | * | | * | | | | | * | | Minimal +ve |
| 5 | Economic opportunities | | | * | | * | | | | * | | * | | | Moderate +ve |

*Note:*
*Impact: +ve = positive; -ve = negative*
*Duration: S = Short-lived; T = Temporary; P = Permanent*
*Extent: O = on-site; L = Local; C: Chennai Metropolitan Area (regional)*
*Intensity: L = low; M = medium; H = high*
*Likelyhood: U: unlikely; L: likely; D: definite*

164. The potential impacts listed in the screening matrix are briefly described and mitigating measures have been proposed.

### 5.4. Impacts identified in Environmental Impact Assessment (EIA) of part Corridor 3

165. Corridor 3 which forms part of Chennai Metro Phase 2 comprises two sections namely

a) section from Madhavaram Milk Colony to Sholinganallur via Adyar

b) section from Sholinganallur to SIPCOT 2.

166. Findings of EIA pertinent to section from Madhavaram Milk Colony to Sholinganallur are summarized here so as to provide a backdrop to the current report.

167. At baseline locations sampled during July 2016 to May 2017, air quality was well within upper limits except for CO; daytime noise was found to be exceeding CPCB limits for day and night by significant margin; water quality at 6 locations in terms of $CaCO_3$ alkalinity, $CaCO_3$ hardness, Mg, Flouride, calcium and TDS was more than acceptable but less than permissible limit in 5, 3, 2, 3, 4 and 4 locations respectively. 212 trees excluding SIPCOT depot will be felled or transplanted; no archaeological or heritage assets will be impacted; projected noise level during construction will meet the daytime Ambient Noise Quality Standards 55 dB (A) for residential landuse at distance more than 1000m, projected noise level during operation will be marginally higher than baseline; flooding due to climate change between Thoraipakkam and Siruseri; power demand and water demand during operation are high at 72 MVa and 4140 KLD respectively due to more underground stations. Mitigation measures included compensatory plantations, noise barriers on elevated sections, rainwater harvesting on elevated sections and Madhavaram maintenance depot, The alignment is located within 10 km from the Guindy National Park and as such falls in the default Ecologically Sensitive Zone of the National Park. Therefore In accordance with 2011 Guidelines for declaration of ESZ around national parks and wildlife sanctuaries, activities relevant to the project will be regulated. The alignment is located within 0.5 km from Pallikaranai wetland and bird sanctuary and at 5.2 km from Nanmangalam reserve forest which houses avifauna: thus the 8.4 km long double elevated section from Nehrunagar to Sholinganallur will impact avifauna during construction and operation of the metro. This section will also adversely impact aesthetics.

### 5.5. Impacts prior to mitigation

168. Table 5-3 shows that during the pre-construction phase the most significant impacts to be expected are:

- Aestethic impact due to location and design;
- Noise impact due to choices in design;
- Vibration impact due to choices in design;
- Impact on Health and Safety due to communicable diseases such as Covid-19

169. During construction phase the following impacts are of major significance:

- Impacts due to sourcing of construction material;
- Impact on air quality die to emissions from machinery, vehicles and site operations;
- Impact on land due to dumping at excavate and waste disposal sites
- Impact due to traffic diversions

170. **Impact due to increased noise and vibration from construction equipment**During the operational phase the major impact that can be expected is an increase in noise and vibration due to operation of the metro.

In the following paragrapgh the identified impacts on each of the VECs will be described including the measures that will be taken to mitigate these impacts. If the expected impacts cannot be mitigated completely the residual impact is described including its significance (see also table 5-3).

## 5.6. Air quality

171. A major benefit of metro is reduction in ambient air pollution and greenhouse gases with consequent costs of health and accidents due to shift of passengers from usage of current road based modes. Based on number of daily vehicle kilometer reduction, daily reduction in fuel (diesel and petrol) consumption has been estimated (see annexure 6). The reduction has been estimated based on retiral - without addition - of pre-Bharat Stage VI (BS VI) vehicles from year 2020 onwards so that by year 2035 only BS VI vehicles will be on road. Reduction in fuel consumption and pollution is reported in Table 5-4.

**Table 5-4: Reduction in Fuel Consumption and pollution**

| | | 2025 | 2035 | 2045 |
|---|---|---|---|---|
| Diesel reduction | (million liters) | 6.51 | 0.05 | 0.15 |
| Petrol reduction | (million liters) | 1.27 | 0.70 | 1.80 |
| CO | (ton) | 213 | 39 | 67 |
| PM | (ton) | 3.90 | 0.20 | 0.30 |
| HC+NOx | (ton) | 161 | 6 | 11 |
| Net CO2* | (ton) | 6799 | 22043 | 16549 |

***** *Net reduction in CO2 has been estimated as result of trade-off between ambient reduction due to operation of metro rail and increase due to grid power used to operate the Metro*

172. **Impacts**. Air pollution can be caused on construction sites during excavation, demolition, operation of construction equipment, blasting in rock; on routes of transportation of construction material, precast elements, excavated material and waste; at construction yards during aggregate crushing / screening, construction material and precast elements; at disposal sites during disposal of waste and excavated material. Emissions from DG sets, emissions from fuel and other hazardous chemicals are other sources of pollution. Open burning of solid waste and solid fuel in labour camps could cause air pollution. The pollution is in terms of fugitive dust and particulate and chemical emissions from trucks. Air pollution from road based vehicles especially particulate is found to cause diseases of brain, heart, lungs and kidneys.

173. Trucks are required to transport raw material to casting yards and Ready Mix Concrete (RMC) plants; from pre-cast yards and batching plants to construction site and between construction site and excavate and waste disposal site. Vehicular emission is estimated as in Table 5-5. The estimate is based on vehicle km of truck movement to transport precast elements and material from construction yard and earth from site to disposal location for typical leads.

**Table 5-5: Emissions due to truck movement during demolition and construction**

| Pollutant | Emission (ton) |
|---|---|
| Carbon Monoxide (CO) | 35 |
| $PM_{2.5}$ | 1.5 |
| Hydro-Carbons (HC) | 1.1 |
| Nitrogen Oxide ($NO_x$) | 72 |

| Pollutant | Emission (ton) |
|---|---|
| VOC | 11 |
| Carbon dioxide ($CO_2$) | 4455 |

174. **Mitigation.** Contractor's transport vehicles and other equipment will conform to emission standards. The Contractor will carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.

175. Procedure for truck maintenance, including selection of service providers considering environmental aspects, application of low-Sulphur fuel, no idling of trucks, routine maintenance (including assurance of proper engine operations related to emissions and noise), and disposal of used oil and other fluids, batteries, and tires etc.

176. DG sets compliant with emission standards will be used

177. The following dust protection methods will be used:

- Dust screens during excavation and demolition near sensitive receptors
- Dust filters atop cement silos
- Wet suppression for aggregate crushing and screening.
- Good quality project roads with added petroleum emulsions and adhesives, speed control, traffic control.
- Material of specifications as per contract will be procured by Contractor from Government-approved quarries

178. The Contractor will ensure that trucks carrying loads of sand and aggregate required in construction being transported to construction yards are covered and loaded with sufficient free - board to avoid spills--within the largest compartment of tanker truck. Transportation will be scheduled by time and route to minimize air pollution in inhabited (homes or workplaces or sensitive receptors such as schools, hospitals) areas.

179. The Contractor will ensure that all trucks carrying loose C&D waste will be covered and loaded with sufficient free - board to avoid spills through the tailboard or sideboards. Transportation of C&D waste (muck) will be scheduled by time and route to minimize air pollution in habitat areas. Disposal of Hazardous waste will be done by licensed vendors at sites pre-approved independent of the project. Contractor will ensure that the vendor transports the waste with due care to avoid escape of fumes or spillage en route.

180. Temporary storage will be maintained by the Contractor at all times until the excavate is re-utilized for backfilling and C&D waste is evacuated from site. Dust control activities will continue even during any work stoppage. Soil erosion by runoff will be controlled by installing proper drainage systems using contour information. It is suggested to avoid bringing soil from outside the project boundary and to use the excavated mounds for filling low lying area where it is necessary.

181. The Contractor will provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from construction depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt.

182. Construction yards with aggregate crushing and screening, pre-casting, material and fuel storage and GC plants as well as excavate/waste disposal sites will be located away from inhabited or ecologically sensitive areas.

183. Labour residing in camps will be provided with LPG fuel for cooking.

184. **Residual impact**. Through modal shift from fossil-fuel driven transport to metro the air quality will be positively impacted. The magnitude of the beneficial impact of metro will increase with increasing ridership. For a more efficient movement of people the alignment will be designed with less number of curves and a curve radius better than minimum value. Stations will be designed with optimal platform and concourse space as per standard planning and design codes. Integration of metro with other modes especially walk, public transport and intermediate public transport (hired modes) is found to increase ridership and lessen congestion inside and outside the stations. Residual impact is high positive.

### 5.7. Surface water and groundwater quality

185. **Impact.** The waste water discharged from the project during construction and operation can pollute surface water bodies and ground water if not handled and treated properly. However as a feature of design, all stations will be connected to the municipal sewerage and therefore such water will be treated by municipal authorities as per norms before discharge into surface water bodies. Estimated sewage of 141 KLD will be generated. The stations will therefore have an impact on the amount of sewage to be treated throughout the operational phase and, in case of insufficient treatment, indirectly have an impact on the water quality. In case of poor maintenance of the sewage system leakages might start to occur, thus impacting the quality of ground water.If the drainage capacity of the existing sewerage system is inadequate to handle the additional sewage the risk of localized flooding emerges.

186. Waste construction materials and hazardous waste from construction sites; used water from the RMC plant; water used for dust suppression at aggregate crushers are sources of pollution of surface water bodies or groundwater. Sewage from labour camp can also pollute surface water bodies or groundwater. Groundwater which seeps into excavations can get contaminated by chemicals used in construction and consequently pollute groundwater outside the excavations upon dewatering. Hazardous waste would mainly arise from the maintenance of equipment which may include used engine oils, hydraulic fluids, waste fuel, spent mineral oil/cleaning fluids from mechanical machinery, scrap batteries or spent acid/alkali, spent solvents etc. Percolation / leaching of toxic substances at C&D waste disposal sites and hazardous waste disposal sites can pollute water.

187. **Mitigation**. As per design the stations will be connected to the municipal sewerage system. Prior to commencement of the works contractor will verify with the municipal authorities if the existing sewerage capacity is adequate to handle the extra sewage or if additional works on the existing sewerage system are necessary. This in order to prevent uncontrolled discharge of sewage into the environment.

188. In order to detect any leaks in the sewer system as soon as possible during the operational phase, it is important to carry out regular visual inspections of the terrain surrounding the stations. If subsidence of the ground is observed the sewer must be excavated for inspection and repairs when necessary.

189. **Residual impact.** Although waste water let into the sewers will be treated by municipal authorities to general effluent standards before discharge into surface water or groundwater, minimal negative impact on receiving bodies might occur in case of insufficient treatment. The stations will have an impact on the amount of sewage to be treated throughout the operational phase and, in case of insufficient treatment, indirectly have an impact on the water quality. Temporary leakages of the sewerage at the stations cannot be ruled out completely. Therefore a minimal negative residual impact will exist.

## 5.8. Surface water and groundwater quantity

190. **Impact.** Water consumption during construction is of the order of 148 KLD for MDB Corridor 3. Dewatering necessary for pile foundation construction will lead to a decrease in ground water quantity.

191. Water demand at stations during operation is estimated at 166 KLD and will be met through municipal water supply, thus impacting the availability of this commodity.

192. **Mitigation**. Stations of MDB corridor 3 will be connected to the municipal water supply system; there will be no direct use of surface water. However since Chennai is partly depending on surface waters for its water needs, the water use of the stations will impact the quantity of surface water indirectly to a certain extent.

193. As a design feature, rainwater harvesting at elevated stations and along the viaduct will be implemented as an environmental conservation measure, to conserve and augment the storage of groundwater. Each pillar will have inbuilt downpipes to collect the rainwater from the viaduct and rooftop of elevated stations and then led into underground tanks through layers of sand and gravel. At annual rainfall of 1,541mm, potential for rainwater harvesting is 1.65 lakh per year. Regular inspection and maintenance of the rainwater harvesting system will be required in order to let it function effectively.

194. Water for dust suppression (sprinkling) and tire washing will be sourced from surface runoff, wastewater from construction sites, construction yards and seawater. Used water from tire washing will be collected, subjected to precipitation and re-used. Groundwater will not be used in view of status in Chennai. Water for curing of concrete will be sourced from municipal supply, surface runoff or water from dewatering. Water for concrete batching plant and labour camps will be sourced from treated municipal water.

195. Waste water from construction yards, sites and labour camps that cannot be used for dust suppression or tire washing will be discharged into public sewers after precipitation; it will be treated by municipal agencies to Environment Protection Rules (EPR) 1986 Schedule VI standards of discharge of general effluents into surface water. In view of the distributed nature of the linear construction and quantities of waste water, it is not proposed to install sewage and effluent treatment plants by CMRL.

196. **Residual impact**. Rainwater harvesting will be implemented to recharge groundwater. Since no groundwater will be extracted for the project the residual impact on groundwater quantity is high positive.. Since Chennai is partly depending on surface waters for its water needs, the use of municipal water at the stations will impact the quantity of surface water indirectly to a certain extent. This commodity cannot be completely mitigated through rainwater harvesting. A minimal negative residual impact on surface water quantity will therefore remain.

## 5.9. Land degradation

197. **Impact**. Construction yards with aggregate crushing and screening, pre-casting, material and fuel storage and ready-mix concrete plants and sites for disposal of C&D waste and disposal of surplus excavated soil can cause topography-related drainage changes, pollution of air, water and soil.

198. Metro construction is a material intensive activity. Huge quantity of different construction materials will be required for construction of elevated metro corridor and stations, leading to depletion in construction material at source.

199. Quarry operations are independently regulated activities and outside the purview of the project proponent. It is, nonetheless, appropriate to give consideration to the environmental implications in selection of quarry sources since poorly run operations create dust problems, contribute noise pollution, ignore safety of their employees, or cause the loss of natural resources. So, the construction material will be sourced only from legalized and approved quarries that are in full compliance with environmental and other applicable regulations and have an outstanding environmental track record Opening of a new quarry specifically for MDB corridor 3 is not foreseen under this EIA.

200. Construction activities cause degradation of land in terms of loss of topsoil and pollution. Fertile topsoil which is removed during demolition, site levelling and excavation, if not securely preserved, could be washed off due to surface runoff or be lost as fugitive dust. Soil contaminants include heavy metals and Persistent Organic Pollutants (POPs)[12] (due to processes pre-dating the metro construction activities); Polycyclic Aromatic Hydrocarbons (PAHs) (from exhaust of construction vehicles, equipment, DG sets) and mineral oils (from leakages and spillages).

201. Soil pollution and changes in local water drainage patterns could result from dumping of surplus excavated soil and C&D waste. Hazardous waste will be taken away by licensed vendors who will be responsible for due disposal at pre-approved sites.

202. Solid waste generation from passengers at stations is estimated at 42 ton per day. If this waste is not properly managed it might end up in the area surrounding the stations.

203. **Mitigation.** Construction yards will be located at least 500 m away from habitations and at least 1 km away from environmentally or ecologically sensitive area. Selection of the sites for construction yards, batching plant, casting yard and waste disposal sites has to follow the criteria for site selection as laid down in Annexure 10 of this EIA with the final location and layout of the sites. Locations will be decided by CMRL and cleared by MDBs before construction commencement in consultation with Municipal Corporation/Municipalities and CMDA. Hazardous waste will be taken away by licensed vendors who will be responsible for due disposal at sites pre-approved independent of the project. The contractor will provide a plan with construction yard layout including batching plant, sewage and drainage system, provisions of precipitation tanks, access road, first aid facilities etc, to be approved by CMRL and MDBs before establishment.

204. Soil erosion by runoff will be controlled by installing proper drainage system. Part of the excavated soil from piling would be re-used for refilling and balance will be disposed. Estimated quantity of excavated soil is 61,000 $m^3$ whereas the estimated quantity of disposable soil is 47,244 m3. Responsibility of disposal of this soil lies with contractor and will be regulated by TNCGC rules.

205. C&D waste is part of solid waste that results from land clearing, excavation, construction, demolition, remodeling and repair of structures, roads and utilities. C&D waste has the potential to save natural resources (stone, river sand, soil etc.) and energy, occupying significant space at landfill sites and its presence impedes processing of bio-degradable waste as well as recyclable waste. C&D waste generated from metro construction has potential use after processing and grading. The contractor will segregate and temporarily store the C&D waste till he transports and disposes it at sites approved by TNPCB, CMDA and CMRL for the project. **Disposal of waste should follow good practice and some level of screening should be conducted.** N**ormal construction** waste **can go to existing facilities conform**

[12] Methods Manual of Soil Testing in India from Ministry of Agriculture or any other internationally recommended guideline/standards will be used for the soil investigation.

**to national systems,** however when **large scale spoil disposal will** take place **in specific** designated **locations this will need to be carefully managed.**

206. Prior to demolition of any building or structure contractor has to assess if Asbestos Containing Material (ACM) is potentially present in the building or structure to be demolished. The initial investigation on the potential presence of ACM has to be executed by a compenetent and duly qualified person. If the presence of ACM is likely or confirmed, contractor has to prepare an Asbestos Removal and Disposal Plan prior to the demolition works, to be approved by the PIU.

207. Material will be stabilized by watering or other accepted dust suppression techniques. The excavated soil and C&D waste (muck) will be filled in the dumping site in layers and compacted mechanically. Suitable slopes will be maintained on the stockpile. Once the filling is complete, it will be protected by low walls, provided with a layer of good earth on the top and covered with vegetation. A disposal plan will be prepared by Contractor, which will be approved by CMRL.

208. The contractor will ensure that hazardous wastes from construction activity and equipment are labeled, recorded, stored in impermeable containment and for periods not exceeding mandated periods and in a manner suitable for handling storage and transport. The contractor will maintain a record of sale, transfer, storage of such waste and make these records available for inspection. The contractor will get Authorized Recyclers to transport and dispose Hazardous Waste, under intimation to the Project Authority.

209. Sites for disposal of surplus excavated soil and C&D waste will be decided by CMRL before start of construction in consultation with TNPCB, Municipal Corporation/Municipalities and CMDA. The sites will be located away from residential areas, water bodies and ecologically sensitive locations as to avoid pollution and disruption of natural drainage. Disposal of hazardous waste will be done by licensed vendors at pre-approved sites independent of the project.

210. Non-hazardous solid waste generated in stations will be collected on a regular basis and transported to local municipal bins for onward disposal to disposal site by municipality. Regular inspection and maintenance of the waste collection system will be required in order to let it function effectively.

211. Residual impact. Metro construction will inevitably lead to depletion in construction material at source, the residual impact is considered to be minimal negative.

212. Since it will take some time for soil to settle after the construction works a minimal negative residual impact for soil erosion might exist. Although contractor has to take every effort to prevent contamination of construction yards and muck disposal sites, a certain degree of pollution cannot be ruled out. Construction yards and muck disposal sites could also cause a change in drainage patterns around the sites. Therefore a minimal negative residual impact exists, especially if the contractor's liability for any pollution that has arisen is insufficiently covered.

### 5.10. Flora

213. **Impact**. The alignment has been chosen in such a way that loss of trees and other vegetation is minimized as much as possible. However, the construction of MDB Corridor 3 will require cutting of about 164 public trees of girth 30cm or above. None of trees to be cut are rare or endangered species. With removal of these trees, the process for $CO_2$ conversion will get affected and the losses are reported below:

- Total number of Trees : 164
- Decrease in CO2 absorption due to loss of trees: 492 kg/year[13]
- Decrease in Oxygen production due to tree loss: 1,804 kg/year

214. Fugitive dust from construction yards, construction sites; particulate pollutants and dust from trucks hauling construction material, segments and waste soil and C&D waste disposal sites will be deposited on leaves thus impacting vegetation growth. Construction activities also have the potential to cause physical damage to trees and vegetation nearby the construction sites.

215. **Mitigation**. The loss of trees will be compensated through planting of 12 saplings for each tree felled. Location for compensatory plantation will be decided by CMRL in consultation with owner of the land as well Forest Department such that displacement does not become necessary. Depending on the chosen location, the Department of Forests, GOTN or the Chennai Municipal Corporation will be responsible for the conservation and management of the trees. It is found that about 164 trees are likely to be lost in the project under line and stations, hence 1968 trees are likely to be planted. The native plant species and miscellaneous indigenous tree species are recommended for plantation. These will be planted on government land pockets located on the project corridor. The saplings will be monitored for their survival for three years. Re-plantation shall be taken up every year with new saplings where saplings fail to survive.

216. Efforts will be made to minimize the cutting of trees by transplantation of the young trees when possible. Transplantation will be done in coordination with local forestry department. After completion of construction of the metro, CMRL will plant saplings in the road median: this re-planting is not in scope of works of the construction contractor.

217. Tree cutting and felling shall be done only if the tree is in the way of construction and only after receiving clearance from CMRL. No damage shall be caused to trees during construction activities other than the trees marked for felling. Vegetative cover shall be maintained as much as reasonably possible. Wherever excavations are made in the ground near the roots of trees that need to be maintained, appropriate measures shall be taken to prevent exposed soil from drying out and causing damage to the tree and its roots.

218. **Residual impact**. Although contractor has to take every effort not to damage trees and vegetation that needs to be maintained, the risk of damage to the vegetation cannot be ruled out completely. Since restoration of the vegetative cover will take some time a minimal negative residual impact will exist. Compensatory plantation will be done in a ratio of 12 saplings against each tree felled. Compensatory saplings will take to mature, therefore the short term residual impact of tree cutting will be minimal negative. Once the saplings have matured the residual impact will be positive.

### 5.11. Fauna

219. The alignment does not pass through ecologically sensitive areas. Construction yards and waste disposal sites will not be located near sensitive areas. River sand mining is banned.

220. **Impact**. The elevated project does not impede movement of terrestrial fauna; however the elevated metro could intercept flight paths of birds flying into and from Pallikaranai,

[13] *$CO_2$ sequestered per year per tree has been estimated for this report as 3 kg for typical tree of 30 cm girth. Amount of oxygen produced per tree per year for urban forests was adopted as 11 kg (Oxygen Production by Urban Trees in the United States, David J. Nowak, Robert Hoehn, and Daniel E. Crane, Arboriculture & Urban Forestry 2007). Based on model for tropical trees (Tree allometry and improved estimation of carbon stocks and balance in tropical forests, J.Chave et al, Oecologia 2005) and wood density for Asian species as per Food Agriculture Organization (FAO).*

Nanmangalam Forest and Sholinganallur Lake. Noise and vibration due to construction and operation of metro can impact breeding of terrestrial fauna and migratory birds of Pallikaranai and Nanmangalam howeber these are outside direct impact zone of project. Artificial light at night is known to cause disorientation, disruption in circadian rythms and high mortality in birds due to collision with illuminated buildings.

221. **Mitigation.** With measures to minimize dust, noise and vibration during construction in place no additional measures with regard to fauna will be necessary. Lighting at stations near Sholinganallur Lake will be kept to the minimum and of frequencies and brightness which do not affect bird behavior.

222. **Residual impact**. The impact of noise and vibration and lighting on birds will be accentuated by the height of double elevated structure. Since there are no endangered species present the residual impact will be minimal negative.

### 5.12. Private land and buildings

223. **Impact**. The proposed project will require transfer of 0.615 ha government land and acquisition of 0.203 ha private land. These figures will be revised upon completion of field socio-economic survey of affected families, revision of detailed drawings, preparation of land plan and micro plan of impacts. It is foreseen that 41 families all engaged in commercial activity and all non-titled will be impacted. 4 private commercial structures will be demolished, the affected persons will be displaced.

224. **Mitigation.** Affected persons and will be paid cash compensation at market rates for land and structures, compensation for loss of livelihood and and rehabilitation benefits as per policy approved by GOTN. Details are in the separate Social Impact Assessment Report.

225. **Residual impact**. Involuntary Resettlement is small in magnitude, project affected people will be duly compensated and a R&R plan will be implemented. The residual impact will therefore be minimal negative.

### 5.13. Public property / infrastructure / utility services

226. **Impact**. MDB Corridor 3 is planned to run elevated on existing section of NH49A upto Siruseri (Old Mahabalipuram Road/IT expressway). The alignment will cross sub-surface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, traffic signals, roadside lights, footbridges etc. These utilities/ services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position.

227. The Organizations / Departments responsible for concerned utility services are reported in Table 5-6.

**Table 5-6: Organizations Responsible for Utilities and Services**

| SN | Organization/ Department | Utility/Services |
|---|---|---|
| 1 | Tamil Nadu Public Works Department | Roads and bridges other than National Highways |
| 2 | Chennai Municipal Corporation | City roads and bridges , including hydrants and fountains etc., Roads, surface water drains, nallahs, sewer lines, streetlights |
| 3 | Chennai Metropolitan Water Supply & Sewerage Board | Water and sewage treatment plants, pumping stations sewerage and drainage lines; water mains and their service lines |

| SN | Organization/ Department | Utility/Services |
|---|---|---|
| 4 | National Highway Authority of India | Roads and bridges on National Highways |
| 5 | Indian Railways | Railway crossings, subways, signals, bridges, stations etc. |
| 6 | BSNL (OFC and Telephone Cables) | Tele cables, junction boxes, telephone posts, O.H lines |
| 7 | Airtel, Vodafone, Idea, Jio | Telecommunications cables, junction boxes, telephone posts, etc. |
| 8 | Power Grid Corporation of India Ltd. | HT towers, cables |
| 9 | Irrigation Dept. | Canal |
| 10 | Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO) | HT/other overhead Power lines |

228. As per information provided by utility agencies during preparation of DPR till December 2018, no gas pipelines are located on this road along which the metro is aligned. However in case any gas pipelines have been laid subsequently, a proper HAZOP study (& risk analysis) will be conducted as mentioned in the EMP by contractor and CMRL during pre-construction period for any kind of handling of this issue in concurrence with gas supply agency.

229. During construction period, complete/partial traffic diversions on road will be required, as most of the construction activities are along the road**.** As the alignment runs along centre of existing road, traffic originating from and destined to locations along this section of road will need to be diverted through internal roads. Further, traffic will move on a lesser width of road due to barricading of metro work zone along the road median. This will cause congestion leading to air pollution, fuel consumption, safety risks and passenger time loss due to decreased average speed of movement.

230. In case of shifting of utilities and temporary traffic diversions it might be necessary to temporarily use land outside of the construction zone.

231. **Mitigation.** The alignment of the metro will negotiate a number of utilities which will have to be maintained in working order during construction. They may require temporary or permanent diversion subject to their depth, details such as piling configuration or span of viaduct, utility protection measures, etc. In case public utilities are required to be shifted to private land in exceptional circumstances, then adequate compensation shall be made by CMRL to the property owner on the same principles as temporary land acquisition. Following completion of construction of metro, such utilities shall be rehabilitated on public land.

232. Prior to the start of excavation the contractor will perform a ground survey to confirm location of pipelines and other utilities after which detailed design consultant will revise, where necessary, spans and pile arrangement to ensure that pier foundations do not interfere with major underground utilities.

233. Where the alignment cannot be fine-tuned to avoid conflict with utilities, permanent diversions will be done before commencement of work on the pertinent section; temporary diversions can be done before or during construction. Plans for diversion or relocation of any utilities along with hazard studies if required will be prepared by the Contractor in consultation with and approval of respective utility agencies before finalization of time schedule of metro construction works. Preferably they will have to be diverted by the agencies themselves.

234. In order to retain satisfactory levels of traffic flow during the construction period, traffic management and engineering measures need to be taken. They can be road widening, traffic

segregation, one-way movements, traffic diversions, acquisition of service lanes, etc. Barricading of road space for construction is required along the central median of the road on viaduct and edge of road right of way at stations. To minimise traffic delays, segmental construction will be employed. Maintenance of diverted roads in good working condition to avoid slow down and congestion will be a prerequisite during construction period.

235. The following traffic management guidelines will form basis of procedures to be adopted by contractor to ensure the safe and efficient movement of traffic and also to ensure the safety of workmen at construction sites. The Contractor will develop detailed traffic management plans consistent with the Indian Guidelines on Traffic Management in work zones (IRC:SP:55-2014), prior to mobilization for respective sections with site-specific plans.

- High visibility reflective jackets to construction workers
- Signage to warn the road user clearly and sufficiently in advance.
- Safe and clearly marked lanes and buffer and work zones for guiding road users and workers
- The primary traffic control devices used in work zones will include signs, delineators, barricades, cones, pylons, pavement markings and flashing lights.
- Advance traffic updates/ information for users of affected roads.
- Traffic diversion due to temporary road closures
- At congested sections, temporary traffic coordinators will be engaged to facilitate the traffic management.
- Focus will be on ensuring safe access to properties, passage to pedestrians, parking,
- Construction traffic moving from construction yards to construction sites and from construction sites to soil/waste disposal areas may be confined to certain routes (based on infrastructure capacity) or restricted to certain off -peak hours so to reduce noise pollution at night or to avoid commuting and school hours during the day.
- If necessary, bus service and other public and private transport services in the area should be improved to meet residents' transportation needs.

**Residual impact**. After construction all utilities will be fully functional and temporary traffic diversions will no longer be necessary. Therefore no residual impact will exist after completion of construction.

### 5.14. Aesthetics

236. **Impact**. The metro is proposed as a second level above an elevated road which is planned as a separate project. The spans, columns and foundations of the metro viaduct and stations will be aligned with but structurally independent of the elevated road. As mentioned in project description, columns of metro and elevated road will be mutually independent resulting in average span of about half the typical metro span which means more columns and hindered sightlines. This will result in a large mass of concrete leading to significant distortion of aesthetics.

237. **Mitigation.** Sleek columns will be incorporated in the structural design as much as possible without compromising safety.

238. **Residual impact**. Notwithstanding the sleek structure, the visual impact of the double elevated metro will be high and will be accentuated after the future elevated road is constructed. Since construction will take place in an urbanized area with a lot of concrete buildings already present the overall residual impact will be moderate negative. However in cases where residential buildings are near the alignment the residual impact could be high negative.

## 5.15. Noise

239. Baseline noise without metro is already higher than permissible limits; metro will add to it. Noise during operation of the metro could cause annoyance and disturbance to daily living and impact health of residents and workers along the alignment.

240. Annexure 2 lists a total of 52 identified receptors along MDB corridor 3 such as schools, hospitals, places of worship, high-rise residential buildings, and hotels. From this list 10 representative sensitive receptors were chosen to be included in the initial noise modeling for corridor 3 as a whole, including a total of 3 high-rise residential buildings. Initial modeling is based on a design speed of metro of 80 kmph and was carried out over the lifetime of the project, including increase in estimated number of trains over time as per DPR.

241. **Impact**. Among others noise will be generated from equipment during construction and wheel-rail interaction during operation. Noise generation from metro operation has been recorded from past experience from existing metros in India as presented in Table 5-7 and 5-8. Train running and track structures generally constitute the major noise sources. The noise level at 2 m distance from the rail alignment is about 73 dB(A) which is higher than the CPCB permissible limit of 65 dB(A), and is much higher than the 50 dB (A) daytime limit for silence zone. The noise level reduces with distance logarithmically.

**Table 5-7: Exterior Noise Levels in Metro Stations**

| S. No | Description | Average Noise Levels dB(A) |
|---|---|---|
| | | Elevated tracks |
| 1 | Background Noise Level | 64.0± 1.5 |
| 2 | Train entering the Platform (Max) | 84.0± 1.5 |
| 3 | Train leaving the Platform (Max) | 84.0± 0.5 |
| 4 | Train stopping in Platform | 79.0± 0.0 |
| 5 | Train stationary in Platform | 76.0± 0.5 |
| 6 | Train starting from Platform | 78.5± 1.0 |
| 7 | Train braking | 86.0± 0.0 |
| 8 | Announcement | 74.0± 0.5 |
| **Overall** | | **76.0± 7.0** |

**Table 5-8: Interior Noise Levels in Metro Trains**

| S. No | Description | Average Noise Levels dB(A) |
|---|---|---|
| | | Elevated tracks |
| 1 | Train stationary | 62.0± 1.0 |
| 2 | Train starting | 62.0± 1.0 |
| 3 | Train motoring | 70.0± 2.5 |
| 4 | Train coasting | 72.0± 2.0 |
| 5 | Train at max. speed | 78.0± 1.0 |
| 6 | Train decelerating | 69.0± 0.5 |
| 7 | Train stopping | 64.4± 1.0 |
| 8 | Train braking | 74.5± 1.0 |
| 9 | W/R Noise | 75.0± 1.5 |
| 10 | Door operations (max.) | - |
| **Overall** | | **69.0± 5.0** |

*Source: Studies carried out by Central Road Research Institute (CRRI) for metro projects in India*

242. Noise is a contributing factor to degradation of human health. Noise pollution will be generated by construction activities and equipment; due to demolition of structures to be removed; piling; blasting in rock where required and vehicular movement.

243. The major sources of noise during construction phase are due to operation of various types of construction equipment. Permitted number of impacts (example piling) at various noise levels is prescribed under Model Rules of the Factories Act, 1948. Actual noise from construction equipment (Lmax) measured at 50 feet distance[14] ranged from 76 dB(A) to 84 dB(A); vibratory pile driver at 101 dB(A). The average noise levels generated by various types of construction equipment are given in Table 5-9.

**Table 5-9: Average Noise Levels Generated by Operation of Various Construction Equipment**

| Equipment | Typical Noise Level (dBA) at 50 ft from source |
|---|---|
| Air Compressor | 81 |
| Backhoe | 80 |
| Ballast Equalizer | 82 |
| Ballast Tamper | 83 |
| Compactor | 82 |
| Concrete Mixer | 85 |
| Concrete Pump | 82 |
| Concrete Vibrator | 76 |
| Crane Derrick | 88 |
| Crane Mobile | 83 |
| Dozer | 85 |
| Generator | 81 |
| Grader | 85 |
| Impact Wrench | 85 |
| Jack Hammer | 88 |
| Loader | 85 |
| Paver | 89 |
| Pile Driver (Sonic) | 96 |
| Pneumatic Tool | 85 |
| Pump | 76 |
| Rock Drill | 98 |
| Roller | 74 |
| Scraper | 89 |
| Shovel | 82 |
| Truck | 88 |

*Source: FTA Transit Noise and Vibration Guidance Handbook, May 2006*

**Table 5-10: Actual Noise Levels Generated by Various Construction Equipment**

| Equipment | Actual Lmax Noise Level (dBA) at 50 ft from source |
|---|---|
| Auger drill rig * | 84 |
| Compressor * | 78 |
| Dump truck * | 76 |
| Excavator * | 81 |
| Flat bed truck * | 74 |
| Front end loader * | 79 |

[14] Construction Noise Handbook August 2006, FHWA, USA

| Equipment | Actual Lmax Noise Level (dBA) at 50 ft from source |
|---|---|
| Vibratory Pile driver * | 101 |
| Press Pile | 70 |
| Batching Plant | 90 |
| Booster pump | 80 |

** Source: Construction Noise Handbook, US FHWA, Aug 2006*

244. During construction phase, there will be significant increase in vehicular movement for transportation of construction material. In addition there will be noise from the usual traffic with possible traffic congestion due to traffic diversion. During construction phase, the increase in vehicular movement is expected to increase up to a maximum of 5 to 6 trucks/hour.

245. The effect of high noise levels on the operating personnel has to be considered as this may be particularly harmful. It is known that continuous exposures to high noise levels above 90 dB(A) affects the hearing acuity of the workers/operators and hence, should be avoided. To prevent these effects, it has been recommended by Occupational Safety and Health Administration (OSHA) that the exposure period of affected persons is limited (Table 5-11).

**Table 5-11: Maximum Exposure Periods Specified By OSHA**

| Maximum equivalent continuous Noise level dB(A) | Unprotected exposure period per day for 8 hrs/day and 5 days/week |
|---|---|
| 90 | 8 |
| 95 | 4 |
| 100 | 2 |
| 105 | 1 |
| 110 | ½ |
| 115 | ¼ |
| 120 | No exposure permitted at or above this level |

246. **Mitigation**. The design will include noise reducing features such as, but not limited to, baffle wall as parapets up to the rail level, resilient mounting and dampers and welded rails. In order to establish feasibility of noise mitigation for corridor 3 initial noise modeling has been carried out at residential, educational, medical and physical cultural buildings located within recommended screening distance of 100m (RRT, intervening buildings) for noise on either side of alignment For the MDB corridor 3 section the initial noise modeling focused on 1 police station, 4 religious buildings, 2 hospitals and 3 residential high-rise buildings as sensitive receptors along the alignment. The predicted noise levels during construction phase are summarized in table 5-12.

**Table 5-12: Summary of predicted Noise Levels during Construction**

| No | Name of the Sensitive Receptors | Type of Receptor | Distance (m) | Baseline Noise levels db(A) | Without Barrier | | | With Barrier | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Predicted Noise Model levels db(A) | Predicted Noise | Status - No Barrier | Predicted Noise levels db(A) | Predicted-Mitigated Noise | Status |
| | | | | $L_{eq}$,d | $L_{eq}$,d | $L_{eq}$,d | $L_{eq}$,d | $L_{eq}$,d | $L_{eq}$,d | $L_{eq}$,d |
| 1 | Sholinganallur junction | Police station | 42 | 72 | 67.5 | 73 | No-Impact | 63.8 | 72.3 | No-Impact |

| No | Name of the Sensitive Receptors | Type of Receptor | Distance (m) | Baseline Noise levels db(A) | Without Barrier | | | With Barrier | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Predicted Noise Model levels db(A) | Predicted Noise | Status - No Barrier | Predicted Noise levels db(A) | Predicted-Mitigated Noise | Status |
| | | | | $L_{eq}$,d | $L_{eq}$,d | $L_{eq}$,d | $L_{eq}$,d | $L_{eq}$,d | $L_{eq}$,d | $L_{eq}$,d |
| **2** | Greensville Appaswamy | Residential | 35 | 65 | 64 | 67 | Impact | 59 | 66 | No-impact |
| **3** | Veerasakthi vinayagar temple | Temple | 38 | 93 | 63.1 | 93.1 | No-Impact | 60.6 | 93.1 | No-Impact |
| **4** | Sri ponniyamman temple | Temple | 25 | 56 | 50.2 | 57 | No-Impact | 45.5 | 56.4 | No-Impact |
| **5** | St. joseph college | college | 42 | 60 | 55.4 | 61.4 | No-Impact | 43.2 | 60.3 | No-Impact |
| **6** | RSK Orchid Garden | Residential | 81 | 62 | 69 | 70 | Impact | 58 | 64 | No-Impact |
| **7** | Sri bala vinayagar temple | Temple | 30 | 69 | 62 | 69.5 | No-Impact | 57.9 | 69 | No-Impact |
| **8** | Jamia masjid islamic centre | Temple | 45 | 65 | 68.9 | 70.4 | Impact | 63.8 | 67.5 | No-Impact |
| **9** | Radiance Ivy Terrace | Residential | 48 | 64 | 65 | 68 | Impact | 60 | 66 | No-Impact |
| **10** | Madhura hospital | Hospital | 55 | 68 | 63 | 69 | No-Impact | 55 | 67.9 | No-Impact |

247. Table 5-12 shows that in most cases construction noise is not expected to increase baseline noise with more than 3 dB(A). If an impact is expected than noise barriers can mitigate construction noise to an extent that baseline noise is not increased with more than 3dB(A). Furthermore the high levels of construction noise can be related to piling operations in those instances where in-situ casting is not possible. These piling operations will be restricted during day time hours only, the piling operation would be short term, few hours in a day and therefore the significance of the noise disturbance is not continuous and can be reduced by carefully planning the piling operations.

**Table 5-13: Summary of predicted Noise Levels during Operation**

| Sl. No | Name of the Sensitive Receptors | Baseline Noise levels db(A) | | Operation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Without Barrier | | | | | With Barrier | | | | |
| | | | | Predicted Noise levels db(A) | | Final Noise | | Remarks | Predicted Noise levels db(A) | | Final Noise | | Status |
| | | Leq,d | Leq,n | Leq,d | Leq,n | Leq,d | Leq,n | | Leq,d | Leq,n | Leq,d | Leq,n | |
| **1** | Sholinganallur junction – police station | 72 | 68 | 69 | 60 | 73 | 68 | No-Impact | 55 | 47 | 72 | 68 | No-Impact |
| **2** | Greensville Appaswamy | 65 | 57 | 9 | 12 | 65 | 57 | No-Impact | 12 | 15 | 65 | 57 | No-Impact |
| **3** | Veerasakthi vinayagar temple | 93 | 63 | 65 | 57 | 93 | 64 | No-Impact | 52 | 44 | 93 | 63 | No-Impact |
| **4** | Sri ponniyamman temple | 56 | 50 | 43 | 39 | 56 | 50 | No-Impact | 53 | 45 | 58 | 51 | No-Impact |
| **5** | St. joseph college | 60 | 55 | 64 | 61 | 66 | 62 | Impact | 43 | 35 | 60 | 55 | No-Impact |
| **6** | RSK Orchid Garden | 62 | 56 | 40 | 42 | 62 | 56 | No-Impact | 36 | 39 | 62 | 56 | No-Impact |
| **7** | Sri bala vinayagar temple | 69 | 62 | 76 | 72 | 76 | 73 | Impact | 52 | 44 | 69 | 62 | No-Impact |
| **8** | Jamia masjid islamic centre | 65 | 69 | 66 | 63 | 68 | 70 | Impact | 55 | 46 | 65 | 69 | No-Impact |
| **9** | Radiance Ivy Terrace | 64 | 58 | 19 | 21 | 64 | 58 | No-Impact | 36 | 38 | 66 | 62 | No-Impact |

| Sl. No | Name of the Sensitive Receptors | Baseline Noise levels db(A) | | Operation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Without Barrier | | | | | With Barrier | | | | |
| | | | | Predicted Noise levels db(A) | | Final Noise | | Remarks | Predicted Noise levels db(A) | | Final Noise | | Status |
| | | Leq,d | Leq,n | Leq,d | Leq,n | Leq,d | Leq,n | | Leq,d | Leq,n | Leq,d | Leq,n | |
| **10** | Madhura hospital | 68 | 51 | 61 | 52 | 68 | 55 | Impact | 53 | 45 | 68 | 52 | No-Impact |

248. During the operational phase 4 out of 10 of the selected sensitive receptors would be impacted without additional mitigation measures. The initial noise modeling shows that a 3 meter high noise barrier would reduce operational noise to acceptable levels at these locations. The noise modeling report also suggests noise barriers to be put in place near curves in the alignment and at station locations.

249. **Embedded Measures:** Noise barriers shall be placed along the curved portion of the viaduct and at stations during operation. The ballast-less track supported on two layers of rubber pads can reduce track noise and ground vibrations. In addition, providing skirting of coach shell covering the wheel will screen any noise coming from the rail wheel interaction as of propagating beyond the viaduct. Screening of noise can be ensured by providing parabolic noise barriers on each side of the track along the curved portion of the viaduct and at stations during operation. Polycarbonate noise barriers 15 mm to 25 mm are known to reduce noise level by between 30 dB to 33 dB. Elevated stations located at the median of existing roads will be 140 m long and 24 m wide. In view of adequate right of way of road, the stations will be constructed on portal frames. The typical elevated station consists of three levels: ground, concourse and platform. Passenger facilities, operational and commercial areas are provided at the concourse level. The viaduct is 2-level comprising space for the future construction of an elevated road at lower level with a minimum vertical clearance of 5.50 m above road level and metro at the higher level.

250. **Proposed Measures:** When noise mitigation treatments cannot be applied at the noise source or additional mitigation is required after treating the source, the next preferred placement of noise mitigation is along the noise propagation path between the source and receiver. Common path treatments are described below.

- Noise Barriers – Noise barriers are effective in mitigating noise when they break the line-of-sight between source and receiver. The necessary height of a barrier depends on the source height and the distance from the source to the barrier;
- Noise barriers close to vehicles – Barriers located very close to a rapid transit train, for example, may only need to be approximately 1 to 3m above the top of rail to be effective. Standard barriers close to vehicles can provide noise reductions of 6 to 10 dB; and
- Noise barriers at ROW line – Barriers on the ROW (Right of Way) line or for trains on the far track, the height must be increased to provide equivalent effectiveness to

barriers located close to the vehicles. Otherwise, the effectiveness can drop to 3 dB or less, even if the barrier breaks the line-of-sight.

251. In order to verify the predicted noise levels, the EMP provides for noise monitoring during the first three years of operation.

252. During construction various measures such as noise mufflers, enclosures, low-noise equipment and temporary noise barriers will reduce noise. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to be less than level prescribed in these standards. Vehicles and construction equipment will be in good state of maintenance, where feasible of low noise design, fitted with noise mufflers. Other mitigation measures to be taken are:

- At sensitive locations, auger piling will be carried out in place of mechanical (by driven) piling which will generate less noise than mechanical piling (around 70-75 dB(A)). Also 2m high barricade of GI sheet will be installed on all sides of piling operations. This could effectively cut down noise levels by 10-15 dB (A). Piling operations will be restricted during day time hours only
- Noisy construction activities will be enclosed by use of transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities;
- RCC pumps will be covered from all sides. Bends and excessive head will be avoided;
- If needed, construction traffic may be confined to certain routes (based on infrastructure capacity) or restricted to certain off -peak hours (that is, to reduce noise pollution at night or to avoid commuting and school hours during the day);
- Local residents and shop owners will be informed about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement;
- Noise monitoring is required during construction, including field observations and measurements.

253. Exposure of workers to high noise levels will be minimized by measures such as the following:

- Personal protective equipment such as passive or active ear-muffs
- Use of electric instead of diesel powered equipment
- Use of hydraulic tools instead of pneumatic tools
- Acoustic enclosures for noise generating construction equipment like DG sets
- Scheduling work to avoid simultaneous activities that generates high noise levels
- Job rotation where feasible
- Sound-proof control rooms
- Automation of equipment and machineries, wherever possible.

254. **Residual impact**. Even with the proposed design features metro operation will add to the baseline noise and vibration levels that are already high enough to cause annoyance. Without additional mitigation the residual impact could be moderate negative. Initial noise modelling shows it is feasible to mitigate the operational noise by means of noise barriers, the final layout, height and length of noise barriers required has to be established during detailed design. It is expected the increase in noise can be mitigated to an extent that the increase is less than 3dB(A), thus a minimal negative residual impact will remain.

## 5.16. Vibration

255. Construction and operation of metro will cause vibration from equipment during construction and wheel-rail interaction during operation. As part of the detailed design, a vibration analysis (mathematical modeling) at pre-identified receptors comprising residential, educational, medical and physical cultural buildings and other fragile buildings located within recommended screening distance of 62m (RRT, cat.2) on either side of alignment will be carried out, based on which, a set of mitigations will be prepared and shared with all lenders for review, prior to commencement of construction.

256. However, as part of this EIA, an initial vibration assessment has been conducted by Aimil Limited and AV Ingenieria Vibroacustica in May 2021, , in which a general vibration and annoyance assessment for both construction and operational phase has been carried out as well as an assessment of the vibration impacts on 8 selected sensitive receptors has been provided. The vibration assessment required as a prolonged annoyance has been carried out based on the methodology proposed by the Federal Transient Administration of USA in Transit Noise and Vibration Impact Assessment Manual. The vibration induced during the operational phase is based on the USA Federal Transient Administratons methodology to create a ground-borne vibration prediction model to assess metro operation related vibration into buildings.The assessment also followed the “Metro Rail Transit System. Guidelines for Noise and Vibrations” elaborated by CT-38 Track Design Directorate, Research Designs and Standards Organisation (RDSO), Ministry of Railways of India.

257. **Impact**. Based on the general vibration assessment, it is concluded that during construction, pile drivers (impact or sonic), clam shovel drop, and vibratory roller are the most significant equipments of impact. Depending on the building structure type, pile driving can affect buildings up to 40 meters distance. Annoyance from piling could be felt at a distance of up to 100 meters, as shown in Table 5-14 and Table 5-15 and presented in the vibration assessment report in Annexure 11. The sensitive receptors that were considered for the initial vibration assessment are shown in Table 5-18**Error! Reference source not found.**.

**Table 5-14: Predicted affected area for structural damage during construction per structure type**

| Construction equipment | Affected area distance from construction zone (m) – Considering the structure type | | | |
|---|---|---|---|---|
| | structure type 1 (0.5 inch/s) | structure type 2 (0.3 inch/s) | structure type 3 (0.2 inch/s) | structure type 4 (0.12 inch/s) |
| Impact pile drive (upper range) | 16 m | 23 m | 30 m | 41 m |
| Sonic pile drive (upper range) | 10 m | 14 m | 19 m | 25 m |
| Impact pile drive (typical range) | 9 m | 12 m | 16 m | 23 m |
| Clam shovel drop | 4 m | 6 m | 8 m | 11 m |
| Vibratory roller | 4 m | 6 m | 8 m | 11 m |
| Sonic pile drive (typical range) | 4 m | 6 m | 6 m | 9 m |

**Table 5-15: Predicted affected area for annoyance during construction considering the land use**

| Building structure | Affected area distance from track centre (m) – Considering the land use | | |
|---|---|---|---|
| | Category 1 (65 VdB) | Category 2 (72 VdB) | Category 3 (75 VdB) |
| Impact pile drive (upper range) | 100 m | 100 m | 100 m |
| Sonic pile drive (upper range) | 100 m | 93 m | 76 m |
| Impact pile drive (typical range) | 100 m | 89 m | 70 m |
| Clam shovel drop | 69 m | 41 m | 32 m |
| Vibratory roller | 69 m | 41 m | 32 m |
| Sonic pile drive (typical range) | 64 m | 37 m | 30 m |

258. Affected areas for vibration during operation of the metro system are presented in **Table 5-16Error! Reference source not found.Error! Reference source not found.** and **Table 5-17** presented in the vibration assessment report in Annexure 11.

**Table 5-16: Predicted affected area for annoyance during operation in the underground section for design and scheduled speed considering the land use**

**Design speed 80 kmph**

| Building structure | Affected area radius from track centre (m) – Considering the land use | | |
|---|---|---|---|
| | Category 1 (65 VdB) | Category 2 (72VdB) | Category 3 (75 VdB) |
| Wood-Frame Houses | 70 m | 36 m | 26 m |
| 1-2 Story Masonry | 58 m | 29 m | 20 m |
| 3-4 Story Masonry/ Large Masonry on Piles | 44 m | 20 m | 13 m |
| Large Masonry on Spread Footings | 32 m | 13 m | -- |

**Scheduled speed 32 kmph**

| Building structure | Affected area radius from track centre (m) – Considering the land use | | |
|---|---|---|---|
| | Category 1 (65 VdB) | Category 2 (72VdB) | Category 3 (75 VdB) |
| Wood-Frame Houses | 32 m | 14 m | -- |
| 1-2 Story Masonry | 20 m | 10 m | -- |
| 3-4 Story Masonry/ Large Masonry on Piles | 18 m | -- | -- |
| Large Masonry on Spread Footings | 12 m | -- | -- |

***Source: AV Ingenieros / Aimil Ltd. Vibration Forecasting report***

**Table 5-17: Predicted affected area for annoyance during operation in the elevated section for design and scheduled speed considering the land use**

**Design speed 80 kmph**

| Building structure | Affected area radius from track centre (m) – Considering the land use | | |
|---|---|---|---|
| | Category 1 (65 VdB) | Category 2 (72VdB) | Category 3 (75 VdB) |
| Wood-Frame Houses | 36 m | 16 m | 10 m |
| 1-2 Story Masonry | 29 m | 12 m | 7 m |
| 3-4 Story Masonry/ Large Masonry on Piles | 20 m | 7 m | 4 m |
| Large Masonry on Spread Footings | 13 m | 3 m | 2 m |

259. During operation of the metro system in the underground section in balance corridor 3, buildings within a maximum distance of 58 m will be affected by induced vibration if 80 kmph design speed and masonry building structures are considered. This distance will be reduced to 20 m if 32 kmph scheduled speed is considered. For elevated sections, a maximum distance of 29 m will be affected if 80 kmph design speed and masonry building structures are considered. This distance will be reduced to 10 m if 32 kmph scheduled speed is considered.

260. **The 8 sensitive receptors that were considered for the initial vibration assessment are shown in Table 5-18**Error! Reference source not found.**.**

**Table** 5-18**: Sensitive receptors for vibration assessment**

| S. No | Location No | Location | Elevated / Underground | Distance from alignment [m] | Location coordinates |
|---|---|---|---|---|---|
| 1 | C3-A | Purasaivakkam (Tana Road) | UG | 15 | Lat: 13° 5'10.99"N Long: 80°15'19.20"E |
| 2 | C3-C | Good Shepherd School | UG | 70 | Lat: 13° 3'56.09"N Long: 80°14'40.48"E |
| 3 | C3-D | Royapettah Govt. Hospital | UG | 2 | Lat: 13° 3'18.69"N Long: 80°15'52.64"E |
| 4 | C3-E | MGR Janaki College | UG | 41 | Lat: 13° 1'1.11"N Long: 80°15'39.34"E |
| 5 | C3-F | Shivalayam Temple | Elevated | 30 | Lat: 12°50'47.66"N Long: 80°13'34.42"E |
| 6 | C3-G | Vinayagar Temple | Elevated | 41 | Lat: 12°53'8.80"N Long: 80°13'35.50"E |
| 7 | C3-H | St. Joseph College of Engineering | Elevated | 60 | Lat: 12°52'12.78"N Long: 80°13'33.60"E |
| 8 | C3-I | Madhura Hospital | Elevated | 28 | Lat: 12°50'13.54"N Long: 80°13'40.67"E |

*Source: AV Ingenieros / Aimil Ltd. Vibration Forecasting report*

261. The first 4 sensitive receptors are located at the underground section of balance corridor 3, C3-F to C3-I are located along the elevated section of MDB corridor 3. With regard to the specific sensitive receptors during construction,1 out of 8 could be exposed to induced vibration levels higher than the damage criteria. The construction equipment could cause annoyance to 5 out of 8 sensitive receptors (see Annexure 11).

262. During the operational phase 1 out of 8 sensitive receptors could be impacted if scheduled speed of 32 kmph is considered and if the assumptions with regard to building and foundation type are correct, this location is Royapettah Government Hospital.

263. As a feature of design, track fittings during operation will reduce vibration. Baseline vibration without metro is already higher than annoyance limits; metro will add to it. Vibration during operation of the metro could cause annoyance and disturbance to daily living of residents and workers along the alignment. Vibration could damage fragile and old buildings over a period of time.

264. Pile driving for viaduct piers and buildings generate vibrations. Apart from distance from the alignment, soil, age and condition of buildings adjacent to the alignment determines extent of damage to such buildings due to vibration. Continuous effect of vibration on the buildings can cause damage to buildings. Table 5-19 provides typical PPV values at 25 ft for several types of construction machinery.

265. Vibration from pile driving can be calculated with the following equation (FTA, 2018):

$$PPV_{\text{Impact Pile Driver}} = PPV_{Ref}\,(25/D)^{1.5}$$

In which: $PPV_{Ref}$ = 0.644 in/sec (for a typical pile driver at 25 ft.)
D = distance (from pile driver to the receiver in ft.)

**Table 5-19: Vibration source levels for construction equipment (FTA)**

| Equipment | | PPV at 25 ft, in/sec | Approximate Lv* at 25 ft |
|---|---|---|---|
| Pile Driver (impact) | upper range | 1.518 | 112 |
| | typical | 0.644 | 104 |
| Pile Driver (sonic) | upper range | 0.734 | 105 |
| | typical | 0.17 | 93 |
| Clam shovel drop (slurry wall) | | 0.202 | 94 |
| Hydromill (slurry wall) | in soil | 0.008 | 66 |
| | in rock | 0.017 | 75 |
| Vibratory Roller | | 0.21 | 94 |
| Hoe Ram | | 0.089 | 87 |
| Large bulldozer | | 0.089 | 87 |
| Caisson drilling | | 0.089 | 87 |
| Loaded trucks | | 0.076 | 86 |
| Jackhammer | | 0.035 | 79 |
| Small bulldozer | | 0.003 | 58 |

* RMS velocity in decibels, VdB re 1 micro-in/sec

266. Based on this equation and the damage criteria as mentioned in paragraph 4.3.6 a typical engineered concrete or masonry building is potentially at risk if it is located within 22 meter of the pile driving works. As mentioned under Location and Design, further vibration modeling will be conducted, based on the detailed engineering design to inform the incremental impacts and suggest the mitigations accordingly.

267. During operation vibration is found to be higher with higher speeds and lower with heavier transit structure.

268. **Mitigation**. The design will include vibration reducing features such as, but not limited to ballast less track structure supported on two layers of rubber pads, resilient mounting and dampers and welded rails.

269. Construction activities shall be scheduled such that demolition, earthmoving and ground-impacting operations do not occur in the same time period. At locations, where the alignment is close to sensitive structures, the contractor shall prepare a monitoring scheme prior to construction at such locations. In case of sensitive structures, vibration mitigation measures will be implemented.

270. Vibratory rollers near sensitive receptors shall be avoided.

271. The contractor should prepare a mitigation plan and implement the same during the final design and construction phase of the project. This scheme shall include:

- Monitoring requirements for vibrations at regular intervals throughout the construction period;Pre-construction structural integrity inspections of sensitive structures.

- Information dissemination about the construction method, probable effects, quality control measures and precautions to be used.

- vibration monitoring plan during final design and the implementation of a compliance monitoring program during construction

272. Damping treatments, localized stiffening or mass addition at the receptors to reduce post -construction vibration. Wave-impleding blocks (WIP) , subgrade stiffening and wave barriers can be effective measures of interrupting the propagation of waves through the soil.

273. Visual inspections of pre-identified buildings at risk of damage caused by vibrations during construction shall be done so as to serve as baseline to monitor progression of building damage if any. The visual inspections will be done in attendance of the owner of the building and will be recorded.

274. Contractor has to ensure that vibration levels at receptors comprising educational, medical and physical cultural buildings and other fragile buildings located within recommended screening distance of 62m on either side of alignment will not exceed 2.5. mm/s (especially at the Roya pettah Government Hospital).

275. Cast-in-situ piling will be deployed so as to reduce vibration.

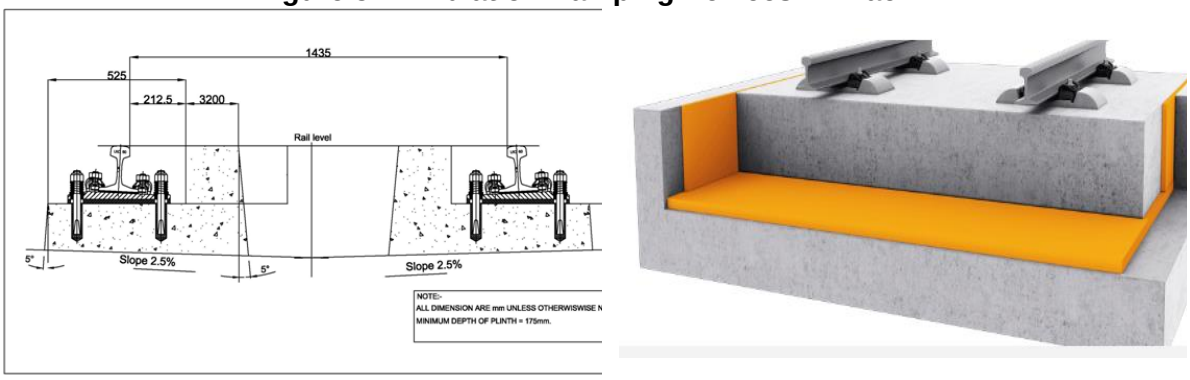
276. In the case of vibrations from road traffic and pile driving, very deep barriers (in excess of 10 m) shall reduce vibration. In-ground barriers are trenches that are either left open or filled with a material (such as bentonite or concrete) that has stiffness or density significantly different from that of the surrounding soil. However, trenches may be too costly for situations involving houses. They could perhaps be justified for larger buildings with strict vibration limits, such as operating theatres of hospitals or high-tech factories with sensitive processes. An economical alternative to trenches in a residential area could be a row of lime or cement piles of diameter 0.5 m to 1 m and a depth of 15 m in the right-of-way adjacent to the road. However, the effectiveness of such pile-walls has not yet been demonstrated[15.] Measures will be decided upon forecast of vibration.

277. Detailed vibration modeling is needed if sensitive receptors are located within the reported distances from the track in order to determine if the negative impacts can be fully mitigated through the following mitigation measures:

[15] NRC-CNRC Construction Technology Update No. 39, 2000, Vibrations in Buildings by Osama Hunaidi and A review on the effects of earth borne vibrations and the mitigation measures, BOO Hyun Nam et al, IJR International Journal of Railway, Sept 2013.

- Ballasted tie-welded track with elastic steel fastenings and plastic or rubber absorbing pad will reduce noise and vibration levels. Surface irregularities on the wheel and rail will be minimized by good maintenance of wheel and rail condition.
- Elastic pad between seat of the rail and the track slab as well as between track slab and the superstructure beneath it will reduce vibration will be installed to reduce transmission of vibration from the track and superstructure. Indicative arrangement is depicted in Figure 5-3.Using floating slab and high resilience fasteners to reduce the vibration at the point of emission.

**Figure 5-1: Vibration Damping Devices in Track**




*Source: Getzner Werkstoffe*

278. **Residual impact.** Baseline vibration is already high enough to cause annoyance and operation will add to it. However, since vibration impacts decrease with an increase in distance from the alignment, the impact will be much localized. Therefore the residual impact is considered minimal negative.

279. **Mitigation.** Vibration monitoring and building condition surveys is required to determine if there are negative impacts and annoyance post mitigation implementation.

280. In cases, especially at the Royapettah Government Hospital, additional mitigation measures shall be provided to ensure that vibration and annoyance impacts are below the threshold criteria.

## 5.17. Occupational Health and Safety

281. **Impact**. Safety and health of metro personnel can be impacted in terms of failure of equipment or operating personnel or security in stations and on trains. Proper design of health and safety features in stations and trains can reduce this impact.

282. It is estimated that about 1907 persons will work during peak construction activity on site and casting yards. Estimated total population in the labour camps will be 1708. The water requirement at camps will be 231 KLD, wastewater generation 196 KLD & municipal solid waste generation 0.5 ton per day. This is tentative and will vary depending on the construction schedule during construction. Unclean water can cause health problems to residents of worker camps. Problems could arise due to cultural differences between workers from outside and local residents. Construction workers are more prone to infectious diseases and lack of sanitation facilities (water supply and human waste disposal) and insect vectors. Covid-19 poses a greater hazard with a higher risk for workers in the labour camps due to proximity of living spaces of individuals and families. Sleeping and eating spaces and public conveniences will require area much higher than are as per current norms. Further, practices of personal hygiene such as hand sanitizing and face protection need to be incorporated in the psyche of

the camp residents as well as local people who operate small shops at the camp. Testing, transportation and hospital facilities of a much higher order of safety will be required.

283. The following elements impact worker safety – working at heights, excavations, electrical and mechanical; gases; machinery; equipment; blasting; formwork; piling; PPE; medical facilities; firefighting; housekeeping; segment launching; batching plant; transport; security; explosives; general safety. Covid-19 poses a hazard with a high risk for workers due to proximity of working and quality and safety inspections.

284. Harmful electromagnetic radiation is emitted by electrical traction and rolling stock: exposure of personnel needs to be minimized; electronic equipment needs to be immunized. CMRL personnel could be impacted by the effects of electromagnetic interference, electromagnetic radiation, musculoskeletal disorders (MSDs), stress and communicable diseases such as Covid-19.

285. Electromagnetic Interference (EMI) in metro railway can disturb electronic circuits in 3 ways:

- EMI in railway infrastructure like signaling caused by rolling stock. Considering the criticality of signaling, such disturbances can cause accidents and safety of staff as well as passengers.
- EMI in environment caused by rolling stock. The railway can impact environment upto at least 10m from the track (Railway EMI impact on train operation and environment, A Morant etal, IEEE, Dec 2012)
- EMI in rolling stock caused by environment.

286. **Mitigation.** CMRL has an HSE Manual in place outlining the minimum Health and Safety standards that shall be required by CMRL during construction of the Chennai metro rail project. Furthermore, the manual has been developed to give guidance and assistance to the respective Contractors in the development and production of their Site Health and Safety Plans, to satisfy the required H&S standards established by the Contract Conditions and the Employer's Requirements. The SHE Manual forms integral part of the bidding documents for the works to be undertaken. Construction works will be executed as laid down in the manual as applicable to MDB corridor 3. The applicable sections are i) Control Document; ii) Health and Safety Manual; and iii) Environmental Management Arrangements. Control comprises: Legal requirements; standards; Contractor`s organisation and interfaces with CMRL; procedures to identify hazards and estimate risk, hazard mitigation measures; emergency response plan; resources; arrangements for training, inspection, communication, compliance, reporting, documentation and audit, review; complaint reddressal. The Health and Safety Manual covers**:** Contractor organisation; accidents; hazards and risks; emergency preparedness plan; signage; industrial health and welfare; works - heights, excavations, electrical and mechanical; gases; machinery; equipment; blasting; formwork; piling; PPE; medical facilities; firefighting; traffic management; housekeeping; launching; batching plant; transport; security; explosives; general safety; flooding etc.

287. Environmental Social Health and Safety (ESHS) Requirements comprising sections i),ii) and iii) above as mandated by CMRL for elevated construction are placed in Annexure 4 to EIA report. Compliance with sections i) and ii) is mandatory, section iii) is intended to provide guidance to the contractor. While complying with this SHE Manual, site-specific and construction work-specific procedures will be prepared by the Contractor and approved by CMRL. Hazards and requisite safety measures related to working at height are of primary focus on this corridor.

288. Prior to construction, necessary (temporary) living facilities for project workers will be provided by the contractor. Locations of such camps, their layout and level of facilities so as

to minimize health risks will be put up for approval of CMRL, CMDA and Public Health Officer of Greater Chennai Corporation and Siruseri panchayat. As per Building & Other Construction Workers (BOCW Regulation of Employment and Conditions of Service) Act, 1996 the employer (contractor) is liable to arrange for sanitation, health care facilities of labourers free of charge. Labour camps will be in full compliance of BOCW Act. Uncontaminated water will be provided for drinking, cooking and washing, health care.

289. Waste water from cooking, bathing and washing including sewage from toilets will be discharged into municipal drains. Such waste water will be treated by municipal agencies to Environment Protection Rules (EPR) 1986 Schedule VI standards of discharge of general effluents into surface water. In view of the distributed nature of the linear construction and quantities of waste water, it is not proposed to install sewage treatment plants by CMRL for construction and operation phases.

290. Garbage bins will be provided in the camp and regularly emptied into municipal bins. Municipal solid waste will be collected and taken away and disposed by municipality.

291. The Contractor will implement Covid-19 guidelines and Operating Procedures as part of the Contract. Residents of worker camps will be sensitized about need to implement precautions and trained in social distancing, sanitizing, avoiding groups; arrangements for thermal scanners and provision of sanitisers, face masks, gloves etc will be made by contractor. Site record of covid hospitals will be maintained and fully equipped ambulances will be available to transport sick camp residents to hospitals. Daily disinfection of camps will be carried out.

292. The construction works will be undertaken in accordance with all applicable legislation and Indian statutory requirements and guidelines-OHSAS 18001-2007: Occupational Health and Safety Management System and ISO 14001-2015: Environmental Management Systems.

293. As part of medical facilities for workers, the Manual mentions support to the HIV/AIDS control agency. Measures to minimize Covid transmission are contained as Annexure 5 in this report. This Annexure will form part of the ESHS Requirements in the contract documents so as to guarantee that the Contractor will implement Covid-19 guidelines and Operating Procedures as part of the Contract. The procedures include: thermal scanning, hand sanitization and face masking at entry and exit to/from work areas; hand gloves for those who handle material received from outside work area; social distancing at toilets and eating areas; daily disinfection of site, equipment and vehicles; site record of covid hospitals; fully equipped ambulances to transport sick workers to hospitals; signage and regular awareness sessions; staggered hours of work start and close to ensure social distancing at gates; all construction material arriving at site should be left idle for 3 days before use to ensure safe usage; non-touch garbage bins with biodegradable garbage bag for waste collection; proper disposal of garbage bags along with daily cleaning and sanitization of bins. In addition fully equipped ambulances will be available to transport the sick to hospitals.

294. In order to safeguard CMRL personnel during operation of the metro system, the design includes installing Automatic Train Protection and Automatic Train Supervision sub-systems, a backup power arrangement in form of DG sets and a Closed Circuit TV for security and crowd control. Specifications and layout of equipment will be decided so as to minimise exposure of personnel to harmful electromagnetic radiation.

295. To reduce conducted or radiated emissions detailed specification and layouts of equipment e.g. power cables, rectifiers, transformer, E&M equipment etc. will be framed as per appropriate international standards. Electromagnetic Compatibility and maximum electromagnetic emission levels of whole railway system to the outside world measured at the railway boundary fence will comply with EN50121-2.

296. Musculoskeletal disorders (MSDs) and stress were identified by the industry as their major work related ill health issues (Position Paper on Work related stress in the rail industry, Office of Rail Regulation U K, June 2014). No such published data is available in India.

297. MSD risk can be eliminated or minimized through product design, mechanization, appropriate handling aids, risk assessments, training and better use of specialists such as ergonomists and physiotherapists.

298. Stress can be managed at three levels of intervention:

- Primary level intervention: The main priority for CMRL will be to assess and reduce the risk of harmful levels of workplace stress from occurring. This may require action at an organisational level, for example by changes to job design, task allocation, training, and supervision.
- Secondary level intervention: Good practice at the secondary level typically involves building individuals' ability to cope with stress, for example by emotional resilience training, relaxation, or mindfulness; employee assistance programmes (EAPs); 'buddying' schemes; or healthy lifestyle promotion.
- Tertiary level intervention: This focuses on recovery and rehabilitation, for example trauma focussed cognitive behavioural therapy; counselling; EAPs and staged returns to support early return to work.

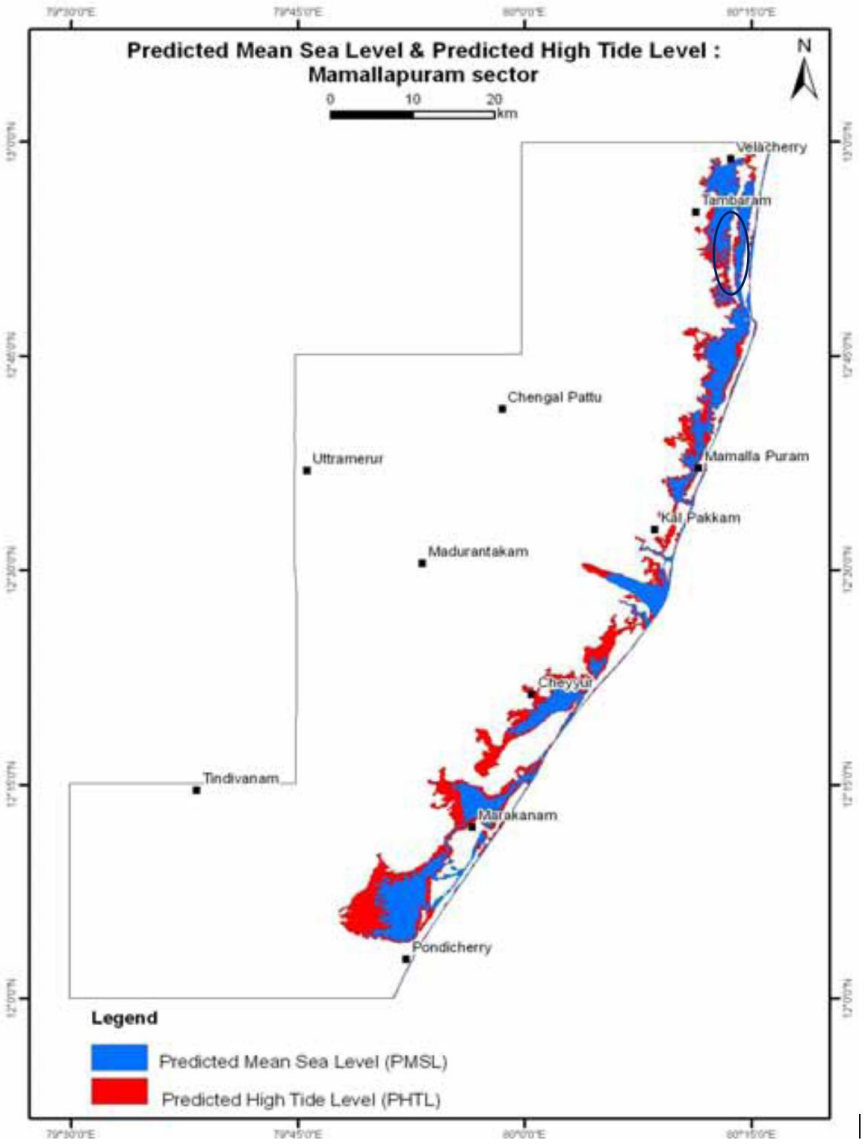
299. The risk of Covid-19 will be reduced as much as possible through CMRL's operational procedures. Government of India protocols governing Covid precautions shall be fine-tuned; staff shall be trained; staff and commuters shall be informed of precautions such as social distancing, sanitizing; arrangements for stationary and hand-held thermal scanners; provision of sanitizer pedestals, vending machines of face masks and gloves etc will be provided in stations; site record of covid hospitals; protected ambulances at stations; daily disinfection of operating rooms, circulation spaces, equipment and vehicles.

300. **Residual impact**. Even with SHE manuals and procedures in place the risk of workplace accidents during construction, risk of accidents due to failure in operating systems and security and risk of exposure to electromagnetic radiation will be a continuing feature, however proven technologies will ensure that the residual impact is minimal negative. During operation safety risks can be mitigated to a large extent through proper equipment, ppe's, procedures and education, however a chance remains the procedures may not always be followed in full. Therefore a moderate negative residual impact remains.

### 5.18. Public Health and Safety

301. **Impacts.** Vulnerability of project to rise in mean sea level (submergence) and high tide level (degradation) on the project is indicated in Figure 5-2. Corridor 3 will not entail significant adverse impacts other than likely submergence/ degradation of belt of width 5km to 10km of developed area from Thoraipakkam to Siruseri due to climate change. Since the majority of the alignment will be constructed in the median of the IT expressway, which in itself has a road level significantly higher than the surrounding area, the risk of flooding of the entrances to the elevated metro system is small.

**Figure 5-2: Predicted MSL and HTL in Mamallapuram Sector**

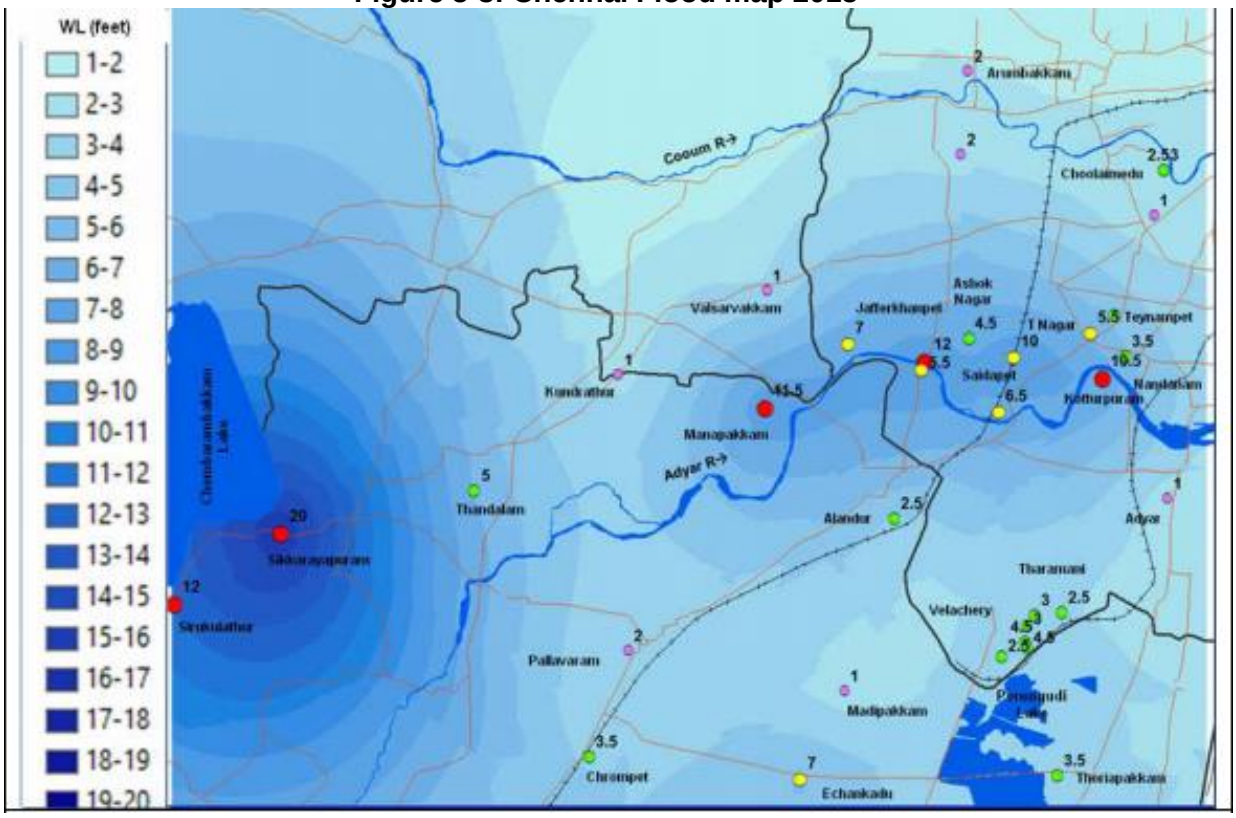



*Source: Coastal Zones of India, SAC ISRO- MoEF&CC, 2012*

302. In year 2015 Chennai was flooded due to exceptionally heavy rainfall. Flooding was observed in areas adjoining Adyar river though lesser along Cooum river. The alignment of MDB Corridor 3 is not located near these rivers[16] and therefore flooding is not a likely impact. Moreover Pallikaranai marsh could store excess water thus reducing flooding. Figure 5-3 depicts the inundated areas.

[16] Sholinganallur station is 7 km away from Echangadu which had 7 feet of water during 2015 flood.

**Figure 5-3: Chennai Flood map 2015**




*Source: Chennai Floods, 2015 A Satellite and Field Based Assessment Study, Disaster Management Support (DMS) Division National Remote Sensing Centre (NRSC / ISRO) Hyderabad, India*

303. Project site in located in the moderate seismic zone: earthquakes can cause high additional stresses in metro structures. Since the construction of the metro system and the construction of the future elevated road are structurally independent, the combination of these two structures will not lead to an increased earthquake risk.

304. During construction impacts on community H&S due to exposed to traffic, noise, dust and vibration disturbance and the risk of road traffic accidents are anticipated. Risk to existing buildings is minimal as the elevated alignment does not fly above existing buildings. However as the alignment runs high above existing road carrying heavy traffic, risk of falling objects is high.

305. Infection transmission during operation could impact services and ridership although infection transmission could be minimized over a reasonable period of time. This risk is significant because the train is a closed system subject to dense passenger loads.

306. Besides the risk of contracting communicable diseases such as Covid-19 due to sealed coaches and density of commuters in trains and stations, an important impact is incidents which disrupt services with or without loss of life. Possible incidents are:

- Failure of signal system, Failure of traction power supply, Failure of rolling stock, Failure of track and structures
- Failure of Platform Screen Doors / car doors
- Natural disasters

- Fire, explosion, security threats
- Theft etc or any other event which reflects a system failure but has not affected train operation.

307. **Mitigation.** As part of the World Bank's "Chennai Urban Development Program" an increase in capacity of stormwater drainage will be made so as to deal with extreme flooding in addition to demand of future landuse growth along this alignment. Number of pits for rainwater harvesting from elevated metro will be increased to cater to flood waters and heavy rains.

308. Design of viaduct and elevated stations will be done to facilitate robust safety against earthquakes and quicker evacuation. Structural design will be done to account for seismic forces.

309. Infection transmission will be managed by implementing Health protocol as described under section on operation.

310. Where a site boundary adjoins roads, streets or other areas accessible to the public, a fence should be provided along the entire length except for a site entrance or exit. Safe passage for pedestrians with proper sunshade / fall protection and signage will be planned. Access to the construction site by the public shall be strictly prohibited.

311. Activities such as girder launching will be done during off peak hours of day and night. Tasks involving welding will be taken up with due real-time on-site guidance to road users: barricading is usually inadequate to mitigate this hazard.

312. Any incidence of Covid-19 and similar illnesses will be immediately communicated to the health authorities: suitable channels of communication with citizens located in proximity of worker camps will be maintained.

313. In case of road closure or traffic diversion, the Contractor will ensure that information on the timing of construction works and notifications of road closure (if any) is provided via local media (radio, TV, newspaper etc.) or through the local community heads.

314. During operation accidents related to train operation like collision, derailment, fire, power outages, or operation stoppage may occur. Administration of safety during operations is governed by Chennai Metro Safety Manual. The Manual defines "Accident" as any occurrence which causes or has the potential to cause death or injury to staff, passengers or other persons or cause damage to the property of the Metro Railway, passengers or other persons. The Manual prescribes:

- Duty Lists of Train Operator, Station Controller, Traffic Controller at OCC, site officers and security personnel
- Accident reporting
- Rescue and Relief Arrangements
- Accident Investigations and Enquiries.

315. Procedures to be implemented during operational emergencies are included in the Emergency Preparedness and Response Plan in this report.

316. Design of the metro system provides for operational safety. Some of such features are mentioned below:

317. In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. A standby silent

type DG set of adequate capacity at stations will sustain the following: essential lighting, signaling, and telecommunications, fire-fighting system and lift operation. Coaches will be reserved for women, seats in all coaches will be reserved for women, elderly and disabled. Bus stops, pick up drop off points will be well lit and provided with messaging.

318. To provide a high level of safety with trains running at close headway ensuring continuous safe train separation, eliminate accidents continuous speed monitoring and automatic application of brake in case of disregard of signal / warning by the driver, and provides safety and enforces speed limit on section having permanent and temporary speed restrictions Automatic Train Protection and Automatic Train Supervision sub-systems will be installed.

319. CCTV system will provide video surveillance and recording function for the operations to monitor each station. The monitoring will be possible both locally at each station and remotely from the operation control center. All trains will have public address systems to warn the passengers of any emergency situation.

320. To mitigate the risks of Covid-19 face protection and hand sanitizing are of critical importance. Testing, transportation and hospital facilities of a much higher order of safety will be provided at stations.

321. Standard Operating Procedure (SOP) for operation of metro services protecting from Covid infection has been prepared by all metro operators in India. Chennai Metro SOP comprises the following actions:

- Number of passengers will be regulated at entry to station so that social distancing inside stations and on trains is maintained
- Alternate seats on platforms and on trains will be marked out of bounds
- Dwell time of trains at stations will be increased to 50 seconds (instead of 30 seconds pre-Covid) to allow more time for boarding/alighting
- Intake of fresh air on trains will be increased; temperature maintained at 24 to 30 degrees Celsius
- Trains will not stop at stations falling in containment zones; such stations will not be open to users
- Some stations may be skipped to ensure social distancing
- Train doors to be open for 2 minutes at terminal stations to let fresh air infusion.

322. **Residual impact**. Due to the planned extra storm water drainage and the earthquake-proof design the residual impact from flooding or earthquake will be minimal negative.

323. Due to the closed nature of metro coaches, the risk of exposure to communicable diseases such as Covid-19 leads to a moderate negative residual impact even with health protocols in place. However the availability of vaccinations in the near future might reduce this impact to minimal negative before the start of metro operation.

### 5.19. Physical Cultural Resources

324. No known protected archaeological monuments / sites or heritage assets are located on the project corridor.

325. **Impact**. 35 other resources of educational, religious, cultural, medical nature are located within 200m from the alignment: of these 27 are located within screening distance (100m) for noise and 18 within screening distance for vibration (62m). None are located in project zone of direct impact.

326. Since the project involves piling for piers there are possibilities that artefacts are encountered during construction.

327. **Mitigation.** The physical cultural resources located within the screening distance (100m) for noise and screening distance (62m) for vibration will form part of the detailed noise and vibration analysis.

328. The project will implement, where required, chance finds procedure contained in ESS8 of WBG ESF which includes a requirement to notify relevant authorities of found objects or sites; to fence-off the area of finds or sites to avoid further disturbance; to conduct an assessment of found objects or sites by cultural heritage experts; to identify and implement actions consistent with the requirements of this ESS and national law; and to train project personnel and project workers on chance find procedures.

329. Before start of civil work the contractor and CMRL will coordinate with State Archeological department to reconfirm that there is no presence of buried artifacts along the metro line alignment. No piling or excavation will be allowed unless cleared by the Archeological Department.

330. All workers will undergo a briefing with the Archaeology Department to ensure safeguarding of heritage resource and cultural/religious practices.

331. A proof of compliance to this requirement to include the name of participants and date and location of briefing will form part of the monthly report to CMRL.

332. The contractor will comply with the FIDIC Sec. 4.24 on Fossils. Recording (including chain of custody) will be made by the contractor to be validated by the CSC, and expert verification will be made by the Archaeology Department. Temporary work stoppage in the immediate area of the chance find for up to 72 hours to allow for the on-site representative of Archaeology Department to visit the site to make an assessment and provide instructions. Work in the areas adjacent to the chance find will continue as provided in the detailed design.

333. **Residual impact.** Since no PCRs are located within the project's direct zone of impact no residual impact is expected.

### 5.20. Energy consumption

334. **Impact**. Metro is an electrical energy intensive transport system, needing power for traction, train control, depots and station facilities. Such demand will increase with increase in passenger demand over time. Demand details are given under section on operation.

335. **Mitigation.** In accordance with the GRIHA (version 2015) norms, the following measures will be implemented to a feasible degree in the stations and depots.

- Control annual heat gain through favourable orientation and design of facades
- Site planning according to contours
- Site plan designed to preserve existing vegetation/ existing water bodies / other topographical features like boulders etc.
- Manage storm water on site through rainwater harvesting
- Mitigate heat island effect by ensuring that building surface visible to sky is shaded by trees. Ensure zero SWD post-construction by means of ground water recharge and recharge of groundwater aquifers by rainwater. The building will be designed to incorporate low ODP materials, indoor air quality and comfort, low-VOC paints and adhesives, reduced landscape water demand, sustainable building materials and renewable energy utilization etc.

- For the utilization of renewable energy, wherever feasible, installations for solar power can be implemented on roof of elevated stations. Installation and maintenance of solar power infrastructure is proposed to be awarded to developer along with Power Purchase Agreement (PPA). The power will be purchased by CMRL on the basis of the unit rate specified by Power Purchase Agreement (PPA).

336. In conformity to other metro corridors in Chennai, the following system design elements which increase energy efficiency and safety will be implemented:

- High voltage electric traction which have ability to carry high traffic at a reduced cost with higher efficiency of operation
- Rolling Stock is of light weight stainless steel / aluminium resulting in energy efficiency and improved life thus improving resource utilization and environmental quality. Standard Gauge rolling stock results in recurring saving in energy consumption during operation as for the same passenger carrying capacity, gross weight of a metro coach is lower.

337. The contractor will use and maintain energy efficient equipment. Measures to conserve energy include maintenance of energy efficient tools, plant and equipment of; lamps and DG sets to comply with TNPCB norms; Promoting awareness through energy saving trainings.

338. **Residual impact.** Energy saving features of the metro such as regenerative braking, lightweight coaches and efficient power equipment and green buildings reduce the negative impact of increased energy demand. The residual impact will therefore be minimal negative and will be reduced even further when more grid electricity is produced by renewable energy sources.

# 6. ANALYSIS OF ALTERNATIVES

## 6.1. Introduction

339. This section presents the symmetrically compared feasible alternatives to MDB Corridor 3 which runs along NH 49A. Alternatives such as other sources of transport (road, mono-rail, suburban rail), proposed design etc. have been considered and analyzed for its likely impacts on various environmental parameters. Additionally, an evaluation of potential environmental impacts in terms of 'with' and 'without' project situation has been considered for the justification of the project. This section also presents a discussion on how environmental parameters were assigned due importance and considered in the analysis of alternatives.

## 6.2. Selection of alignment and stations

340. In May 2019 the final version of the Comprehensive Mobility Plan (CMP) for CMA was published (http://www.cmdachennai.gov.in/pdfs/ComprehensiveMobilityPlan-CMA.pdf). The ultimate goal of this CMP is to provide a long-term strategy for the desirable mobility pattern of a city's populace for the next 30 years with the help of an urban transport planning model. The objectives of the CMP are:

- To develop a long-term vision for desirable urban development in CMA;
- To illustrate a basic plan for urban development and include a list of proposed urban land use and transport measures to be implemented within a time span of 30 years;
- To ensure that the most appropriate, sustainable and cost-effective implementation program is undertaken in the urban transport sector;
- To identify feasible short-term, medium-term and long-term traffic management measures and transport infrastructure to facilitate safe and efficient movement of people for the present and future.

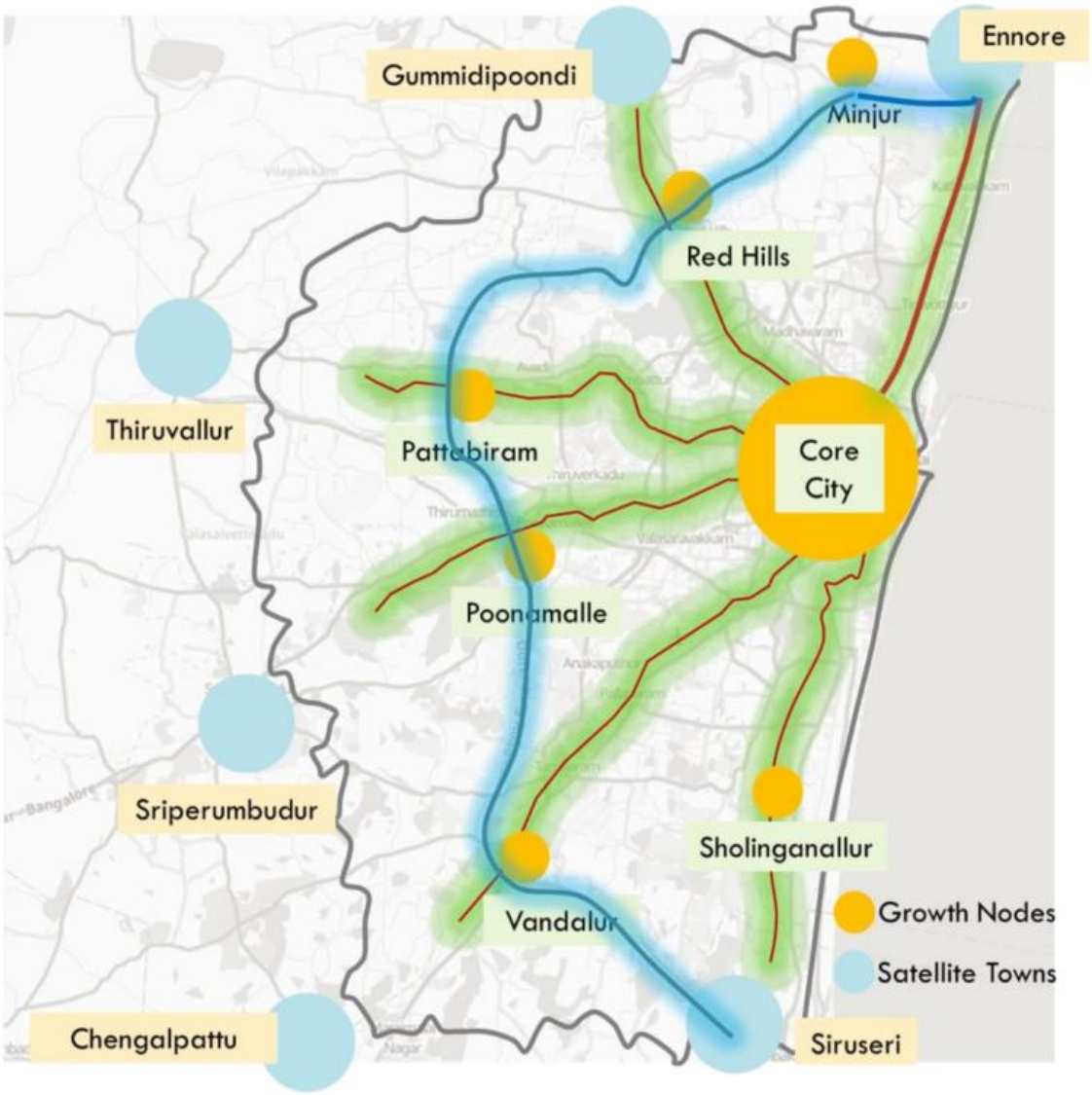
341. The four major elements that outline the city's vision on the moibilty of people and goods in Chennai are:

- Sustainability: The transportation system of the City shall be conducive to lower consumption of fossil fuels. It shall be based on managing the travel demand itself, rather than trying to provide for whatever demand exists and allowing demand to grow in an unplanned way.
- Equity: Transportation in the City shall be accessible to all demographic sections of society. The City shall provide "Mobility for all", meaning any person above a certain age should be able to travel independently. Special attention shall be paid to school students, senior citizens, people from financially weaker sections, women - especially pregnant women, physically challenged persons.
- Convenience: Not only residents of the City, but also visitors should also be able to figure their way around the city very easily.
- Safety: Rates of fatal and serious traffic accidents should be at par with the best in the world. Two wheelers and pedestrians account to 85% of the accident victims calling for the need for improvement in road conditions and raising safety concerns

342. The transport network of city is dependent on its land use. Land use and the transport network strategy development must go hand in hand. Connectivity helps in the realization of the land use planned. The land-use transport strategy developed focuses on accessibility, connectivity, and mixed land use developments to minimize private vehicle trips, encourage transit-oriented development. In the long term, the transport strategy should be based on the urban growth envisaged for the city. Transport network strategy, therefore, enables the city to take an urban form that best suits the geographical constraints of its location and also one that best supports the key social and economic activities of its residents.

343. The CMP observes that the city road network has a radial pattern depicting a finger-like plan radiating form the city center towards transport nodes and satellite towns. This semi-ring radial network is designated as the structure for mobility corridors, as illustrated in figure 6-1.

**Figure 6-1: Mobility corridors in Chennai**




344. Transport Demand Modelling has been carried out to replicate the Chennai's "real" transportation system and forecasting the state of the system for the targeted horizon year (2048) under various scenarios. These scenarios are based on: socio-economic transitions, population projections, employment projections and landuse transitions. Considered scenarios are:

- Business as usual (do nothing)
- Business as usual (do minimum / implement committed development projects)
- Sustainable Urban Transport

345. The Transpprt Demand modeling has shown that in the "do noting" scenario, average congestion will increase form a V/C ratio of 0.51 in 2018 to a ratio of 1.20 in 2028 (V/C ratio greater than 0.85 indicates congestion). Tthe average network speed will decrease from 25.4

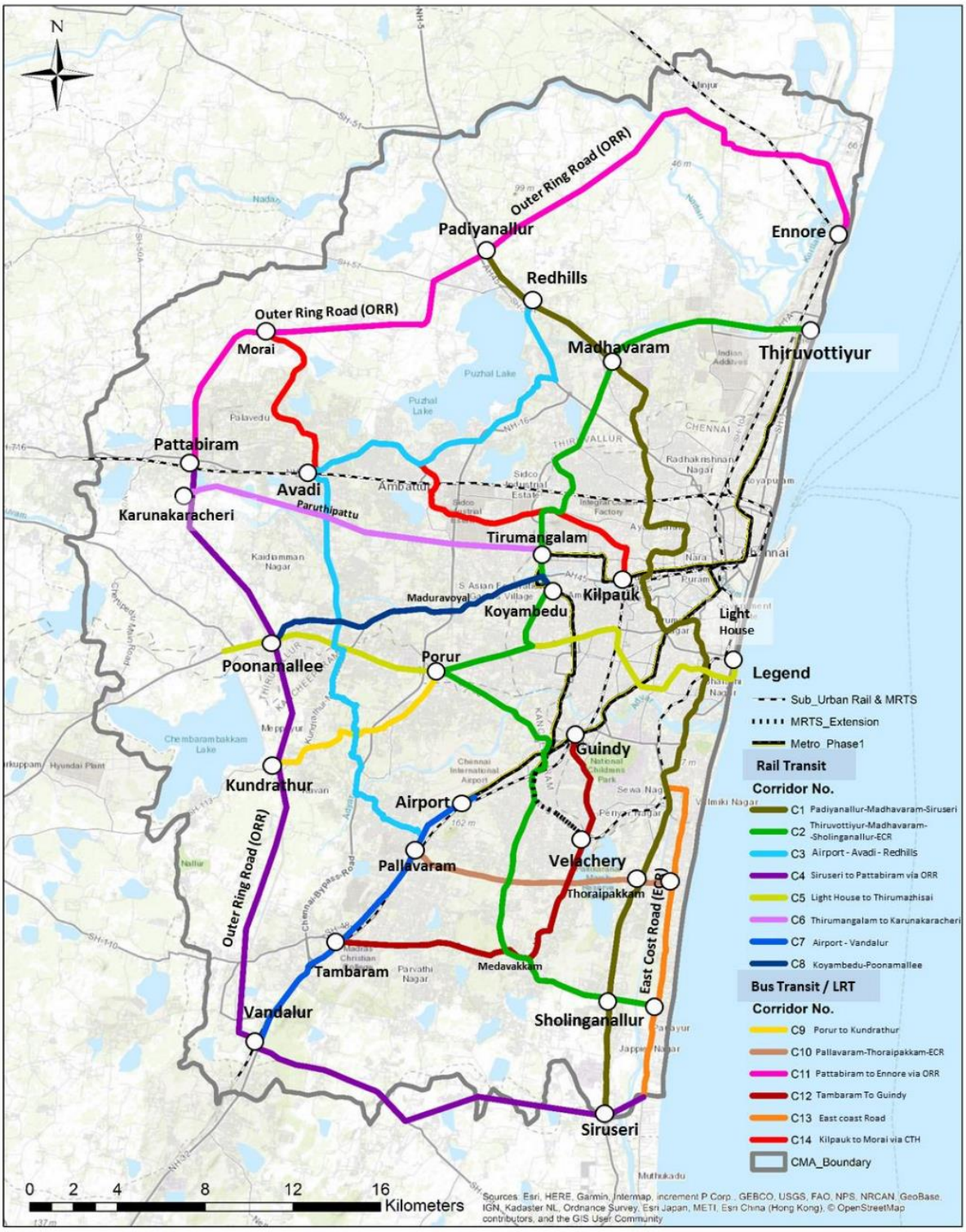
kmph in 2018 to 10.20 kmph in 2048. In the “do minimum” scenario these numbers are slightly better (average V/C ratio of 1.10 and average speed of 12.10 kmph in 2048) but still unfavourable. The sustainable urban transpprt scenario on the other hand indicates an average V/C ratio of 0.74 and an average speed of 24 kmph is achievable in 2048.

346. In order to achieve these targets the CMP proposes, among others, improvements in the road network, service improvements in the exisiting bus service and mass rapid transit (MRT) options. Choices for the MRT corridors are, among others, based on:

- The mobility corridors as depicted in figure 6-1;
- Possibilities for mulit-modal integration with existing and proposed transportation networks;
- Expected pphpd, where buses are the preferred mode of tansport for a pphpd < 10,000 and where rail-based systems are preferred for a pphpd > 10,000.

347. Based on the above the CMP proposes the mass transit corridors as depicted in figure 6-2.

**Figure 6-2: Proposed mass transit corridors in Chennai**




| | | |
|---|---|---|
| Title | Proposed Mass Transit Corridors | Prepared by Urban Mass Transit Company Limited |
| Project | Comprehensive Mobility Plan for Chennai Metropolitan Area | |

348. Phase II metro corridor 4 broadly corresponds with the proposed light green corridor shown in figure 6-2 (C5, Lighthouse to Thirumazhisai). Since the Lighthouse – Poonamallee corridor proves to be one of the fastest growing corridors in terms of population it is justifiable to give priority to the development of corridor 4 of Chennai Metro.

349. The CMP anticipates that the proposed plans will help to achieve sustainable development goals by means of reducing private mode share, emission levels and travel time. Anticipated impacts of the proposed mass rapid transit projects are segregated into social and environmental impacts. The main impacts considered are:

- Land acquisition / Right of Way;
- Rehabilitation and resettlement;
- Improved mobility and reduction in travel time
- Increase in air pollution, noise, traffic congestion during construction phase;
- Improved air quality and reduction of GHG emission during operational phase.

350. In the Alternatives Analysis Report for Chennai Metro Rail Phase II Corridors of May 2018 a comparison has been made between different modes of transport for corridor 4. Table 6-1 presents an overview of the impacts and screening parameters that were considered.

**Table 6-1: Qualitative criteria for impact screening**

| Factor | Criteria | Level | | |
|---|---|---|---|---|
| | | ◇ | ◆ | ◆ |
| Travel Mobility Impacts | System Capacity in PPHPD | Cannot accommodate future demand in horizon years | Moderate accommodation of future demand in some sections of the corridor | Adequate accommodation of future demand in all sections of the corridor |
| | Travel Time Savings for typical journeys | Minimal travel time saving | Moderate travel time saving | Maximum travel time saving |
| | Congestion Impacts on major road links along route | Near zero impact on V/C | Moderate reduction in V/C | High reduction in V/C |
| | Interchange Opportunities (at least one interchange less than 5 minutes / 500 m walk) | No interchange opportunities | Interchange with buses only | Interchange with bus and metro |
| Engineering Impacts | Right of Way Required | Shared RoW | Dedicated RoW on road | Decongested RoW at-grade / elevated / underground |
| | Land Acquisition Required | Maximum land acquisition required | Moderate land acquisition required | No Land Acquisition |
| | Construction Period | 1 to 3 years | Less than 1 year | Quick Implementation |
| | Construction Capital Costs | Between Rs 10,000 Cr and Rs 20,000 Cr | Less than Rs 10,000 Cr | No Construction capital costs |
| Environ-mental Impacts | Environmental Impact of Operations (reduced emissions) | Negative/Nil impact on emissions | Moderate positive impact on emissions | High positive impact on emissions |

Source: CMRL

351. The results of applying the qualitative parameters to each mode is shown in table 6-2 below.

**Table 6-2: Evaluation of Alternate Modes on Qualitative criteria**

| Factor | Criteria | Metro Rail | Mono Rail | LRT | BRTS | Regional Rail |
|---|---|---|---|---|---|---|
| Travel Mobility Impacts | Transit System Capacity in PPHPD | Favourable | Moderate | | | |
| | Travel Time Savings for typical journeys | | | | | |
| | Congestion Impacts on major road links along route | | | | | |
| | Interchange Opportunities (at least one interchange less than 5 minutes / 500 m walk) | | | | | |
| Engineering Impacts | Right of Way Required | | | | | |
| | Land Acquisition Required | | | | | Unfavourable |
| | Construction Period | | | | | |
| | Construction Capital Costs | | | | | |
| Environmental and Social Impacts | Environmental Impact of Construction (increased emissions per year of construction) | | | | | |
| | Environmental Impact of Operations (reduced emissions | | | | | |

Source: CMRL

352. can be seen from table 6-2 Metro Rail is the overall most favourable option, taking into account the specific challenges the proposed alignment poses. For metro the corridor as proposed in the CMP is used, for mono rail, LRTand BRTS the nearest road alignment is considered. Choices between at-grade, elevated or underground are based on the available RoW and the technical difficulties that existing infrastructure is posing (such as flyovers, bridges, existing mass rapid transport infrastructure, etc). Furthermore while fixing the alternatives on proposed corridor, following requirements/ constraints have been kept in view:

- To remain on corridor of the existing road or Government premises/land to the extent feasible.
- To utilize the existing road Right of Way to the maximum extent in order to minimise the land acquisition and also length of diversions.
- To avoid dismantling of existing structures/buildings etc. to the extent feasible.
- To avoid private built up areas, villages, habitation and religious structures etc. to the extent feasible.
- To provide adequate clearance from existing Railway/ Highway structures.
- To satisfy the requirements of sound economic engineering practices

- To rationalise the location of proposed stations and underground ramps

353. The assessment of the environmental and social impacts of the alternate modes of transport can be found in table 6-3 below.

**Table 6-3: Environmental impacts of alternate modes of transport**

| | Metro | BRTS | Monorail | LRT |
|---|---|---|---|---|
| ***Impact due to Project Design*** | Lowest as land acquisition is least | Highest land acquisition requirement | Lower than LRT but higher than metro | Almost similar to BRTS |
| ***Impact on Air Quality*** | Significant negative impact only during construction | Significant negative impact during construction and operations | Significant negative impact only during construction | Significant negative impact only during construction |
| ***Impact on Noise Levels*** | Negative impact during construction only | Negative impact during construction and maintenance | Negative impact during construction only | Negative impact during construction only |
| ***Impact due to Waste Disposal*** | Significant impact due to high amount of excavated soil and construction debris | Waste generated not as high as Metro | Waste generated higher than BRTS | Waste generated higher than BRTS |
| ***Impact due to Vibrations*** | Significant during underground and elevated construction | Significant during construction | Significant during construction | Significant during construction |
| ***Impact on Water Resources and Land*** | Medium impact on land and water | Medium impact on land and water | Medium impact on land and water | Medium impact on land and water |

Source: CMRL

354. When comparing the capital costs of all four modes, the metro is quite clearly the most capital-intensive urban transport solution. However, when looked at life cycle economic benefits in terms of value of time, vehicle operating cost, accident reduction, pollution reduction, decongestion and reduced road stress Metro Rail is far more favourable than the other modes of transport. The analysis concludes that the metro achieves the highest Economic Internal Rate of Return (IRR) and as a result, from a financial and economic viability perspective, the metro is recommended as the preferred mode of mass transit.

# 7. PUBLIC CONSULTATIONS AND INFORMATION DISCLOSURE

## 7.1. Consultations

355. MDBs' policies require projects to carry out meaningful public consultation on an ongoing basis. Public consultation will: (i) begin early and carry on throughout the project cycle; (ii) provide timely disclosure of relevant information, understandable and accessible to people; (iii) ensure a free and un-intimidated atmosphere without coercion; (iv) ensure gender inclusiveness tailored to the needs of disadvantaged and vulnerable groups; and (v) enable the incorporation of all relevant views of affected people, and stakeholders into project decision making, mitigation measures, the sharing of development benefits and opportunities, and implementation issues.

356. Public consultation and participation are a continuous two way process, involving, promoting of public understanding of the processes and mechanisms through which developmental problems and needs are investigated and solved. The public consultation, as an integral part of environmental and social assessment process throughout the project preparation stage not only minimizes the risks and manages the expectation of the project but also abridges the gap between the community and the project formulators, which leads to timely completion of the project and making the project people friendly.

357. Public consultation/information is an integral part of the Chennai metro project cycle. Public consultations with the people of different sections of the society along the project alignment, shopkeepers, and influential persons of the project area were made. Potential vulnerable people like, squatters, encroachers, schedule caste, and other backward section of society were consulted to make them aware and identify adverse impacts of the project.

358. The consultation process started early in 2017. CMRL held extensive consultation with the local community to share information of potential impacts and mitigation measures etc.

## 7.2. Identification of Stakeholders

359. Key stakeholders at central, state, district and local level will be consulted as part of the consultation process.

- Ministry of Environment, Forests and Climate Change (MoEF&CC),
- Central Pollution Control Board,
- Tamil Nadu State Pollution Control Board,
- State Environmental Impact Assessment Authority
- Tamil Nadu Coastal Zone Management Authority
- State Traffic Police Department
- Municipal Corporation
- State Archaeology Department
- Central Ground Water Authority
- District Forest Office
- Indian Meteorological Department
- Non-government organizations
- Women groups
- Shopkeepers associations

## 7.3. Public Consultations

360. In order to enhance public understanding about the project and address the concerns of the community pertaining to mitigation of adverse impacts due to the Corridor, meetings with groups of persons in the community were conducted in January 2020 at proposed locations of stations. These consultations are summarized in Table 7.1. The total number of attendees during the consultations in this period were 71, of which 15 were females and 56

were males. The participants at were informed verbally that a station will be constructed at respective location and alignment is on the road. No drawings were discussed. Stakeholders at central, state, district and local level as listed above were not consulted during these public consultations.

**Table 7-1: Public Consultations at station locations**

| Venue | Date | Number of persons attended | Suggestions / Opinions |
|---|---|---|---|
| Sholinganallur | 04.04.2019 | 6 | Metro offers ease of travel, better connectivity. Fare should be low. |
| Sholinganallur lake | 24/02/2019 | 4 | Metro offers comfortable travel and better connectivity. Fare should be low. |
| Sri Ponniamman Temple | 2/4/2019 | 7 | Metro offers ease of travel, better connectivity. Fare should be low. |
| Sathyabama University | 24/2/2019 | 9 | Metro offers time savings, comfortable travel and better connectivity, reduction in road congestion and pollution. Fare should be low. If construction activities go long more than expected, then it incurred loss to commercial/ shops |
| St. Joseph College | 6/3/2019 | 12 | Metro offers time savings, reduction in road congestion, accidents and pollution. Fare should be low.<br>There is a possibility of pollution and traffic problem during construction of the metro project. |
| Semmancheri | 7/3/2019 | 10 | Metro offers reduction in road congestion and pollution. Fare should be low. |
| Perumpakkam | 6/4/2019 | 5 | Metro offers time savings, reduction in road congestion and pollution. |
| Gandhi Nagar | 8/3/2019 | 6 | Metro offers time savings, reduction in road accidents and pollution. Due to metro train, other facilities will come such as infrastructure development. Local economy will boost up. |
| | 26/32019 | 7 | |
| Navallur | 8/3/2019 | 8 | Metro offers time savings, comfortable travel and better connectivity, reduction in road accidents and pollution. Fare should be low. |
| | 26/3/2019 | 5 | |
| Siruseri | 24/3/2019 | 5 | Metro offers ease of travel, better connectivity, reduction in road congestion. |
| | 26/3/2019 | 8 | |
| Sipcot 1 & 2 | 24/3/2019 | 4 | If construction activities go long more than expected, then it incurred loss to commercial/ shops. |
| TOTAL | | **71** | |

**Meetings with Title Holders in CMRL office**

| Station Name | Date | Number of participants | Number of Tenants & Vendors | Number of Squatters | Number of Vulnerables |
|---|---|---|---|---|---|
| Sathyabama University | 22/01/2020 | 2 | 0 | 2 | 0 |
| Gandhi Nagar | 22/01/2020 | 6 | 4 | 1 | 1 |
| Navalur | 22/01/2020 | 5 | 3 | 2 | 0 |
| Siruseri | 22/01/2020 | 4 | 3 | 1 | 0 |
| St. Joseph College | 22/01/2020 | 4 | 4 | 0 | 0 |
| TOTAL | | **21** | 14 | 6 | 1 |

**Meetings with Non-title holders (shopkeepers and local road passengers in CMRL office**

| Location | Date | Number of Participants | Impacts cited by participants |
|---|---|---|---|
| Sri Ponniamman Temple | 08/01/2020 | 10 | • Project will decrease road accidents<br>• Project will help easy traveling<br>• Project will reduce pollution<br>• Project will help overall development<br>• Project will reduce road traffic<br>• Construction damage to nearby structures<br>• Business Loss during construction |
| Sathyabama University | 08/01/2020 | 8 | |
| St.Joseph's College | 09/01/2020 | 7 | |
| Semmancheri | 09/01/2020 | 6 | |
| Gandhi Nagar | 10/01/2020 | 10 | |
| Navallur | 11/01/2020 | 6 | |
| Siruseri | 11/01/2020 | 10 | |
| Sipcot | 12/01/2020 | 6 | |
| TOTAL | | **63** | |

361. Consultations with Government agencies are yet to be conducted.

362. Public consultations during construction and operation will form part of semi-annual monitoring reports sent by CMRL to MDBs. These consultations will focus on the impact mitigation measures being implemented and their efficacy.

363. Due to COVID-19 challenges, consultations during project implementation will be virtual wherever possible. ADB staff will be involved with efforts made for staff's virtual participation through advanced discussion and agreements on agenda items amongst project team members. Translators shall be engaged, where necessary and post consultation follow ups on targeted issues will be undertaken. Where local travel is permitted, ADB mission will seek support from relevant Resident Mission staff members to participate in public consultations on behalf of ADB project team. When virtual participation of project team or RM staff is not possible, the project team, may engage a staff consultant to attend the consultations on behalf of the project team, who will record the minutes of the meeting.

### 7.4. Information Disclosure

364. Information disclosure will follow the procedure and disclosure requirements of MDBs' policies for category A projects. As per ADB's SPS 2009, the draft EIA including the draft EMP will be disclosed 120 days prior to the Board consideration.

365. All environmental documents such as the final EIA, any updated EIA, corrective action plans prepared during project implementation and the environmental monitoring reports are subject to public disclosure, and therefore, will be made available to the public. This EIA and the Executive Summary (in both English and Tamil) will be disclosed on CMRL and MDBs' websites. The hard copies of EIA will be made available at CMRL office as well as at other locations accessible to stakeholders. CMRL will ensure that meaningful public consultations, particularly with project affected persons' are undertaken throughout the design, construction and operation stages.

# 8. GRIEVANCE REDRESS MECHANISM

366. Grievance Redress Mechanism (GRM) is an integral and important mechanism for addressing/resolving the concern and grievances in a transparent and swift manner. Grievances related to the implementation of the project, particularly regarding the environmental management plan, rehabilitation and resettlement, compensation etc. will be acknowledged, evaluated, and responded to the complainant with corrective action proposed using understandable and transparent processes that are gender responsive, culturally appropriate, and readily accessible to all segments of the affected people. Records of grievances received, corrective actions taken, and their outcomes will be properly maintained and form part of the semi-annual environmental monitoring report to MDBs.

367. Many minor concerns of peoples are addressed during public consultation process initiated at the beginning of the project. However the most common reason for delay in implementation of projects in urban areas is grievances of people losing their land and residential and commercial structures. Resolving such cases in the Court of Law will be a very time consuming process. Considering this and based on CMRL's past experiences of dealing with PAP grievances in phase I of the metro project, a common GRM has already been put in place in order to address social, environmental or any other grievances of project affected persons related to the investment project. Such a redress mechanism available at the project level itself will mean that the complainants do not necessarily have to directly approach a Court of Law although availability of Grievance Redress Committee (GRC) mechanism will not bar them from doing so. Although the project has one common GRM, the composition of the GRC's for social and environmental issues differ to ensure a dedicated and timely resolve of specific social or environmental grievances. Often the resettlement/social grievances will be resolved at a higher level GRC, whereas environment safeguard issues can be resolved at the working level GRC.

368. GRM will be in two layers: a) executing engineer from Project Implementation Unit (PIU) and b) GRC. The first level of interaction of GRM with the stakeholders will be the Executing Engineers from PIU to resolve ground level grievances including construction nuisances with support from contractor GRM focal. Issues should be resolved within 14 days. Those that cannot be resolved by PIU will be escalated to the 2$^{nd}$ level, to be examined by the GRC. Alternately complainants aggrieved by inadequacy of actions taken by the executing engineer of the PIU can escalate to the GRC.

369. The Environmental Health and Safety Expert on the CMRL PIU who is an environmental engineer will coordinate the GRC-Environment (GRC-E) which will report to MD, CMRL and Director Projects, CMRL. The other members of the GRC-E will be**:**

- CMRL Project Manager of the package/section
- EMP implementation teams from CMRL and GC
- EMP Manager from construction contractor
- Assisting NGO in case of Rehabilitation & Resettlement
- PAPs and representatives
- With a view to Affirmative Action to enhance women inclusivity, one-woman representative of local community from each 5km section of the alignment will be members of the Environmental and Social Grievance Redressal Committee. The representative(s) from the location(s) to which the grievance(s) pertain(s) will be invited to deliberations of the Committee.

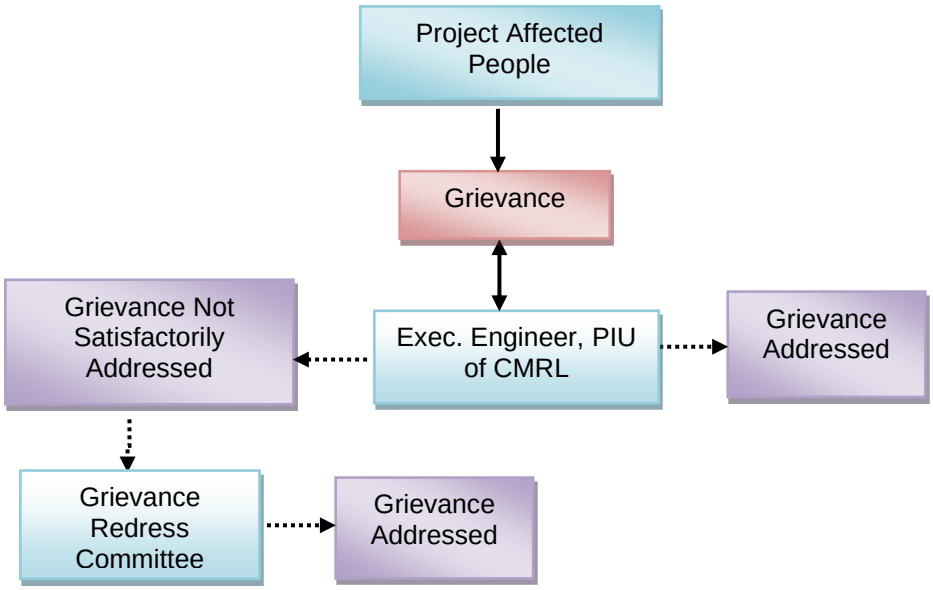
370. Records of the following stages will be maintained in the PIU office, on website of CMRL throughout the life of the project:

- Complaints received, including date and contact details of the complainant
- Acknowledgement of receipt of complaint by executing engineer PIU
- Actions taken by executing engineer and their efficacy
- Escalation by executing engineer or by aggrieved parties
- Records of further action and closure of complaints
- The number of grievances recorded and resolved and the outcomes.

371. Complaints and escalation by aggrieved parties can be done by paper mode as well as through email. The GRC-E will deliberate upon time limits for each of the above stages; the time limits will be placed on website of CMRL.

372. The flow chart of how environmental issues are addressed through the GRM is presented in Figure 8-1.

**Figure 8-1: Grievance Redress Mechanism Environmental Issues**




373. The following process is followed for consideration of various cases by GRC:

- GRC function independently
- All grievances are received in written form by GRCs and a separate record of the same, including contact details, is maintained
- A separate file / processing document is created for each case, based on its category (project, location etc.) and all observations and documents related to the case are maintained in such file
- Cases related to environment pollution, noise, eligibility, entitlements, disputes etc. are promptly handled after consultation with relevant authorities
- GRCs can seek necessary record / information (such as survey details, past written communication etc.)
- Written notices are sent to the aggrieved persons and respondents to appear for hearing along with documents, and further dates are provided in case of genuine inconvenience to the party about the appointed date
- Multiple hearings are conducted as per the requirements of cases and aggrieved persons (including their representatives) and respondents are heard and are provided opportunities to submit further documents / proofs
- Site visit documents submitted by the parties are verified from appropriate sources, as may be considered necessary

- In normal circumstances (excluding those requiring information from external agencies) the entire process is carried out in a time bound manner (On an average, it takes about 1-2 months for disposal of each case in GRC)
- After due consideration of the cases, written and reasoned orders are passed under the signature of Head of concerned GRC
- Any fatality accident should be reported to GRC and MDBs immediately

374. In addition to the above GRM for addressing complaints from the local community, a separate GRM will be constituted for addressing the issues of the workers, forming part of the bidding document for CMRL to review and clear. The clauses in the tender include the following:

- Enquiries, complaints and requests for information can be expected from a wide range of individuals and organisations both private and government. The majority of complaints is likely to be received by CMRL, although the site offices are also likely to be contacted.
- The objective of complaint process is to ensure that public and agency complaints are addressed and resolved consistently and expeditiously.
- The Contractor's Project Manager will be notified immediately on receipt of complaint that may relate to environmental impacts. The Project Manager will immediately inform the Employer's Representative.
- Field investigation should determine whether the complaint has merit, and if so action should be taken to address the impact.
- The outcome of the investigation and the action taken will be documented on a complaint Performa prepared by the Contractor and submitted for notice by the Employer's Representative in advance of the works.
- Where possible, a formal response to each complaint received will be prepared by the Contractor within seven days in order to notify the concerned person(s) that action has been taken.
- Grievance log should be prepared and documented in the monitoring report with the resolution details.
- GRM for workers will be established as early as possible to function no later than construction commencement.
- The GRM information and focal should be disseminated to public.

# 9. ENVIRONMENTAL MANAGEMENT PLAN

## 9.1. Introduction

375. The Environmental Management Plan (EMP) consists of a set of mitigation, monitoring and institutional measures to be taken for MDB Corridor 3 to avoid, minimize and mitigate adverse environmental and social impacts and enhance positive impacts. The plan also includes the actions needed for the implementation of these measures. The major components of the EMP are:

- Mitigation of potentially adverse impacts;
- Environmental monitoring;
- Emergency response procedures;
- Institutional arrangements and reporting mechanism;
- Implementation Schedule;
- Training and capacity building, and
- Cost estimates.

376. The purpose of environmental monitoring is to ensure that the EMP is fully and competently implemented across all phases of the project's development, and to provide a basis for appropriate and timely corrective action when it is found not to be. The environmental monitoring process should be understood not only as a means of supervision and enforcement, but also as a vehicle for organizational learning and progress towards mainstream international best practice in construction site and facility management. Effective monitoring can also be a vital tool in forestalling conflict with the communities most likely to suffer the consequences of negative environmental impacts, as problems can be identified and corrected in a timely manner, before they grow to nuisance or dangerous levels. Environmental monitoring must continue until issuance of a Project Completion Report (PCR).

## 9.2. Objectives of Environmental Management Plan

377. The main objectives of this EMP are:

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

## 9.3. Institutional Arrangement

### 9.3.1 Executing Agency

378. Government of Tamil Nadu (GoTN) created a Special Purpose Vehicle (SPV) for implementing the Chennai Metro Rail Project. This SPV named as "Chennai Metro Rail Limited" was incorporated on December 03, 2007 under the Companies Act. It has now been converted into a Joint Venture of Government of India (GoI) and GoTN with equal equity holding.

379. The Department of Planning, Development and Special Initiatives under the GoTN acting through Chennai Metro Rail Limited (CMRL) will be the Executing Agency of the proposed MDB Corridor 3-CMRL (Phase-II).

380. CMRL will be responsible for implementation of the metro rail project. Managing Director, CMRL will be in charge of the overall project activities. CMRL will be accountable to the GoTN (i.e. the EA).

381. Project Implementation Unit (PIU), CMRL headed by the Project Director (PD) is responsible for the overall execution of the project and implementation of the EMP. The PIU will be assisted by General Consultant (GC). The safeguard role of GC is to assist CMRL in review of documentation and monitoring of implementation of EMP and monitoring plan during construction and operation by means of scheduled inspections, meetings and reports submitted to CMRL. The terms of reference are attached as Annexure 7.

### 9.3.2 Implementation of EMP

382. CMRL: EMP will be committed by CMRL as part of its agreement with Multilateral Development Banks (MDBs). The responsibility to implement the EMP including Grievance Redressal rests with CMRL. Environment clearances related to locations and design of the project will be secured before start of construction. Permissions/certifications required during operation of the project. Environment monitoring during operation.

383. Contractor: Permits required during construction and those directly related to construction. The EMP will be implemented by the contractors of different packages based on the contract agreement. The contractor SH&E team will be headed by senior Manager assisted by qualified and trained safety professionals and environment engineers along with onsite junior field personnel. This team will be assisted by:

- electrical and mechanical engineers qualified in safety evaluation;
- environment engineer;
- traffic engineer;
- professionals in occupational health and labour welfare.
- Environment monitoring during construction
- Regular monthly reports on implementation will be submitted by contractor to (GC).

384. The Employer Requirements for Health, Safety and Environment have been prepared for Corridor 3; they will be issued to the Contractor as part of the contract documentation for construction. The requirements comprise the following 3 documents.

- Volume 1. Control Document
- Volume 2. Health and Safety Manual
- Volume 3. Environmental Management Arrangements

385. CMRL and GC: Supervision and review of implementation will be the responsibility of GC. With assistance from GC, CMRL will also be responsible for reviewing and approving any specific documents/plans that have to be provided by contractors (traffic management plan, site waste management plan, excavated soil and C&D waste (muck) disposal plan etc.). In view of the common principles of EMP and common project implementation philosophy of MDB projects, GC will be common for all MDB projects in Phase II that is Corridor 4, MDB Corridor 5 and MDB Corridor 3. Implementation of EMP will be continuously monitored by the Safety, Health and Environment (SH&E) team of environment experts from the GC and CMRL. Separate CMRL team will work on construction of each MDB project; GC team will be common for all MDB projects with a view to facilitate unified approach and knowledge enhancement.

386. The CMRL's SH&E team will headed by senior Manager assisted by qualified and trained mid-level safety professionals, environment engineers, traffic engineer, labour welfare

officer. The Manager SH&E for the project in CMRL will report directly to Director (Works) and Managing Director, CMRL.

387. GC will contribute,

- Specialists from fields of safety, environment, traffic engineering, occupational and community health, ecology, noise and vibration
- Onsite junior field personnel.
- The visits and review meetings will comprise:
- Weekly site visits independently by CMRL and jointly with contractor;
- Weekly review meetings by CMRL and contractor.
- Periodic quarterly reports will be submitted on implementation of EMP and its internal monitoring by CMRL to MDB.
- Orientation and training of CMRL team in implementation of EMP and environmental monitoring will be undertaken at the beginning of the project.

388. MDBs: Implementation of the EMP will be monitored half yearly by MDBs through their experts.

389. External Monitor: An external agency will be engaged by CMRL in consultation with MDBs to evaluate the environmental performance of abovementioned parties. The agency will report to CMRL who in turn report it to MDBs. Separate External Monitor will be engaged for MDB Corridor 3. The terms of reference are attached as Annexure 8. and include:

- To conduct third party monitoring of environmental compliance under the project;
- To ensure that the Project will be implemented in conformity with the policies of GoI, GoTN, as well as MDBs' policies;
- To Identify any safeguard related implementation issues and necessary corrective actions and reflect these in a time-bound corrective action plan for CMRL to implement;
- Capturing social, environmental and economic benefits and particular potential benefits to the poor and vulnerable groups in the corridor;
- Involving users and stakeholders in the monitoring process; and
- Strengthening the capacity of the CMRL to manage and replicate third-party monitoring with rail users and stakeholders.

390. The reporting line of all relevant parties is, Contractor  PIU  CMRL and GC  MDBs. The external monitor will conduct independent monitor to inform CMRL any remediation actions to ensure the safeguard compliance.

391. An EMP Matrix is presented in Table 9.3.

### 9.4. Development and Implementation of Subplans

392. As part of the construction environmental management plan, contractors need to develop various subplans as discussed in the EMP (item 4 to 13 during pre-construction stage) and in the ESHS system requirements as described in CMRL's Health and Safety Manual (annexure 5). These plans are aimed at good environmental management practices and serve as guide documents. While the relevant impacts have been adequately assessed in the EIA, further topic or location specific information from the contractor will be needed to complete these plans which is not available for inclusion in the main EMP at the time of approval. These subplans will form part of construction EMP be consistent with the contractor's SHE plan and will be included in the bid documents. Table 9-1 present some of the key plans to be developed by contractor and responsible party for it's approval.

**Table 9-1: Contractors'subplans and approval**

| Plan | | Description | Approvals | | |
|---|---|---|---|---|---|
| | | | PIU | GC | ADB[17] |
| 1. | Work plan for securing all permits and approvals | The plan will list all necessary permits, approvals and/ or consent including the responsible authorities and the timeframe of obtaining them. | Yes | Yes | No |
| 2. | Construction and labor camp Management Plan | The plan will provide a layout map of the construction sites and campsite and clearly show the access road, entry and exit and different facilities inside the camp. Facilities inside the camp may include contractor's office, residential quarters, toilets, health center, construction plants, storage areas etc. The plan will include information on waste management, supply of water for drinking and bathing, waste water and drainage management, traffic movement routes etc. | Yes | Yes | No |
| 3. | Site and Camp Restoration Plan | Describes the clean-up and restoration operations to be implemented by the Contractor prior to demobilization including clearance of all temporary structures, disposal of all garbage, night soils and petroleum, oil and lubricants wastes and filling and sealing of all disposal pits or trenches. | Yes | Yes | Yes |
| 4. | Muck Disposal Plan | The plan shall describe sources of muck generation (piling work for viaducts etc), type and quantity of muck generated from various sources, use of muck generated, method collection and transportation, transportation routes, disposal site location and design, approvals required for disposal sites, and treatment method. Recommendations provided in the EIA must be considered. | Yes | Yes | Yes |
| 5. | Waste Management Plan | The plan shall describe waste streams and amounts, describe recycling/reuse methods for each material, identify the waste destinations and transport modes, including what materials are being segregated on site for reuse or recycling, specify responsibilities for managing and disposal of waste. Describe special measures for material use and handling. Describe communication and training to support and encourage participation from everyone on site. Recommendations provided in the EIA must be considered. | Yes | Yes | No |
| 6. | Traffic Management Plan | The plan shall be designed to ensure that traffic congestion and traffic safety impacts due to construction activities and movement of construction vehicles, haulage trucks, and equipment is minimized. The plan shall be prepared in consultation with traffic officials. The | Yes | Yes | Yes |

[17] ADB will provide a no objection rather than an approval as the document will be delivered by the contractor with whom ADB does not have a formal relationship

| Plan | | Description | Approvals | | |
|---|---|---|---|---|---|
| | | | PIU | GC | ADB[17] |
| | | plan shall identify traffic diversion and management issues, haul road network plan, traffic schedules, traffic arrangements showing all detours/lane diversions, modifications to signaling at intersections, necessary barricades, warning/advisory signs, road signs, lighting, and other provisions to ensure that adequate and safe access is provided to motorists and other road users in the affected areas. Pre-construction access road surveys will also form part of the TMP. The plan shall also include locations for pedestrian crossings and conditions for the management of these crossings, including the use of flagmen. | | | |
| 7. | Occupational and Community Health and Safety Plan | Consistent with international standards (e.g., World Bank Group Environmental, Health, and Safety Guidelines, 2007) and Labor Code of India. The Plan shall address health and safety hazards associated with construction activities (e.g., excavations, tunneling etc.), use of heavy equipment, transport of materials and other hazards associated with various construction activities and shall provide links to existing government health programs. The plan will include a Covid-19 response and management plan. The document to be read together with the Camp Management Plan. Recommendations provided in the EIA must be considered. | Yes | Yes | Yes |
| 8. | Labor and Working Conditions Management Plan | This will include: policy/legal framework information (including labor and OHS requirements of national legislation, ADB SPS 2009), workforce induction and information on rights, child and forced labor, equal opportunity, migrant workers, promotion of local employment opportunities, labor union, worker accommodation requirements, provision for retrenchment plans, workforce grievance mechanism, security personnel (Voluntary Principles on Security and Human Rights), etc. Contractor needs to ensure that the core labor requirements are cascaded down across the entire contracting chains, including sub-contractors and suppliers of core materials. The plan shall also be in compliance with IFC Guidance Note “Workers’ accommodation: processes and standards”. | Yes | Yes | Yes |
| 9. | Code of Conduct | The Contractor shall prepare a Code of Conduct that outlines camp rules articulating acceptable behaviors of the workforce with local communities. Associated induction training will be provided to ensure rules are well understood and enforced. | Yes | Yes | Yes |
| 10. | Emergency Response Plan | This plan shall prescribe measures to prevent, mitigate, respond to and recover from emergency | Yes | Yes | No |

| Plan | Description | Approvals | | |
|---|---|---|---|---|
| | | PIU | GC | ADB[17] |
| | events that could occur due to project activities such as accidents, spills of hazardous substances, fire, extreme weather events, and others; measures to prevent, mitigate, respond to and recover from emergency events that could occur due to project activities such as accidents during tunneling (e.g., tunnel collapse, electrocution, etc.), release of toxic gas during tunneling, spills of hazardous substances, fire, floods, and other events. | | | |
| 11. Construction Vibration Management Plan | Detailing the procedures for vibration surveys, monitoring and control. Such details shall include; procedures to complete condition surveys (for all properties indicated in this EIA), Measurement locations and methods; Method statements for works likely to induce vibrations, including programs of trial construction sections to determine the likely magnitude of vibrations at defined distances from the vibration source, in sufficient detail for the contractor to develop a final method for constructing the works without excessive vibration; Description of the instrumentation and equipment to be used; Copies of the instruction manuals and the laboratory calibration and test equipment certification; The resumes of the vibration monitoring technical support personnel, sufficient to define details of relevant experience; Procedures for data collection and analysis; Frequency of measurements; Means and methods of providing warnings when the specified construction vibration limits are reached; and Action plans to be implemented in the event the specified construction vibration limits are reached. The generalized plans of action shall comprise the positive measures by the Contractor to control vibrations using alternative construction methods. | Yes | Yes | Yes |
| 12. Construction Water Management Plan | Plan to describe the water sources, required permits and ways to minimize water wastage | Yes | Yes | No |
| 13. Utility shifting and restoration plan | Plan to describe temporary or permanent diversions of utility services in order to secure that utility services remain operational during the entire construction period and after completion of project. | Yes | Yes | No |

## 9.5. Environmental Monitoring and Reporting Program

393. Environmental Monitoring Plan (EMoP) is a companion document of the EMP. EMoP contains parameters, location, sampling and analysis methods, frequency, and compared to

standards or agreed actions that will indicate non-compliances and trigger necessary corrective actions. More specifically, the objectives of the EMoP are:

- Ensure that impacts do not exceed the established legal and project specific standards
- Check the implementation of mitigation measures in the manner described in the EIA report
- Monitor implementation of the EMP
- Provide an early warning of potential environmental damage
- Check whether the proposed mitigation measures have been achieved the intended results, and or/ other environmental impacts occurred

394. The monitoring plan will be used for performance monitoring of the project. A monitoring plan defining all parameters to be monitored, with tentative location, project stages for measurements, implementation and institutional responsibility for different environmental components is prepared for all stages of project and presented in Table 9.4.

395. Monitoring and Reporting Frequency for implementation of the EMP is shown in Table 9.2.

**Table 9-2: Monitoring and Reporting for EMP and EMoP**

| Particulars | Frequency of reporting | Reporting by / Reporting to | Review by/ Monitoring by |
|---|---|---|---|
| Starting from deployment of construction contractor from site selection period<br><br>a) Implementation of EMP and EMoP<br>b) Monitoring of implementation of EMP and EMoP<br>c) Grievance Redressal | a) Monthly till completion of construction<br>b) Monthly till completion of construction<br>c) Quarterly till completion of construction | a) Contractor / GC<br>b) GC / CMRL SH&E team, CMRL SH&E team/MD, CMRL<br>c) CMRL SH&E team/MD, CMRL | CMRL |
| a) Implementation of EMP, EMoP and Grievance Redressal and their internal (CMRL) monitoring<br>b) Outcome of continuing public consultations | Semi annually **until completion of** construction | All by CMRL / MDBs | • MDBs<br>• TNPCB |
| Evaluate implementation and internal monitoring of EMP, EMoP, Grievance Redressal and their efficacy | Semiannually **during** construction | External Expert / CMRL | MDBs |
| a) Implementation of EMP by CMRL and EMoP by external agency<br>b) Monitoring of EMoP<br>c) Grievance Redressal | Quarterly during first 2 years of operation & maintenance | a) and b)<br>• EMoP Agency / GC<br>• GC / CMRL SH&E team<br>• CMRL SH&E team/MD, CMRL<br>c) CMRL SH&E team/MD, CMRL | CMRL |
| a) Implementation of EMP, EMoP and | Semiannually during first 2 | CMRL / MDB | • MDBs<br>• TNPCB |

| Particulars | Frequency of reporting | Reporting by / Reporting to | Review by/ Monitoring by |
|---|---|---|---|
| Grievance Redressal and Internal (CMRL) monitoring<br>b) Outcome of continuing public consultations | years of operation & maintenance | | |
| Evaluate implementation and EMP, EMoP, Grievance Redressal and their efficacy | Annually during first 2 years of operation & maintenance | External Expert / CMRL | MDBs |

**Table 9-3: Environmental Management Plan Matrix**

Note: This EMP Matrix will form part of the contract document together with CMRL's SHE Manual for all contractors. This EMP has been aligned with the SHE Manual wherever possible, and in places, cross referencing has been resorted to.

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| **Planning and Design Phase** | | | | | | |
| 1. | Land Acquisition and resettlement | Social | Permanent acquisition of 0.203 ha private land as minor depot in SIPCOT has been dropped. The final size of land to acquired will be updated based on the optimization of project design. | 1. Compensation and Resettlement benefits as well as livelihood restoration measures are under approval by GoTN. Land Acquisition is being carried out as per the provision of GoTN, GoI and ADB policies. The affected people will be compensated and assisted as per the provisions of Resettlement Action Plan (RAP). | CMRL | GoTN |
| 2. | Change in Land use | Land | Land use will be slightly changed | 1. CMRL developed the Comprehensive Mobility Plan for CMA in 2015 to identify the present and future mobility patterns of Chennai Metropolitan Area, including development of Corridor 3.<br>2. Proper clearance/permission/consents will be sought from competent authority before construction. | CMRL | CMDA |
| 3. | Contractor Management | EHS | EHS accidents<br>Reputational Risk | 1. Integration of EHS contractor management into broader project management, procurement, human resources, legal, and financial management.<br>2. "Prevention through design": assessment of what prime contractor does versus what subcontractors do; contractor prequalification (when, if, and for what); use of information technology tools (identification cards and tracking and reporting systems for personnel and training).<br>3. Prime contractor will be responsible for EHS practices of the subcontractor including human resource policy which complies with applicable labour legislations, including decisions on material supplies and equipment given environmentally friendly priorities, and prepare subcontract agreements accordingly.<br>4. Contractor management incorporates "adaptive management" to monitor and adapt over time; integration with sustainable procurement approach or concepts.<br>5. Building culture and commitment by demonstrating the importance of EHS management to the president or director of project-implementing agency and president or director of subcontractor; including EHS aspects in routine senior | Contractor / GC | CMRL |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | | | | management project contractor meetings and reports, reflecting both criticisms or suggestions and praise; designating responsibilities of EHS staff (for example, work stoppage); requiring strong and consistent training and participation of managers; acknowledging managers' participation in on-site supervision and resolution of issues; and providing awards, recognition, and incentives.<br>6. Training and quality control plans. | | |
| 4. | Contractor Preparatory Works (Upon issuance of Notice to Proceed) | EHS | Non-compliance with contract conditions and regulatory requirements. | 1. The Contractor shall complete the following activities no later than 30 days upon issuance of Notice to proceed, (a) appoint contractor's Safety, Health and Environmental Officer (SHEO); (b) SHEO will engage GC-Environment Specialist to discuss EMP, seek clarification and recommend corresponding revisions if necessary; (c) SHEO will agree with GC the monthly monitoring template and deadlines for submission; (d) SHEO will submit for GC's approval all necessary subplans as listed in the EIA section 9.4 and in CMRL's Health and Safety Manual (Volume 1, section 4) The plans will include a work plan to secure all permits and approvals needed to be secured during construction stage which will include but are not limited to: i) operation of crushers and hot mix plants, ii) transport and storage of hazardous materials (e.g. fuel, lubricants, explosives), iii) waste disposal sites and disposal management plan, iv) temporary storage location, iv) water use, and v) emission compliance of all vehicles. Arrangements to link with government health programs on hygiene, sanitation, and prevention of communicable diseases including Covid-19 will also be included in the action plan; (e) SHEO will submit for GC's approval of the construction camp layout and management plan before its establishment; and (f) SHEO will update EIA (in consultation with GC, in case of design changes) and also prepare site-specific EMPs. | Contractor / GC | CMRL |
| 5. | Labour Management | Labour | Labour right | 1. Compliance with GoI labor legislation, ratified International Labour Organization conventions.<br>2. Prohibition of child labor, including prohibition of persons under 18 years old from working in hazardous conditions (which includes construction activities) and from working at night; medical examinations required to determine that persons above 18 years old are fit to work.<br>3. Elimination of discrimination with respect to employment and occupation, to be defined as any distinction, exclusion, or preference based on race, gender, religion, political opinion, trade union affiliation, national extraction, or social origin. | Contractor | GC / CMRL |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | | | | 4. Human resource policy or plans that establish (a) the rights and responsibilities of project company employees and any contractor employee working in the project regarding remuneration, working conditions, benefits, disciplinary and termination procedures, occupational safety and health, promotion procedures, and training and (b) the rights, responsibilities, and requirements in contractor or subcontractor agreements related to worker rights.<br>5. Grievance Redress Mechanism for workers should be established as early as possible to function no later than construction commencement.<br>6. There will be provision for group accidental and medical insurance for the workers.<br>Contractor has to prepare a Code of Conduct that outlines camp rules articulating acceptable behaviors of the workforce with local communities. Associated induction training will be provided to ensure rules are well understood and enforced. | | |
| | | Health and Safety | Accidents/illness | 1. Make mandatory the use of safety gears (helmets, safety belts, masks, gloves, Ear plugs/ muffs and boot) by workers depending on nature of work.<br>2. Necessary planning and safety approach will be made for rescue during emergency.<br>3. Use of dust controls (exhaust ventilation) for dust control<br>4. Workers will be provided with first aid and health facilities at the site.<br>5. There should have facility to deal with medical aspects of HIV/AIDS treatment with specialized services<br>6. CMRL Covid-19 protocols forming part of the Environmental Social Health and Safety Requirements contained in the contract document shall be followed; labour shall be trained and informed of precautions such as social distancing, sanitizing, avoiding groups; arrangements for thermal scanners; provision of sanitisers, face masks, gloves etc; site record of Covid-19 hospitals; daily disinfection of site, equipment and vehicles. | Contractor | GC / CMRL |
| | | | COVID-19 response | 1. Taking cognizance of situation at time of mobilisation, the Contractor shall undertake a COVID-19 risk assessment of project area and prepare a COVID-19 Response and Management Plan (C-R&MP) and submit to CMRL and GC for approval.<br><br>2. The preparation of C-R&MP shall consider guidance of GoI, especially the Standard Operating Procedures and Guidelines for Construction Sites for COVID-19 Outbreak, other guidelines of WHO, International Labour Organisation, International Financial Corporation and World Bank's interim | Contractor | GC / CMRL |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | | | | guidance note etc. The key points on COVID-19 Response and Management measures is at Annexure 8.<br><br>3. The contractor shall submit a weekly monitoring and progress report to CMRL and GC. | | |
| 6. | Obtaining Clearance, Permission and Consents | Regulatory Compliance | Tree felling information, Consents to establish labour camps, pre-casting and material yards, depots, establish and operate hot mix plant, crushers, batching plant, DG sets, etc. C&D waste (muck) disposal | 1. Consultation and coordination with relevant authorities to prepare the documents to obtain clearance, permission and consents.<br>2. Conditions set in permission and consents to be incorporated into the site-specific EMPs, with dedicated officers to maintain the regulatory compliance tracker. | CMRL / Contractor | Tamil Nadu Forest Dept., / TNSPCB |
| 7. | Site Clearance and Demolition | Tree felling | About 164 trees will be affected on viaduct and stations. Additionally, in some areas, pruning will be required. 4 commercial structures which are semi permanent in nature will be demolished. | 1. CMRL and Contractor need to conduct a final tree inventory survey (number, type, height) with the final designs of alignment and station. Trees with conservation value should be transplanted. Plan to avoid cutting patrimonial trees, including adjustments in project design to minimize effect on such trees.<br>2. Revisit the works in public parks or green spaces and potential tree removal, especially involving patrimonial trees of special significance, so minimize the impacts as much as possible.<br>3. If unavoidable, implementation of acceptable plans for transplanting (to the extent technically and economically viable) or replacing such trees and for their short-term maintenance and care.<br>4. Adequate coordination with applicable government regulatory authorities. As alignment passes through built land use, green belt development along elevated section is not feasible. Compensatory plantation of 12 saplings for every tree felled will be done in sites to be identified. CMRL to allocate sufficient tree replantation budget.<br>**5.** Stakeholder communication to avoid or minimize public concerns or protests.<br>**6.** Definition of adequate budget and contingencies as well as financial resources to cover all related costs. This will be finalized before work on relevant section is commenced between CMRL and Contractor. | CMRL / Contractor | Forest Dept. GoTN and CMDA, GCMC |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | | | | **7.** Families impacted due to fully affected (displaced/demolished) structures and partially affected structures will be compensated in accordance with the approved Resettlement Action Plan. | | |
| | | Noise | Noise will be generated by the use of hand tools such as jackhammers, sledgehammers and picks etc. | 1. The procedure of demolition will be conducted as per the demolition plan prepared by the Contractor in consultation with CMRL.<br>2. The existing structures should be demolished one after another cautiously. | Contractor | GC / CMRL |
| | | Physical Cultural Resources | Historic and Cultural Value Loss | 1. Contractor to conduct pre-construction structural integrity inspections if there are known or a significant likelihood of archeological and/or culturally valuable sites or finds in the project's direct area of influence.<br>2. Prepare a monitoring scheme prior to construction based on the above inspections, with a focus on pre-identified receptors comprising educational, medical and physical cultural buildings located within recommended screening distance of 62m (for cat. 2) on either side of alignment, or finds in the project's direct area of impact.<br>3. Compliance with applicable legislation (permits and procedures) and good international practice.<br>4. Adaptive management in site-specific EMP during final design, including site locations (stations and construction staging areas).<br>5. Chance finds procedure to be prepared by Contractor and reviewed by GC/CMRL before submitting to all lenders. | Contractor | GC / CMRL / CMDA |
| 8. | Severance of utilities | Social<br>EHS | The proposed alignments will cross drains and utility services such as sewer, storm water drains, water and wastewater pipes, roadside lights, telephone cables, electricity power lines, electric poles, natural | 1. Assets and utilities will be maintained without affecting and damages by shifting temporary/ permanently where it is necessary.<br>2. Based on utility maps and network information, CMRL and Contractor in collaboration with utility owners oversees an investigation of existing utility supply infrastructure using trial pits or mix of 3D imaging and trial pits where pits pose safety hazards in built areas. CMRL and Contractor to conduct on-site inspections and a topographic survey. Even when utilities are far enough below the surface, to avoid damage from construction, they may need to be diverted so that their maintenance will not affect the safe and efficient operations of the train system once construction is completed. Utility owners will be involved in providing any new utilities needed for the rail system and in designing the necessary | CMRL / Contractor | CMRL / CMWSSB, TANGEDCO, Telecom companies |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | | | gas lines and traffic signals etc. | diversions and protection measures to minimize the risk to existing utilities from ground movement and surface settlement.<br>3. For gas pipeline, Contractor will conduct the hazardous operation study to ensure the smooth and safe shifting.<br>4. Utility shifting plan will be developed by CMRL and Contractor in coordination with concerned authorities and shifting of utilities will be done as per agreed utility shifting plan prior to construction commenced. The plan will include required EHS management measures, supervision and monitoring of implementation, and final report and confirmation that construction works will be properly closed (for example, all waste will be removed or re-pavement will be completed as required). In case public utilities are required to be shifted to private land in exceptional circumstances, then adequate compensation shall be made by CMRL to the property owner on the same principles as temporary land acquisition. Following completion of construction of metro, such utilities shall be rehabilitated on public land. | | |
| 9. | Noise and Vibration Impacts Related Design | Environmental Nuisance and possible structural damages due to vibration. | Noise and vibration from construction and train operation | 1. The detailed noise and vibration analysis (mathematical modeling) at pre-identified receptors comprising educational, medical and physical cultural buildings and other fragile buildings located within recommended screening distance of 62m (RRT, cat.2 ) for vibration and 100m (RRT, intervening buildings) for noise on either side of alignment based on final engineering designs should be carried out, based on which, a set of mitigations should be prepared and shared with all lenders for review, prior to commencement of construction.<br>2. Visual inspections of these buildings shall be done by the contractor so as to serve as baseline to monitor progression of building damage if any due to vibration.<br>3. Ballast less track structure is supported on two layers of rubber pads to reduce noise and vibrations. In addition, baffle wall as parapets will be constructed up to the rail level so as reduce sound levels. Noise at source will be controlled or reduced by incorporating suitable feature in the design of structures and layout of machines and by use of resilient mounting and dampers etc.<br>4. Noise barriers made of suitable polycarbonate as per tender document will be installed. | Contractor | GC / CMRL |
| 10. | Coordinate with the Traffic Department on Traffic | Land<br>Occupational safety | Nuisance from traffic congestion | 1. The Contractor shall develop detailed and robust traffic management plans consistent with the Indian Guidelines on Traffic Management in work zones (IRC:SP:55-2014), prior to mobilization for respective sections with site- or | Contractor | GC/ CMRL/ Traffic Police |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | Management Plan | Community safety | | station-specific plans and measures to minimize the overall impact on traffic throughout the construction and operation periods.<br>2. At congested sections, the temporary traffic coordinators will be engaged by CMRL to facilitate the traffic management.<br>3. At the minimum, the traffic management plans will have the following components: construction traffic, ensuring access to properties, accommodating pedestrians, parking, access by construction vehicles, faulty traffic lights and problem interchanges, use of public roads, parking provision during construction, use of residential streets and traffic diversion due to temporary road closures, and construction and use of temporary access roads.<br>4. Strengthening impact and risk prevention measures, such as establishing construction site works to minimize the entrance and exit of vehicles at stations during peak traffic.<br>5. The logistics should be considered to manage transport materials from storage areas outside of the dense urban core to worksites and to return excavated soil and other materials to disposal locations. If needed, construction traffic may be confined to certain routes (based on infrastructure capacity) or restricted to certain off -peak hours (that is, to reduce noise pollution at night or to avoid commuting and school hours during the day).<br>6. Any diversions of traffic will cause considerable confusion for pedestrians and drivers as they rearrange their itineraries, hence, to minimize the effects of the diversion or reorganization, it is necessary to conduct communication campaigns and disseminate appropriate information to urban residents and taxi and bus drivers in advance of disruptions. Efforts will be given to divert traffic to roads wide enough to accommodate extra traffic. Compliance with scheduled deadlines for the detour is essential. If necessary, bus service and other public and private transport services in the area should be improved to meet residents' transportation needs.<br>7. CMRL and local authorities continue to play an oversight role in approving these plans during construction, evaluating their cumulative impact with other infrastructure projects in the region, and ensuring their dissemination to all relevant stakeholders. | | |
| 11. | Construction method, construction | Environment | Pollution and nuisance | 1. Contractor is committed to use environmentally friendly construction methods and materials, including cement, asphalt, and base materials etc.<br>2. Construction material shall be sourced from legalized and approved quarries. Extraction from river beds is banned. | Contractor | GC / CMRL |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | material and sites selection | | | 3. Energy saving technologies will be embedded into the Project design wherever possible. For instance, solar panels, rainwater harvesting.<br>4. Update of plan based on final contractor-defined estimated volumes and timing for groundwater pumping with intension of minimizing the groundwater consumption. The primary objective shall be to avoid extraction of groundwater for construction. However use of groundwater which has been generated by dewatering of excavations can be used in construction activities. In those instances where extraction of groundwater becomes unavoidable, contractor shall, with consent of CMRL and the respective Water Authority, resort to such extraction. In such instances contractor-defined estimated volumes and timing for groundwater pumping with intention of minimizing the groundwater consumption.<br>5. Procedures for minimizing waste segregation, reuse, temporary storage, recycling, donation, and disposal.<br>6. Selection of waste disposal service providers (transport, recycling, and disposal) based on EHS criteria (including compliance with all regulatory requirements, no documented EHS issues related to materials at operation or site facilities, and agreement to provide access for site visits to discuss EHS management).<br>7. Final selection of disposal or reuse sites for extracted soils from construction and assessment and determination of truck routes from project sites to disposal or reuse site.<br>8. Focus will be placed on reuse of the extracted soil for enhancement of green space, waste recycle, and storm water runoff.<br>9. Construction yards with aggregate crushing and screening, pre-casting, material and fuel storage and ready-mix concrete plants will be located away from habituated or ecologically sensitive areas. Locations will be decided by CMRL and cleared by MDBs before construction commencement in consultation with Municipal Corporation/Municipalities and CMDA.<br>10. Sites for disposal of excavated soil and C&D waste (muck) will be decided by CMRL before start of construction in consultation with SPCB, Municipal Corporation/Municipalities and CMDA, to ensure a safe distance from residential areas, water bodies and ecologically sensitive locations as to avoid disrupting natural drainage. The muck shall be filled in the dumping site in layers and compacted mechanically. Suitable slopes will be maintained on the stockpile. Once the filling is complete, it will be protected by low walls, provided with a layer of good earth on the top and covered with vegetation. A muck disposal plan will be prepared by Contractor and approved by CMRL and TNPCB. Hazardous | | |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | | | | waste will be taken away by licensed vendors who will be responsible for due disposal at permitted sites. | | |
| 12. | Climate Designs | Health and Safety | Natural disasters generated health and safety accidents<br>Maintenance Cost | 1. Vulnerability of project to disruption of road level access to stations from Thoraipakkam to Siruseri due to rise in mean sea level is indicated in Figure 5.1. Disaster management plan will pay special attention to road drainage on this section.<br>2. Other climate adaptation designs will be embedded in the final design, such as (a) Increase in capacity of stormwater drainage will be made under the Tamil Nadu Sustainable Urban Development Project so as to deal with extreme flooding in addition to demand of future landuse growth along this alignment..<br>3. Increased number of pits for rainwater harvesting from elevated metro to cater to flood waters and heavy rains.<br>4. Climate change mitigation measures shall be implemented, such as solar panels on station buildings and roofs to reduce the extensive use of grid-generated electricity supplied to the station for operation and maintenance. | Contractor | GC / CMRL |
| 13. | Site-specific Environmental Baseline Collection and Assessment | Environment | Benchmark of assessing project impacts | 1. Prior to mobilization, contractor to collect a full set of baseline data of air, water (surface and ground), noise and vibration and soil quality.<br>2. Additional investigations in areas identified as having contaminated soil or groundwater to define the degree and extent of contamination and alternatives for soil and groundwater disposal. Assessment of potentially contaminated soil at site locations where soil work and excavations will be performed to examine the site situation. If there is a reasonable likelihood of contamination, then a specific management plan that includes (a) monitoring during construction consisting of visual inspections, on-site and in-situ monitoring to detect and confirm levels of contamination (and supplemented as needed by laboratory analysis), (b) on-site temporary storage and treatment, (c) final disposal (both for water and soil), and (d) worker health and safety procedures.<br>3. Assessment and site-specific measures for controlling noise, dust, and illumination during construction (for example, when working 24 hours a day).<br>4. Confirmation of potential uses of groundwater. Efforts on minimizing the groundwater consumption.<br>5. Contractor to prepare site-specific EMPs for CMRL to approve before mobilization. | Contractor | GC / CMRL |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | | | | 6. Based on detailed construction work plan and associated occupational health and safety risks, strengthening the contractor health and safety management system in site-specific EMPs.<br>7. CMRL and GC to provide EMP orientation to contractor. | | |
| 14. | Documents Review and Information Disclosure | Environment | Unanticipated impacts management | 1. With the assistance of GC, CMRL will review the above said data collections, surveys and pre-construction plans prepared by Contractor.<br>2. CMRL will submit to all lenders to review the documents and disclose in a timely and meaningful manner prior to construction. | CMRL | GoTN |
| 15. | Establishment of Grievance Redress Mechanism | EHS | Complaints not resolved in time | 1. Grievance Redress Mechanism for workers and project affected people should be established as early as possible to function no later than ground work commencement.<br>2. The Grievance Redress Mechanism information and focal should be disseminated to public through the CMRL website or other media as approved by CMRL. | CMRL | GoTN |
| 16. | Community Liaison | Social | Complaints | 1. To ensure that Grievance Redress Mechanism to function effectively for affected people on construction nuisance at ground level with grievance log well documented.<br>2. Contractor to develop a community communication plan per the construction plan, including important measures to reduce community risk, such as fence and related protection around work sites (including strength and visual protection), education and awareness signs and information, and placement of safety risks (explosive and flammable materials, generators). | Contractor | GC/ CMRL |
| **Construction Phase** | | | | | | |
| 17. | Construction Monitoring | ESH | Breach of legislation, EIA, EMP, Contracts<br>Accidents | 1. Contractor to collect and monitor the Ambient environmental data of air, water (surface and ground), noise& vibration, soil quality and submit monitoring reports to GC / CMRL on monthly basis.<br>2. GC / CMRL to review the data compared to baseline data and urge Contractor to take immediate actions over any project generated pollution / contamination.<br>3. GC to submit monitoring reports on quarterly basis to CMRL.<br>4. If any unanticipated EHS impacts arise during construction, implementation or operation of the Project that were not considered in the EIA / EMP, Contractor and GC to promptly inform CMRL of the occurrence of such risks or impacts, with detailed description of the event and proposed corrective action plan. CMRL will report to all lenders accordingly. | Contractor / GC / CMRL | TNSPCB |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | | | | 5. CMRL to engage qualified and experienced third party monitor to verify information produced through the Project monitoring process, and facilitate the carrying out of any verification activities by such third party monitor.<br>6. CMRL to submit the semi-annual monitoring reports (GC's and third party's) using the agreed the template to all lenders.<br>7. CMRL to report all lenders any actual or potential breach of compliance with the measures and requirements set forth in the EMP promptly after becoming aware of the breach. | | |
| 18. | Community Liaison | Social | Complaints | 3. To ensure that ongoing timely consultations / communications with communities are provided on the progress of the project together with feedbacks on the environmental management performance of the project.<br>4. Grievance Redress Mechanism for affected people should function effectively with grievance log well documented.<br>5. Contractor will provide a minimum of two (2) weeks notification to directly affected residents, businesses and other relevant groups of the intended construction commencement date. In providing a mechanism for communication between the contractor and the community and informing the public of construction details (timing, expected impacts), CMRL will undertake consultations.<br>6. Adaptive management that monitors, adjusts, or adds measures to reflect actual community risks.<br>7. Important measures to reduce community risk, such as fence and related protection around work sites (including strength and visual protection), education and awareness signs and information, and placement of safety risks (explosive and flammable materials, generators). | Contractor | GC/ CMRL |
| 19. | Truck and Driver Management | Environment<br>Social | Community disruption<br>Accidents<br>Reputational risk | 1. Contractor's transport vehicles and other equipment shall conform to emission standards.<br>2. Control, inspection, and documentation of trucks prior to leaving site, including removal of soil on tires. Contractor will provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from construction depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt. Used water shall be collected and re-used after settling in a settling basin or tank.<br>3. Definition of allowable routes, speeds, and times (day or week).<br>4. Driver requirements and controls, including prework medical (and blood tests) and physical inspections, ongoing monitoring (of visual and alcohol or drug use), driver training, daily total allowable work time, and allowable deviations. | Contractor | GC/ CMRL |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
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| | | | | 5. Driver contracts with clearly specified requirements and remedies for noncompliance.<br>6. Use of electronic monitoring (GPS), driver training, and stops.<br>7. Procedure for truck maintenance, including selection of service providers considering environmental aspects, application of low-Sulphur fuel, no idling of trucks, routine maintenance (including assurance of proper engine operations related to emissions and noise), and disposal of used oil and other fluids, batteries, and tires etc. | | |
| 20. | Leveling of Site | Land | Surface leveling will alter the soil texture and compactness, which will affect the infiltration and soil ecology. Also leveling will involve alteration of natural drainage | 1. Interim drainage system will be installed prior to construction.<br>2. Where feasible, infiltration losses will be countered by installing Rainwater Harvesting pits away from construction site. | Contractor | GC/ CMRL |
| 21. | Mechanical piling | Noise | During mechanical piling operations, noise will be generated which may go up to 88-90 dB (A) at a distance of 5m | 1. At sensitive locations, auger piling will be carried out in place of mechanical (by driven) piling which will generate less noise than mechanical piling (around 70-75 dB(A)). Also 2m high barricade of GI sheet will be installed on all sides of piling operations. This could effectively cut down noise levels by 10-15 dB (A). Piling operations will be restricted during day time hours only.<br>2. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures.<br>3. Use of low-noise equipment and ensuring good maintenance, and trying to avoid using high-noise equipment simultaneously at the same section.<br>4. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed.<br>5. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan.<br>6. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities.<br>7. Monitoring required during construction, including field observations and measurements. | Contractor | GC/ CMRL |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
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| | | Vibration | Pile driving for viaduct piers and buildings driving generate vibrations | 1. Cast-in-situ piling will be deployed at locations with sensitive receptors so as to reduce vibration.<br>2. At pre-identified receptors comprising educational, medical and physical cultural buildings and other fragile buildings located within recommended screening distance of 62m (for cat. 2) on either side of alignment , the contractor shall implement the pre-construction structural integrity inspections.<br>3. Contractor to ensure that vibration levels will not exceed 5.0 mm/s<br>4. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan.<br>5. Monitoring during construction including field observations and measurements. | Contractor | GC/ CMRL |
| | | Physical Cultural Resources | Historic and Cultural Value Loss<br>Conflicts with community | 1. Before start of piling, Contractor and CMRL will coordinate with State Archeological department to reconfirm that there is presence of buried artifacts along the metro line alignment. No piling will be allowed unless cleared by the Archaeological Department.<br>2. Archeological monitoring during construction stage, including specialists in field with authority to stop work.<br>3. All workers will undergo a briefing with the Archaeology Department to ensure safeguarding of heritage resource and cultural/religious practices.<br>4. A proof of compliance to this requirement to include the name of participants and date and location of briefing will form part of the monthly report to CMRL.<br>5. The project will implement, where required, chance finds procedure contained in ESS8 of WBG ESF. It includes requirement to notify relevant authorities; to fence-off the area of finds or sites to avoid further disturbance; to conduct an assessment of found objects or sites by cultural heritage experts; to identify and implement actions consistent with the requirements of this ESS and national law; and to train project personnel and project workers on chance find procedures. | Contractor | GC/ CMRL |
| | | Health & Safety | Noise and vibration generated during piling will affect the health and safety of the workers | 1. Auger piling methods will be used to reduce the impacts of noise. 2m tall screens of GI sheets will be installed between source (pile driver) and receptors (workers & nearby populations).<br>2. To reduce the harmful effects, personnel working at high noise levels would be provided with noise protective gears such as ear mufflers, sound barriers, job rotations per occupational exposure limits etc. | Contractor | GC/ CMRL |

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| | | | | 3. Procedure to receive, evaluate, and compensate (if applicable) damages due to construction and establishment of financial resources to cover this expense. | | |
| 22. | Excavation (The quantum of excavated soil will be about 0.61 lakh cubic meter) | Air | Excavation will result into fugitive dust generation. | 1. Fugitive dust could be controlled using water sprinkling. Water sprinkling to be carried out by Contract at regular interval (to be mutually decided by the contractor and CMRL). Surface runoff, wastewater from construction sites, construction yards and seawater will be used.<br>2. Imposition of speed controls for vehicles on unpaved site roads. Ten kilometers per hour is the recommended limit.<br>3. Every vehicle should be washed to remove any dusty materials from its body and wheels before leaving the construction sites. Used water shall be collected and re-used after settling in a settling basin or tank. Water for sprinkling and tire washing will be sourced from treated effluent from ETPs located nearby, seawater or surface runoff; use of municipal treated water shall be minimized. Groundwater will not be used.<br>4. Excavation machinery will be topped up by low-Sulphur fuel. | Contractor | GC/ CMRL |
| | | Noise and Vibration | Nuisance | 1. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures.<br>2. Use of low-noise equipment and ensuring good maintenance, and trying to avoid using high-noise equipment simultaneously at the same section.<br>3. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed.<br>4. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan.<br>5. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities.<br>6. Monitoring required during construction, including field observations and measurements.<br>7. Construction activities shall be scheduled such that demolition, earthmoving and ground-impacting operations do not occur in the same time period. At locations, where the alignment is close to sensitive structures, the contractor shall prepare a monitoring scheme prior to construction at such locations. In case of sensitive structures, vibration mitigation measures will be implemented. | Contractor | GC/ CMRL |

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| | | | | 8. Vibratory rollers near sensitive receptors shall be avoided.<br><br>9. The contractor should prepare a mitigation plan and implement the same during the final design and construction phase of the project. This scheme shall include:<br><br>a. Monitoring requirements for vibrations at regular intervals throughout the construction period;Pre-construction structural integrity inspections of sensitive structures.<br><br>b. Information dissemination about the construction method, probable effects, quality control measures and precautions to be used.<br>c. vibration monitoring plan during final design and the implementation of a compliance monitoring program during construction<br><br>10. Damping treatments, localized stiffening or mass addition at the receptors to reduce post -construction vibration. Wave-impleding blocks (WIP) , subgrade stiffening and wave barriers can be effective measures of interrupting the propagation of waves through the soil.<br><br>11.<br>12. Contractor to ensure that vibration levels at receptors comprising educational, medical and physical cultural buildings and other fragile buildings located within recommended screening distance of 62m (for cat. 2) on either side of alignment will not exceed 5.0 mm/s. | | |
| | | Surface water | Dumping of construction waste like concrete, bricks, waste material etc. cause surface water pollution. | 1. Proper drainage systems using contour information will be constructed around active and & large construction sites. After settling, it shall be discharged into public sewers; it will be treated by municipal agencies to Environment Protection Rules (EPR) 1986 Schedule VI standards of discharge of general effluents into surface water.<br><br>2. To avoid water pollution and soil erosion due to flooding, earthwork will be limited during monsoon season. | Contractor | GC/ CMRL |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
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| | | Groundwater | Dewatering (if done) will adversely affect the groundwater regime. | 1. Dewatering due to piling will be small in quantity. It will be done only when required Groundwater will be collected in sedimentation tanks and reused in non-potable uses. Refer to SHE (Addendum to this EIA report).<br>2. This water will be treated to meet General Standards of discharge for environmental pollutants Part A- Effluents, Schedule VI, Environmental Protection Rules 1986 before disposal into municipal sewage system or to recharge groundwater.<br>3. Groundwater monitoring, including groundwater quality and aquifer status. | Contractor | GC/ CMRL |
| | | Soil | Excavation will adversely affect the soil | 1. Soil erosion by runoff will be controlled by installing proper drainage systems using contour information It is suggested to avoid bringing soil from outside the project boundary and to use the excavated mounds for filling low lying area where it is necessary.<br>2. The topsoil should be preserved (by storing it at appropriate places) so that same can be restored after completion of work. | Contractor | GC/ CMRL |
| | | Physical Cultural Resources | Historic and cultural value loss<br>Conflicts with community | 1. Before start of excavation, Contractor and CMRL will coordinate with State Archaeological department to reconfirm that there is presence of buried artifacts along the metro line alignment. No excavation will be allowed unless cleared by the Archeological Department.<br>2. Archaeological monitoring during construction stage, including specialists in field with authority to stop work.<br>3. All workers will undergo a briefing with the Archaeology Department to ensure safeguarding of heritage resource and cultural/religious practices.<br>4. A proof of compliance to this requirement to include the name of participants and date and location of briefing will form part of the monthly report to CMRL.<br>5. The project will implement, where required, chance finds procedure contained in ESS8 of WBG ESF. It includes requirement to notify relevant authorities; to fence-off the area of finds or sites to avoid further disturbance; to conduct an assessment of found objects or sites by cultural heritage experts; to identify and implement actions consistent with the requirements of this ESS and national law; and to train project personnel and project workers on chance find procedures. | Contractor | GC/ CMRL |
| | | Health and Safety | Accidents | 1. To specify the number and length of shifts for each worker.<br>2. Where a site boundary adjoins roads, streets or other areas accessible to the public, hoarding should be provided along the entire length except for a site entrance or exit. | Contractor | GC/ CMRL |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
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| | | | | 3. If there is a reasonable likelihood of contamination, then a specific management plan that includes (a) monitoring during construction consisting of visual inspections, on-site and in-situ monitoring to detect and confirm levels of contamination (and supplemented as needed by laboratory analysis), (b) on-site temporary storage and treatment, (c) final disposal (both for water and soil), and (d) worker health and safety procedures. | | |
| | | Aesthetics | Temporary loss of aesthetics value due to excavation and related activities. | 1. The excavation sites will be barricaded on all sides using GI sheets. Hauling will be carried out in non-peak hours.<br>2. Aesthetic value of the site will be restored after completion of the works. | Contractor | GC/ CMRL |
| 23. | Hauling of excavated material | Air | During transportation of excavated material, fugitive dust will be generated from two sources, (1) from re-suspension of dust from road surface, (2) from the movement of air, against the excavated material being hauled | 1. The traffic management plan will be stringently implemented with regular monitoring and inspections.<br>2. The trucks/dumpers carrying the excavated material will be covered using tarpaulin/similar covering materials.<br>3. Sprinkling of water should be carried out.<br>4. Truck tires will be washed to excess remove soil clinging to it. Contractor will provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from construction depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt. Used water shall be collected and re-used after settling in a settling basin or tank.<br>5. Water for sprinkling and tire washing will be sourced from treated effluent from ETPs located nearby, seawater or surface runoff; use of municipal treated water shall be minimized. Groundwater will not be used in view of status in Chennai.<br>6. Haul roads will be kept in good state of maintenance. | Contractor | GC/ CMRL/ TNSPCB/ Traffic Police |
| | | Noise | Dumper trucks carrying excavated material will result into high noise (typically in excess of 85 dB (A) at one m distance, or 57 dB (A) at 10 m distance). The adverse impacts of noise will be most intense in the | 1. The routing, timing and logistics of the haul truck movement should be planned to have minimal impacts on noise level.<br>2. The route selection will avoid any sensitive receptors.<br>3. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures.<br>4. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed.<br>5. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan. | Contractor | GC/ CMRL |

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| | | | residential / urban areas. | 6. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities.<br>7. Monitoring required during construction, including field observations and measurements. | | |
| | | Social | Incessant movement of trucks could create social issues. | 1. The local community has to be taken into confidence before the construction commences. Their advice must be taken and incorporated in decision making.<br>2. Grievance Redress Mechanism for affected people should function effectively with grievance log well documented. | Contractor | GC/ CMRL |
| | | Health & Safety | The movement of trucks will increase the traffic risk of the commuters. | 1. The routing, timing and logistics of the haul truck movement should be planned to have minimal impact on occupational and community health and safety. | Contractor | GC/ CMRL |
| 24. | Dumping of excavated materials | Air | The dumping operation of excavated material will generate fugitive dust in the nearby areas | 1. Site of dumping will be selected in consultation with authorities.<br>2. The disposal plan will be stringently implemented with site monitoring and inspections.<br>3. It will be located outside of urban habitation.<br>4. Sprinkling of water should be carried out. Water shall be sourced from surface runoff, wastewater from construction sites, construction yards and seawater. Use of municipal treated water shall be minimized. Groundwater extraction shall be avoided. | Contractor | CMRL/ CMDA/ GCMC /TNSPCB |
| | | Soil | Dumping may increase the height of the land and affect the natural drainage pattern of the area | 1. The dumping will be done in pre-designated low lying areas identified by CMDA, SPCB, and CMRL for this specific purpose.<br>2. The disposal plan will be stringently implemented with regular monitoring and inspections.<br>3. Field inspections, monitoring, and documentation of dumping excavated materials. | Contractor | GC/ CMRL |
| 25. | Traffic diversion | Air | The under construction areas will be restricted for human and vehicular movements. This will result in detouring of vehicles and/or pedestrians, on the project line which | 1. Permission from Chennai Traffic Police will be sought before commencement of work. Detours will be properly planned and enacted during non-peak hours only, if possible. Traffic marshals will be posted near such detours. Proper signage has to be posted informing motorists about detours following IRC norms.<br>2. Adaptive management with field inspections and monitoring during plan implementation and adjustments, as needed, to reflect actual traffic congestion or related issues | Contractor | GC/ CMRL/ Traffic Police |

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| | | | passes through busy urban areas. This may also result into traffic congestion and air pollution from stagnated vehicles in urban areas. Primary pollutants will be NOx, CO, NMHC, and VOCs. | 3. The Contractor will discuss and coordinate the implementation of the traffic re-routing scheme particularly at station area when it starts the cut and cover activities and the hauling and disposal of excavated materials to the project sites. | | |
| | | Noise | Barricading & detouring may result into traffic congestion in the urban areas. This will result into (a) noise from vehicular movement and (b) honking noise due to congestion. | 1. Permission from Traffic police will be sought before commencement of work. Detours will be properly planned and enacted during non-peak hours only, if possible. Traffic marshals could be posted near busy intersections, to oversee the smooth flow of traffic.<br>2. Detour route selection to avoid sensitive receptors to noise.<br>3. Adaptive management with field inspections and monitoring during plan implementation and adjustments, as needed, to reflect actual traffic congestion or related issues. | Contractor | GC/ CMRL |
| | | Social | Traffic diversion (esp. for public transport) will create inconvenience | 1. Implement the traffic management plan. Plans will be made to spare traffic diversion during peak hours (morning and evening peaks). Also separate arrangements for bus, auto and taxi parking bays will be made. Street furniture for pedestrians will be provided wherever possible.<br>2. Real-time communication to public prior to site-specific work (for example, via signs, radio, and newspaper) and during key periods of traffic interference or peak traffic.<br>3. Adaptive management with field inspections and monitoring during plan implementation and adjustments, as needed, to reflect actual traffic congestion or related issues. | Contractor | GC/ CMRL |
| | | Resource consumption | Detouring will increase the road length to be travelled by a car, thus, increasing the overall fuel consumption. | 1. The detour will be planned to be optimum in terms of road length. The faster completion of works will also tend to reduce enhanced fuel consumption. | Contractor | GC/ CMRL |

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| 26. | Restricted pedestrian movement | Social | Restricted pedestrian movement will cause social uproar, esp. in people living near metro stations | 1. Safe passage for pedestrians with proper sunshade / fall protection and signage will be planned. Public consensus will be built. Representatives of non-governmental organisations and volunteers from local communities at respective sections of the project shall be invited to participate in meetings with CMRL, GC, and Traffic Police where joint decision on diversion measures will be arrived at.<br>2. Grievance Redress Mechanism for affected people should function effectively with grievance log well documented. | Contractor | GC/ CMRL |
| | | Health & Safety | Movement though constricted space may cause potential health & safety issues amongst pedestrians | 1. Movement through construction area shall be prohibited.<br>2. Safe passage for pedestrians with proper fall protection and signage will be planned. This applies to movement along existing roads on which elevated metro is constructed. It is clarified that their movement through construction areas shall be prohibited. | Contractor | GC/ CMRL |
| 27. | C&D waste (muck) generation & disposal (incl. spent Bentonite & drill fluid and slurry) | Surface water | Muck generated incl. spent Bentonite & slurry from auger drilling operations will drain with surface runoff and pollute nearby water bodies | 1. Muck disposal plan will be stringently implemented with regular monitoring and inspections.<br>2. The construction sites will be provided with garland drains with intercepting pits to trap silt & muck.<br>3. Muck will be stored in lined tanks / ponds. Such tank/ ponds could be covered during monsoon to control runoff.<br>4. The temporary muck storage areas will be maintained by the Contractor at all times until the excavate is re-utilized for backfilling or disposed of as directed by Employer. Dust control activities will continue even during any work stoppage<br>5. Transportation of muck will be scheduled by time and route to minimize air pollution in habitat areas. | Contractor | GC/ CMRL |
| | | Groundwater | Muck, spent bentonite & drill fluids may settle down from pond / tanks and will affect groundwater | 1. The tanks/ ponds holding muck will be lined to prevent infiltration into groundwater. It will be passed through settling chambers and discharged into public sewers; it will be treated by municipal agencies to Environment Protection Rules (EPR) 1986 Schedule VI standards of discharge of general effluents into surface water. Upon discharge of general wastewater into municipal sewers by CMRL, the municipal agencies are required by law to treat it appropriately before disposal. CMRL shall duly consult with the agencies before start of construction.<br>2. Groundwater quality monitoring before, during and after the use of muck tanks/ponds. | Contractor | GC/ CMRL |
| | | Aesthetics | Muck generation will create an aesthetic issue | 1. The construction site will be covered from all sides to reduce visual impacts. | Contractor | GC/ CMRL |

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| 28. | Steel structure preparation | Soil | Steel structure preparation will create steel scraps | 1. Steel scrap will be collected, sorted by diameter and sold to scrap dealers on alter date. | Contractor | GC/ CMRL |
| | | Health & safety | Bar bending & other activities (inc. working at heights) might pose a H&S threat to workers | 1. Workers will be provided appropriate hand gloves and other personal protective equipment (PPE) such as fall protection when working at height.<br>2. Skilled workers working at height or doing hot work will be required to seek permission from site | Contractor | GC/ CMRL |
| 29. | Stacking & warehousing of raw material | Surface water | Washed out raw material could pose serious threat to surface water bodies | 1. Small dikes and garlanding drains along the periphery of the yard and ploy boundary could be constructed. This will control runoff and washing out of finer material. | Contractor | GC/ CMRL |
| | | Soil | Spillage of materials / mix products on the ground could pollute soil | 1. Proper care will be taken. Such spills will be cleared by scraping and disposing the products as road sub-grade material. | Contractor | GC/ CMRL |
| | | Health & Safety | Fine products like cement/ silt/ sand could cause harm to respiratory system. | 1. Cement and sand will be stacked under tarpaulin and secured by GI sheet barricading (working & wind break). Shorter work shift and daily medical checkups of workers will be implemented.<br>2. Dust filters atop cement silos, wet suppression for aggregate crushing and screening will be employed. | Contractor | GC/ CMRL |
| | | Aesthetics | Stacking of raw material will cause aesthetic issues for residential areas located nearby | 1. The height of walls between the residential area and RM yard / construction area will be raised using GI sheets. | Contractor | GC/ CMRL |
| 30. | RCC pouring (using concrete pump) | Noise | RCC pouring using concrete pump will generate low frequency rumbling noise. This will be more | 1. Timing of using RCC pumps will be planned and specified by the Engineer.<br>2. RCC pumps will be covered from all sides.<br>3. Bends and excessive head will be avoided.<br>4. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. | Contractor | GC/ CMRL |

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| | | | perceived and irritating in residential areas. | | | |
| | | Soil | Spillage from concrete pouring may contaminate soil | 1. The spoils from pouring concrete will be collected and reused as sub-grade material in road constriction. | Contractor | GC/ CMRL |
| | | Aesthetics | Spoils from concrete pouring will create unpleasant looking visuals | 1. After each pouring cycle, the spoils will be manually collected and reused as sub-grade material in road constriction. | Contractor | GC/ CMRL |
| 31. | Setting of concrete (using needle vibrator) | Noise | Needle vibrators generate low frequency noise when dipped in concrete and high frequency noise when raised. Sound level varies between 82-93 dB (A). | 1. If the consistency of concrete could be altered, the need for use of vibrator (esp. in low temperature & low thickness casting) could be reduced. Damping could be used to reduce high frequency noise, and thereby reducing the noise levels. Workers should be provided with suitable PPEs.<br>2. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. | Contractor | GC/ CMRL |
| | | Soil | During setting, spillage from cast could take place. | 1. The spoils from pouring concrete will be collected and reused as sub-grade material in road construction. | Contractor | GC/ CMRL |
| 32. | Curing of concrete (use of water) | Surface water | Curing water will drain to the low lying areas and pollute water courses | 1. Garland drainage is proposed to be constructed around the construction yard. This will intercept the runoff generated from site.<br>2. After settling it shall be discharged into public sewers; it will be treated by municipal agencies to Environment Protection Rules (EPR) 1986 Schedule VI standards of discharge of general effluents into surface water.<br>3. Curing needs will be met from municipal supply, water resulting from dewatering during piling and surface runoff water.<br>4. Rainwater harvesting (as a compensatory measure) will be practiced. | Contractor | GC/ CMRL |
| | | Groundwater | Curing water will drain to the low lying areas | 1. In view of recent lowering of groundwater levels w,r,t results of DPR investigations, and risk of saline water ingress due to the proximity of sea coast, use of groundwater will not be resorted to. | Contractor | GC/ CMRL |

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| | | | and pollute water courses | | | |
| | | Aesthetics | Curing will create water impounding and may lead to vector propagation | 1. Garlanding drain will be constructed around the construction area. The curing water impounded will be reused for curing. | Contractor | GC/ CMRL |
| 33. | Use of Crane & Launchers | Noise | Operation of launchers and crane will generate noise which in times may go up to 85-90 dB (A). Legris& Poulin has found that the average daily noise exposure was approx. 84 to 99 dB (A) for heavy equipment, and 74 to 97 dB (A) for the crane operators. | 1. The sensitive receptors (workers & external parties, if applicable) have to be isolated from heavy construction noise generated. This is possible by erecting reinforced 2 m tall GI sheet barrier around the area where heavy construction works is undertaken.<br>2. Workers working inside or near construction equipment should be provided with proper PPEs like ear plugs / muffs complying with IS 4869.<br>3. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed.<br>4. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan.<br>5. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities. | Contractor | GC/ CMRL |
| | | Health & Safety | Cranes and launchers are a major safety concern. | 1. As per SHE, operation of launchers and cranes should be only done under the strict supervision of a qualified engineer and a safety supervisor. Only qualified & trained crane/ launcher operators should be allowed. Proper examination of crane, launchers, labours & operators must take place before commencement of work. | Contractor | GC/ CMRL |
| 34. | Construction of labour camp(s) and associated environmental issues | Surface water | Sewage from labour camps may be discharged into open slopes thus contaminating surface water | 2. Labour camps will be constructed in semi urban / urban set-ups. Sewage shall be discharged into public sewers; it will be treated by municipal agencies to Environment Protection Rules (EPR) 1986 Schedule VI standards of discharge of general effluents into surface water. | Contractor | GC/ CMRL |

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| | | Groundwater | Surface water on flat terrain could percolate and contaminate groundwater. | 1. Contractor to collect the groundwater baseline date prior to construction.<br>2. Disposal in compliance with applicable regulatory requirements.<br>3. Groundwater quality monitoring.<br>4. Water abstracted must be measured/ recorded periodically.<br>5. After Construction, Contractor will conduct groundwater analysis and be obliged to reinstate the used sites no worse than the conditions of pre-construction. | Contractor | GC/ CMRL |
| | | Soil | Solid waste generated from the labour camps will cause soil pollution | 1. Contractor to collect the soil baseline date prior to construction.<br>2. Municipal solid waste will be collected and taken away and disposed by municipality.<br>3. Solid waste will have to be disposed in compliance with Municipal Solid Waste (Management & Handling) Rules, 2000, as amended to date.<br>4. After Construction, Contractor will conduct soil analysis and be obliged to reinstate the used sites no worse than the conditions of pre-construction. | Contractor | GC/ CMRL |
| | | Social | Influx of non-local labours will create a social issue | 1. Mixing of skilled non-local labours with local unskilled people will reduce social frictions.<br>2. To avoid labor influx risk, sensitizing of local community and the non-local workers separately as well as jointly will be done regularly. | Contractor | GC/ CMRL |
| | | Health & safety | Living in congested condition, make-shift temporary arrangement; the labours are prone to diseases. | 1. Regular counselling, medical checkups and treatment at separate clinics, coordination with local health authorities will be conducted.<br>2. Per Building & Other Construction Workers (BOCW Regulation of Employment and Conditions of Service) Act, 1996 the employer (contractor) is liable to arrange for sanitation, health care facilities of labourers, free of charge. Labour camps will be in full compliance of BOCW Act.<br>3. Covid-19 protocols for construction forming part of the Environmental Social Health and Safety Requirements shall be fine-tuned to be adopted for labour camps; camp residents shall be trained and informed of precautions such as social distancing, sanitizing, avoiding groups; arrangements for thermal scanners; provision of sanitisers, face masks, gloves; record of Covid-19 hospitals; protected ambulances at camp; daily disinfection of site, equipment and camp. | Contractor | GC/ CMRL |
| | | Resources | Labours will consume resources like wood for cooking | 1. Liquid petroleum Gas cylinders will be made available free of cost to the labourers by the Contractor.<br>2. Labour camps are provided with canteen systems. They shall be provided with treated water suitable for drinking, bathing and other needs. | Contractor | GC/ CMRL |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| 35. | Loading /unloading of construction material | Air | Loading & unloading of construction material will generate fugitive dust | 1. The traffic management plan will be stringently implemented with regular monitoring and inspections.<br>2. The trucks/dumpers carrying the material will be covered using tarpaulin/similar covering materials.<br>3. Fugitive dust could be controlled using water sprinkling. Contractors should carry out water sprinkling.<br>4. Truck tires will be washed to excess remove soil clinging to it. Contractor will provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from construction depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt. Used water shall be collected and re-used after settling in a settling basin or tank.<br>**5.** Water for sprinkling and tire washing will be sourced from treated effluent from ETPs located nearby, seawater or surface runoff. | Contractor | GC/ CMRL |
| | | Noise | Loading & unloading of construction material will generate noise | 1. The RM storage yard will be separately built and enclosed from all sides. This will reduce noise generation at site.<br>2. Concrete preparation will only take place in casting yards (away from habitation).<br>3. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed.<br>4. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan.<br>5. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities. | Contractor | GC/ CMRL |
| | | Health & safety | Fugitive dust and noise generation will have potential health & Safety implications. | 1. Cement and sand will be stacked under tarpaulin and secured by GI sheet barricading (working & wind break). Shorter work shifts and regular health checkups will be implemented. The RM storage yard will be separately built and enclosed from all sides. The worker will be provided with suitable PPEs. Also they will be trained and encouraged in using PPEs. | Contractor | GC/ CMRL |
| 36. | Use of batching plant | Air | Loading & unloading of construction material into batching plant will generate fugitive dust | 1. High GI sheet screens and water sprinkling will be employed.<br>2. Batching plant / casting yard shall be barricaded and made as a compulsory PPE zone. This will effectively reduce the fugitive dust generation. | Contractor | GC/ CMRL |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | | Noise | Operation of batching plant will generate noise | 1. GI sheet barricading around batching area and worker PPE like ear muffs will be used.<br>2. Batching plant / casting yard shall be barricaded and made as a compulsory PPE zone. This will reduce the impacts of noise generation.<br>3. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. | Contractor | GC/ CMRL |
| | | Soil and Groundwater | Runoff of waste can contaminate soil and groundwater | 1. Contractor to collect baseline soil and groundwater quality data prior to operate the plants.<br>2. Municipal water will be used. In view of fragile groundwater status, extraction will be avoided.<br>3. The construction sites will be provided with drains with intercepting pits in which the cement and sand will settle. After settling it shall be discharged into public sewers; it will be treated by municipal agencies to Environment Protection Rules (EPR) 1986 Schedule VI standards of discharge of general effluents into surface water.<br>4. Soil and Groundwater quality monitoring.<br>5. After Construction, Contractor will conduct soil and groundwater analysis and be obliged to reinstate the used sites no worse than the conditions of pre-construction. | Contractor | GC/ CMRL |
| | | Hazardous waste | Health impacts and soil and groundwater pollution from hazardous water at batching/casting yards | 1. The use and storage of hazardous materials at the casting yard and batching plant should adhere to SPCB requirements.<br>2. The transport, handling and storage of hazardous waste will be done in accordance with the provisions of Hazardous and Other Wastes (Management and Transboundary Movement) Amendment Rules 2019. Hazardous wastes from construction activity and equipment are labeled, recorded, stored in impermeable containment and for periods not exceeding mandated periods and in a manner suitable for handling storage and transport.<br>3. The contractor shall maintain a record of sale, transfer, storage of hazardous waste and make these records available for inspection.<br>4. The contractor shall get Authorized Recyclers to transport and dispose Hazardous Waste.<br>5. Proper collection and storage facilities will be provided especially for hazardous waste. | Contractor | GC/ CMRL |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | | Resources | If the batching plant will get its power from DG sets, substantial diesel will be consumed.<br>(A 30 m3/hr. batching plant will require approx. 60 KW/hr. (or, approx. 75 KVA, assuming PF = 0.8) energy. In most cases the Contractor has used DG sets (from 100 – 250 kVA) for batching plant & ancillary facilities. Thus, the diesel req. will range from 30 - 45L/hr, at 100% load) | 1. As a primary source, power from the grid shall be used with prior permission from power supply company obtained by the Contractor.<br>2. DG sets, if used, should: (a) conform to height of stack norms as per CPCB rules; (b) conform to emission norms as per E (P) Act, 1986; (c) noise level at 1 m distance from enclosure should not be >75 dB(A).<br>3. The required permissions from local Environmental Authorities/Pollution Control Board/ CEIG or any other relevant Authority shall be obtained by the Contractor for using DG sets for power supply.<br>4. Diesel storage if done beyond threshold limit (1000 L) permission should be obtained from Chief Controller of Explosives. Diesel should be stored on pukka platforms and spillages should be avoided.<br>5. Refer to Activity 42 “Use of DG sets” and Activity 44 “Storage of Diesel” for further measures. | Contractor | GC/ CMRL |
| 37. | Casting of segments and I-beams | Groundwater | Casting will require use of water | 1. Municipal water will be used. In view of fragile groundwater status, extraction will be avoided. The construction sites will be provided with drains with intercepting pits in which the cement and sand will settle. After settling it shall be discharged into public sewers; it will be treated by municipal agencies to Environment Protection Rules (EPR) 1986 Schedule VI standards of discharge of general effluents into surface water.<br>2. Groundwater quality monitoring. | Contractor | GC/ CMRL |
| | | Resources | Casting (incl. operation of gantry and hydraulic pre-stressing units) will consume lot of energy | 1. Pre-stressing and casting are basic requirements. However, whenever possible of the power should be drawn from approved lines, not from DG sets. | Contractor | GC/ CMRL |
| 38. | Curing of segments & I-beams | Groundwater | Curing will require a significant amount of water | 1. Garland drainage is proposed to be constructed around the construction yard. This will intercept the runoff generated from site. Stagnation of water (and resultant vector propagation) should be avoided.<br>2. Groundwater quality monitoring. | Contractor | GC/ CMRL |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | | | | 3. After precipitation, it shall be discharged into public sewers; it will be treated by municipal agencies to EPR 1986 standards of discharge of general effluents into surface water.<br>4. Groundwater will not be used. Water will be sourced from municipal supply, surface runoff or water from dewatering. | | |
| 39. | Hauling of segments to site | Air | During transportation of segments, fugitive dust will be generated from re-suspension of dust from road surface. Plus, there will be air emission from trucks | 1. The traffic management plan will be stringently implemented with regular monitoring and inspections.<br>2. Sprinkling of water should be carried out.<br>3. Truck tires will be washed to excess remove soil clinging to it. Contractor will provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from construction depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt. Used water shall be collected and re-used after settling in a settling basin or tank.<br>4. Water for sprinkling and tire washing will be sourced from treated effluent from ETPs located nearby, seawater or surface runoff.<br>5. Haul roads will be kept in good state of maintenance. | Contractor | GC/ CMRL |
| | | Noise | Trucks carrying segments will result into high noise (typically in excess of 85 dB(A) at1 m distance, or 57 dB(A) at 10 m distance). The adverse impacts of noise will be most intense in the residential/urban areas | 1. The routing, timing and logistics of the haul truck movement should be planned to have minimal impacts on noise level. The route selection will avoid any sensitive receptors.<br>2. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures.<br>3. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed.<br>4. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan.<br>5. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities.<br>6. Monitoring required during construction, including field observations and measurements. | Contractor | GC/ CMRL |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | | Social | Incessant movement of trucks could create social issues | 1. The local community has to be taken into confidence before the construction commences. Their advice has to be taken and incorporated in decision making.<br>2. Grievance Redress Mechanism for affected people should function effectively with grievance log well documented. | Contractor | GC/ CMRL |
| | | Health & safety | The movement of trucks will increase the traffic risk of the commuters | 1. The routing, timing and logistics of the haul truck movement will be planned to have minimal impacts on occupational and community health and safety. | Contractor | GC/ CMRL |
| | | Aesthetics | Movement of trucks will create an aesthetic problem | 1. Proper housekeeping activities have to be undertaken near the casting yard and nearby areas. | Contractor | GC/ CMRL |
| 40. | Use of DG sets | Air | Emission of $NO_x$, $SO_x$, CO, $PM_{10}$, $PM_{2.5}$ from DG sets will create air pollution problems | 1. Primary power source will be power distribution company, DG sets will be used only for power back-ups for stations.<br>2. The required permissions from local Environmental Authorities/Pollution Control Board/ CEIG or any other relevant Authority shall be obtained by the Contractor if using DG sets for power supply. DG sets compliant with CPCB norms will be used. Specification no. GSR 520(E) dt. 1-7-2003 for DG sets rating < 800 KW, and GSR 489(E) dt. 09-07-2002 for DG sets > 800 KW under E (P) Rules, 1986.<br>3. Stack height of DG sets will be as per CPCB requirement [stack ht. = 0.2*(rating in kVA)0.5]<br>4. Stack monitoring will be conducted monthly of the criteria pollutants.<br>5. Compliance monitoring will be done to the regularly and check the monitoring instruments.<br>6. Fuels used for DG will be High Speed Diesel with low-sulfur content. | Contractor | GC/ CMRL |
| | | Noise & Vibration | Noise & vibration will be generated from the use of DG sets | 1. DG sets compliant with CPCB norms will be used.<br>2. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed.<br>3. Monitoring required during construction, including field observations and measurements.<br>4. DG sets will be enclosed type, with noise levels approx. 75 dB (A) at a distance of 1m in compliance with GSR 371(E) dt. 17-05-2002.<br>5. Noise will be controlled using acoustic enclosure.<br>6. The DG sets will be mounted on damping skids, which will reduce the vibration generated from DG sets. | Contractor | GC/ CMRL |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | | Resources | DG sets will consume Diesel (and in effect reduce the levels of a non-renewable resource) | 1. DG sets should always be use as a power back up, and not the primary sources of power. This should be made mandatory for all Contractors.<br>2. Refer to Activity 42 “Storage of Diesel” for further measures. | Contractor | GC/ CMRL |
| | | Aesthetics | Operation of DG sets will cause an aesthetic issue | 1. Enclosures will be used to keep them off from public views.<br>2. PM content of DG sets smoke will be as pert the CPCB norms, thus the DG will emit dark smokes only during start-up & shut-down (b) Noise will be controlled using acoustic enclosure. | Contractor | GC/ CMRL |
| 41. | All Construction Activities | Environment | Construction and Demolition (C&D) waste results from land clearing, excavation, construction, demolition, remodeling and repair of structures, roads and utilities | 1. Records of movement and loading/unloading of C&D waste and records of waste loaded by vendors.<br>2. C&D waste will be reused/recycled as it has the potential to save natural resources (stone, river sand, soil etc.) and energy. C&D waste generated from metro construction has potential use after processing and grading.<br>3. The contractor will segregate and temporarily store the C&D waste till the vendor takes it away for recycling and disposal at authorized facilities.<br>4. Contractor will adhere with the C&D Waste Management Rules. | Contractor | GC/ CMRL |
| | | Occupational Health and Safety | Accidents<br>All parties’ reputation | 1. Worker safety is important on all construction projects. It is important to consider the effects of staffing on worker safety and to provide appropriate training in safety awareness for all labor.<br>2. The use of hearing protection should be enforced actively when the equivalent sound level over 8 hours reaches 85 dB(A), the peak sound levels reach 140 dB(C), or the average maximum sound level reaches 110dB(A). Hearing protective devices provided should be capable of reducing sound levels at the ear to at least 85 dB(A). | Contractor | GC/ CMRL |
| 42. | Storage of Diesel | Groundwater | Diesel spillage (from underground or above ground storage facility) will affect groundwater quality adversely | 1. Before it percolates into the groundwater, contaminated runoff water can be run through adsorbents such as bentonite to remove the diesel. The diesel will be quickly collected into steel trays and disposed to authorized recyclers.<br>2. All bulk diesel tanks shall be properly supported in an elevated position to facilitate gravity discharge. They shall stand within a bund constructed to contain a volume of110% of the volume of the tank. There shall be no breaches in the bund wall, no material shall be stored within the bund and rain water collecting in the bund shall be regularly removed to prevent build-up. | Contractor | GC/ CMRL |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | | | | 3. Spillage will be controlled using methods mentioned in the environmental contingency plan, to be included in the emergency response plan.<br>4. Groundwater quality monitoring before installation of the tanks and after demobilization. | | |
| | | Health & safety | Storage of Diesel will attract the provisions of Hazardous Chemicals (Management & Handling) Rules and Petroleum Rules; as amended to date. It could cause serious damage to health & safety of workers / property if ignited | 1. Proper onsite emergency plan will be prepared and will be approved through CMRL.<br>2. If the diesel storage crosses the threshold limits permissions, proper fire protection norms have to be undertaken as per National Building Code, 2005 (if building)/ Oil Industry Safety Directorate Standard 117 (if installation). | Contractor | GC/ CMRL |
| 43. | Cleanup Operations, Restoration and Rehabilitation | Environment | Aesthetics | 1. The clean-up and restoration operations are to be implemented by the Contractor prior to demobilization. All spaces excavated and not occupied by the foundation or other permanent works shall be refilled with earth up to surface of surrounding ground. | Contractor | GC/ CMRL |
| **Operational Phase** | | | | | | |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
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| | | | | | Implementation | Supervision |
| 44. | Operation of metro trains | Noise and Vibration | The most significant source of noise will be rolling noise from contact between wheel and rail including noise from contact between the brake pad and wheel, followed by engine noise and aerodynamic noise. | 1. To minimize operation stage impacts measures such as Ballast less track structure is supported on two layers of rubber pads to reduce noise and vibrations. In addition, baffle wall as parapets will be constructed up to the rail level so as reduce sound levels. Noise at source will be controlled or reduced by incorporating suitable feature in the design of structures and layout of machines and by use of resilient mounting and dampers etc.<br>2. Since the rakes will be air conditioned and enclosed from all side, the impacts of noise on the travelers will be nominal.<br>3. Noise barriers will be installed at locations based on final design noise prediction analysis.<br>4. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. If baseline noise is below the CPCB and IFC-EHS standards, the operation noise has to meet these standards that is, operation noise level has to be less than level prescribed in these standards.<br>5. The mitigations suggested based on the detailed noise and vibration analysis carried out prior to commencement of construction, should be strictly followed.<br>6. Detailed vibration modeling is needed if sensitive receptors are located within the reported distances from the track in order to determine if the negative impacts can be fully mitigated through the following mitigation measures:<br>a. Ballasted tie-welded track with elastic steel fastenings and plastic or rubber absorbing pad will reduce noise and vibration levels. Surface irregularities on the wheel and rail will be minimized by good maintenance of wheel and rail condition.<br>b. Elastic pad between seat of the rail and the track slab as well as between track slab and the superstructure beneath it will reduce vibration will be installed to reduce transmission of vibration from the track and superstructure.<br>c. Using floating slab and high resilience fasteners to reduce the vibration at the point of emission.<br>7. Vibration monitoring and building condition surveys is required to determine if there are negative impacts and annoyance post mitigation implementation.<br>8. In cases, especially at the Royapettah Government Hospital,additional mitigation measures shall be provided to ensure that vibration and annoyance impacts are below the threshold criteria. | CMRL | GoTN |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | | Health and Safety | Accidents<br>Reputational risks | 1. Detailed specification of equipment e.g. power cables, rectifiers, transformer, E&M equipment etc. shall be framed to reduce conducted or radiated emissions as per appropriate international standards.<br>2. The Metro system as a complete vehicle (trains, signaling & telecommunication, traction power supply, E&M system etc.) shall comply with the Electromagnetic compatibility (EMC) requirements of international standards viz. EN50121-3-1, EN50123, IEC61000 series etc. EMC requirements of international standards for whole railway system to the outside world shall comply with EN50121-2.<br>3. Automatic Train Protection and Automatic Train Supervision sub-systems will be installed to provide a high level of safety.<br>4. CCTV system will be installed for local and centralized monitor of operation.<br>5. In view of the potential hazards from system failure resulting to accidents, both on- site and off-site emergency measures will be implemented. All trains will have public address systems to warn the passengers of any emergency.<br>6. Emergency team, ambulance, contact number and hospital should be available. Emergency response plan should be implemented during operation periods. | CMRL | GoTN |
| | | | Operating Personnel Health risks | 1. Operating staff such as drivers and Control Centre staff shall be administered regular medical checkups for musculo-skeletal disorders, fatigue, eye strain.<br>2. Well designed workstations, lighting in Control Centre.<br>3. Emotional resilience training, counselling for recovery and rehabilitation. | CMRL | GoTN |
| | | Health of metro staff and commuters | Severely contagious diseases such as Covid-19 can impact health of staff thereby affecting operations; can cause economic loss to the country and loss of reputation to the project. | Chennai Metro COVID-19 SOP shall be implemented; staff shall be trained; staff and commuters shall be informed of precautions such as social distancing, sanitizing; arrangements for stationary and hand-held thermal scanners; provision of sanitizer pedestals, vending machines of face masks and gloves etc shal be provided in stations; site record of Covid-19 hospitals; daily disinfection of operating rooms, circulation spaces, equipment and vehicles; protected ambulances at stations. | CMRL | GoTN |
| | | Aesthetics | Metro rail will increase the aesthetics of Chennai | 4. A proper housekeeping routine will be followed to enhance the aesthetics of metro rail station. | CMRL | GoTN |
| 45. | Track repair | Environment | Spill accidents | 1. CMRL to ensure no illegal disposal of solid waste or wastewater. | CMRL | GoTN |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| 46. | Use of DG sets | Air | Emission from DG sets will create air pollution problems | 1. DG sets compliant with CPCB norms will be used. Monitoring of air quality shall be done as per CPCB norms. Compliance monitoring will be undertaken as specified in the EMoP.<br>2. Fuel used for DG sets will have a low-sulfur content | CMRL | GoTN |
| | | Noise & Vibration | Noise & vibration will be generated from the use of DG sets | 1. DG sets compliant with CPCB norms will be used.<br>2. Noise enclosures will be used and will be in compliance with GSR 371(E) dt. 17-05-2002.<br>3. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. If baseline noise is below the CPCB and IFC-EHS standards, the operation noise has to meet these standards that is, noise level has to be less than level prescribed in these standards.<br>4. The DG sets will be mounted on damping skids, which will reduce the vibration generated from the use of the DG sets | CMRL | GoTN |
| | | Groundwater | Diesel spillage (from underground or above ground storage facility) will affect groundwater quality adversely | 1. Storage of diesel shall be done in designated areas paved with concrete floors and with an arrangement of oil interceptors to prevent oil entering the groundwater.<br>2. Precautions shall be taken to avoid any spillage of diesel.<br>3. Oil that is mixed in water will be removed in the ETP operated by municipal authorities to EPR 1986 standards before disposal into surface or ground waters. | CMRL | GoTN |
| | | Health & safety | Storage of Diesel will attract the provisions of Hazardous Chemicals (Management & Handling) Rules and Petroleum Rules; as amended to date. It could cause serious damage to health & safety of workers / property if ignited | 1. Diesel should be stored in designated sites prior to final disposal.<br>2. If the diesel storage crosses the threshold limits permissions from Chief Controller of Explosives (CCoE), proper fire protection norms shall be undertaken as per National Building Code, 2005.<br>3. Proper onsite emergency plan will be prepared by GC and will be approved through CMRL. | CMRL | GoTN |
| | | Resources | DG sets will consume Diesel (and in effect reduce the levels of a | 1. DG sets compliant with CPCB norms will be used only as backup. | CMRL | GoTN |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| | | | non-renewable resource) | | | |
| | | Aesthetics | Operation of DG sets will cause an aesthetic issue | 1. Enclosures will be used. | CMRL | GoTN |
| 47. | Development of feeder routes | Social | Along with Metro routes, metro feeder routes will be developed. This will have a positive impact in terms of enhanced connectivity and inclusion in the social mainstream | 1. CMRL will work with bus operators to implement metro feeder routes along major arterial and sub-arterial routes to reduce travel time to the nearest station. Better quality coaches & comfortable rides should be planned to enhance acceptability. | CMRL / GoTN | GoTN |
| | | Health & safety | Better & frequent transport system will reduce risk of traffic accidents | 1. The new feeder routes should (a) follow proper timetable; (b) should have frequent services during the morning & evening peak;(c) should have a limited carrying capacity. The feeder buses should arrive and depart from designated bus bays or similar structures. Proper arrangements for road crossing should be established. The appointed personnel should assist passengers to reach their destinations. An easily accessible grievance redressal system should be established by CMRL. | CMRL | GoTN |
| | | Aesthetics | Better designed coaches will enhance ride pleasure and aesthetics | 1. The buses should be properly maintained from time to time in order to enhance the aesthetic value. | CMRL | GoTN |
| 48. | Generation of employment | Social | The proposed project will result into generation of employment | 1. The project will cause direct and indirect employment generation. Economic activity will be stimulated by easier movement of passengers thus leading to indirect employment generation. | CMRL | GoTN |

| Sl. No. | Activity | Aspect /Parameter affected | Impact | Mitigation measures | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| 49. | Ancillary development along metro route | Land | Ancillary developments will take place along with metro corridor | 1. Provision for increased density of development along project corridor is available through existing byelaws as well as new ToD norms. Mixed land use of ToD tends to reduce non-work trip length and its higher density promotes increased use of metro for work trips on long distances.<br>2. Implementation of increased densities is decided by State Government and managed by CMDA in accordance with demand. | CMRL | GoTN |
| | | Social | Ancillary development along the metro alignment will have positive effect on the social environment | 1. There should be positive participation of the common people in the ancillary development process. An open, transparent & people-centric outlook has to be adopted. | CMRL | GoTN |

**Table 9-4: Environmental Monitoring Plan of MDB Corridor 3**

| Environmental Features | Aspect to be Monitored | Standard to be complied with | Time and Frequency of Monitoring | Location | Estimated cost (USD) |
|---|---|---|---|---|---|
| **Pre-Construction stage** | | | | | |
| Air | Emission of dust and particulate matter as PM2.5 and PM10, NOx and SOx, CO | GoI and WHO/IFC whichever stringent | Once, 24 hours continuously | Each station, batching plant and casting yard, Muck disposal site | 2,000 |
| Water (Surface and Ground) | DO, Turbidity, Conductivity, pH, Heavy metals, E.Coli, TSS, Oil and Grease, VOCs and Volatile Chlorinated Hydrocarbons (groundwater only) and TDS | GoI and WHO/IFC whichever stringent | Once, 3 samples each location | Groundwater at batching plant and casting yard, Muck disposal site, construction camps and 10 excavation sites<br>Surface water at wherever waterbody located within 100m from sites | 4,800 |
| Soil | pH, Sulphate (SO3), Chloride, ORP, water Soluble salts EC, Organic Matter (Mineral Oil (GC)), Heavy metals, Poly-Aromatic Hydrocarbons (PAH), Moisture Content | GoI and WHO/IFC whichever stringent | Once, 3 samples each location | At batching plant and casting yard, Muck disposal site, construction camps and 10 excavation sites | 4,200 |
| a) Noise & vibration<br>b) Building condition survey | Noise levels in dB(A)<br>Vibration PPV mm/s<br>Building condition survey | GoI and WHO/IFC whichever stringent<br>Federal Transit Administration (FTA) Guideline Standards or any other internally recognized standards | a) Once<br>Hourly basis for 24 hours (noise & vibration)<br>b) Building Condition Survey: height measurements, crack survey, detailed photographic records etc. | a) At key structure locations,<br>b) At receptors comprising educational, medical and physical cultural buildings and other fragile buildings located within recommended screening distance of 62m (for cat. 2) on either side of alignment. | a) 8,187<br>b) To be decided during pre-bid joint site visit of CMRL & Contractor and cost included in bid |
| Sub-total | | | | | 19,187 |
| **Construction stage** | | | | | |
| Air | Emission of dust and particulate matter as PM2.5 and PM10, NOx and SOx, CO | GoI and WHO/IFC whichever stringent | 24 hours continuously every month | For each station until civil works completed<br>batching plant and casting yard, Muck disposal site, throughout construction phase | 44,800 |

| Environmental Features | Aspect to be Monitored | Standard to be complied with | Time and Frequency of Monitoring | Location | Estimated cost (USD) |
|---|---|---|---|---|---|
| Water (Surface and Ground) | DO, Turbidity, Conductivity, pH, Heavy metals, TN, TP, E.Coli, TSS, Oil and Grease, VOCs (groundwater only) and TDS | GoI and WHO/IFC whichever stringent | Quarterly, 3 samples each location | Groundwater at batching plant and casting yard, Muck disposal site, construction camps throughout construction phase, and excavation sites stations until civil works completed<br>Surface water at wherever waterbody located within 100m from sites | 33.600 |
| Soil | PH, Sulphate (SO3), Chloride, ORP, water Soluble salts EC, Organic Matter (Oil), Heavy metals, PAH, Moisture Content | GoI and WHO/IFC whichever stringent | a) Quarterly, 3 samples each location | a) At batching plant and casting yard, Muck disposal site, construction camps throughout construction phase<br>b) 10 excavation sites-once during construction, once post-construction | 35,400 |
| a) Noise,<br>b) Vibration<br>c) Building Condition Survey | a) Noise levels in dB(A)<br>b) Vibration PPV mm/s<br>c) Building Condition Survey | GoI and WHO/IFC whichever stringent<br>Federal Transit Administration (FTA) Guideline Standards or any other internally recognized standards | a) Monthly or when complaint is received<br>Hourly basis for 24 hrs (noise)<br>b) Continuous monitoring during piling (vibration)<br>c) Building Condition Survey: crack sensors, tilt sensors, continuous height measurement etc. | a) and b) Key structure locations<br>c) at receptors comprising educational, medical and physical cultural buildings and other fragile buildings located within recommended screening distance of 62m (for cat. 2) on either side of alignment. The vibration survey has been done during pre-construction stage. Any structures identified to be at risk need to be monitored during construction. | a) & b) 9,280<br>c) To be decided during pre-bid joint site visit of CMRL & Contractor and cost included in bid |
| Occupational and Community Health and Safety | As specified in project ESHS plan prepared by Contractor<br>Sub-section F of Section VII and Part D of PCC | IFC General and Sector EHS Guidelines or any other international recognized guidelines | Weekly | Project Site | NA |
| Sub-total | | | | | 1,23,080 |
| **Operation Stage** | | | | | |

| Environmental Features | Aspect to be Monitored | Standard to be complied with | Time and Frequency of Monitoring | Location | Estimated cost (USD) |
|---|---|---|---|---|---|
| Air | Emission from DG sets (SPM, NOx and SOx), Odor | GoI and WHO/IFC whichever stringent | At least 2 times in a year for the first year, annually for another 2 years | DG sets of all stations | 5,333 |
| Groundwater | DO, Turbidity, Conductivity, pH, Heavy metals, TP, TN, E.Coli, TSS, Oil and Grease, VOCs and TDS | GoI and WHO/IFC whichever stringent | At least 2 times in a year for the first year, annually for another 2 years | Groundwater at Station locations | 4,000 |
| Noise | Noise levels in dB(A) | GoI and WHO/IFC whichever stringent | At least 2 times in a year for the first year, annually for another 2 years | Alignment, Stations | 1,067 |
| Vibration | PPV mm/s | Federal Transit Administration (FTA) Guideline Standards or any other internally recognized standards | At least 2 times in a years for the first year, annually for another 2 years | At receptors comprising educational, medical and physical cultural buildings and other fragile buildings located within recommended screening distance of 62m (for cat. 2) on either side of alignment | 32,000 |
| Occupational Health and Safety | As specified in project EMP and CMRL's SHE Manual | IFC General and Sector EHS Guidelines or any other international recognized guidelines | Monthly for 3 years | Station | 20,000 * |
| Sub-total | | | | | 62,400 |
| **Grand total** | | | | | **2,04,667** |

## 9.6. Emergency Preparedness and Response System

396. An Emergency Preparedness and Response System has been prepared as shown in Table 9.4.

**Table 9-5: Emergency Preparedness and Response System**

| Emergency Situations | Community or individuals impacted | Response procedure | Equipment and resources | Responsibilities | Training need | Accident and emergency records |
|---|---|---|---|---|---|---|
| Damage to utilities:<br><br>Damage to one of the utilities water supply, sewage, gas pipelines; electric and telecommunication cables while other utilities are being diverted due to lack of clarity in their location or unexpectedly poor state of their maintenance<br>Damage while additional geotechnical investigations are in progress or during pile driving/in-situ casting. | Community<br><br>In case of live gas lines, the project workforce could also be impacted | • The potential for disruption of utilities during line construction is low as long as proper pre-dig verification procedures are followed. Disruption could range from cable or phone outage to customers, to explosion in gas line with potential risk to human health and life.<br><br>• Contact utility to clear utility related safety hazard (like deactivating the utility).<br>• Seek assistance of the utility to assess damage<br>• Coordinate with un-impacted utilities.<br>• Vital services and infrastructure recovery activities. | ➢For gas utilities<br>• Fire engines to dispense water and foam<br>• Portable extinguishers<br>• Fire protection suits<br>• Breathing apparatus, helmets, goggles and face shield, first aid kits, stretchers, torches, ladders, emergency lighting on standby power<br><br>➢For water and sewage utilities<br>• Quick water sealants | Notification:<br>Contractor to CMRL and utility agency<br>CMRL to utility agency<br><br>Remedial Action by: utility agency | • Mock drills<br>• Use of extinguishers, fire suits, breathing apparatus, first aid kits, water sealants | • Utility location and diversion plans<br>• Record sheet showing type, size and identification number of utility, time of occurrence, time of notifying utility agency, status of other utility lines at the locations, time of repair and resumption of construction activities<br>• Geotagged photographs with date |

| Emergency Situations | Community or individuals impacted | Response procedure | Equipment and resources | Responsibilities | Training need | Accident and emergency records |
|---|---|---|---|---|---|---|
| Collapse or severe degree of damage to existing structures due to unanticipated vibration during construction | Community | • The base document available with the ER Team shows the location of structures which are at risk of damage due to vibration as assessed at start of construction.<br>In case of those structures where damage is expected to be major especially due to age or condition of building, move occupants affected as well as those in their proximity to safer locations *before work is started at those locations.*<br>Arrange for their temporary relocation till the structures are rehabilitated.<br>• In the event of minor damage to non-structural elements of the buildings, the same will be repaired. In case of *unforeseen damage* endangering structural soundness, move occupants of structures affected as well as those in their proximity to safer locations.<br>Arrange for their temporary relocation till the structures are rehabilitated. | | Notification: Contractor to CMRL<br><br>Remedial Action by: Contractor | Mock drills | Vibration records<br>• Record sheet showing type, size and identification number of structure, time of occurrence, type of equipment in use before and when the damage was first noticed, the type of minor repair executed, number of occupants present and evacuated, time of evacuation, status of adjacent structures, type of rehabilitation implemented on each affected structure, date of resumption of construction activities, date of return of occupants<br>• Geotagged photographs with date |
| Fire accidents at electric installations, fuel | Community and project workforce | • Transformer or Sub station fire requires equipment be de-energised. | • Fire engines to dispense water and foam | Notification: Contractor to CMRL and Fire Department, Police, | • Mock drills<br>• First Aid<br>• Use of fire extinguishers, | • Fuel and vapour sample test reports |

| Emergency Situations | Community or individuals impacted | Response procedure | Equipment and resources | Responsibilities | Training need | Accident and emergency records |
|---|---|---|---|---|---|---|
| storage and fueling facilities | | • Use fire water and foam to combat fires of oil.<br>• Immediately cool the equipment and any containers to avoid explosion.<br>• Follow designated stand off distance and stand down period.<br>• Administer first aid | • Portable extinguishers<br>• Fire protection suits<br>• Breathing apparatus, helmets, goggles and face shield, first aid kits, stretchers, torches, ladders, Emergency lighting on standby power | hospitals and Pollution Control Board<br><br>Remedial Action by: Contractor | fire suits, breathing apparatus<br>• Evacuation<br>• Search and Rescue | • Maintenance reports of electric and fuel installations<br>• Record sheet showing location and time of occurrence, number of personnel present and evacuated<br>• Geotagged photographs with date |
| Diesel spill | | • Store and maintain equipment in a designated area.<br>• Perform fueling in designated fueling areas<br>• Check incoming vehicles for leaking oil and fluids<br>• Implement a preventative maintenance schedule for equipment and vehicles.<br>• Keep foam extinguishers and spill kits readily available and functional. | • Spill kits<br>• Portable extinguishers<br>• Breathing apparatus, helmets, goggles and face shield, first aid kits, stretchers, torches, Emergency lighting on standby power | Remedial Action by Contractor | • Training on use of spill kits<br>• Mock drills<br>• Use of extinguishers | • Fuel and vapour sample test reports<br>• Record sheet showing location and time of occurrence, number of personnel present and evacuated |

| Emergency Situations | Community or individuals impacted | Response procedure | Equipment and resources | Responsibilities | Training need | Accident and emergency records |
|---|---|---|---|---|---|---|
| | | • raise alarm, evacuate area, limit spread of diesel, clean up spill using absorbents.<br><br>• If fluids are leaking or have spilled on an impermeable surface, such as a road or parking lot, locate nearest down gradient storm drain and use a berm to block the drain to prevent fluids from entering it. Clean up spill.<br>• Leaks from fuel tanks, an equipment seal, or an hydraulic line should be contained with a spill pad placed beneath the source.<br>• A spill during fueling operations will be contained within a spill pan for small container handling, or portable secondary containment berms in the storage areas.<br>• If a drum is leaking, the drum will be repaired with a patch kit.<br><br>• If a spill occurs onto soil, follow these procedures: Stop operations | | | | |

| Emergency Situations | Community or individuals impacted | Response procedure | Equipment and resources | Responsibilities | Training need | Accident and emergency records |
|---|---|---|---|---|---|---|
| | | Identify the product - check container design, warning labels, markings, etc.<br>Prevent personnel from approaching the site and keep them at a distance sufficiently removed that they will not be injured by, or cause, a fire or explosion.<br>Stop the flow at the source - reduce or terminate the motion of product without endangering anyone.<br>Assess the extent of the spill. | | | | |
| Road accident hazard due to leakage of hazardous waste such as waste fuels, lubricants during transport by vendors | Community and project workforce | • Even if grievous hurt and loss of life to workers and community and property is not caused, if incident occurred in public area posing a hazard, notify Police and alert Pollution Control Board.<br>• Control the leak/flow<br>• Arrange for sampling of any water pollution or potential pollution | • First aid kits, stretchers, torches, ladders, emergency lighting on standby power | Notification: Contractor to CMRL<br>• CMRL to Traffic Police and Pollution Control Board.<br><br>Remedial Action by: Contractor | • Mock drills<br>• First Aid<br>• Use of fire extinguishers, fire suits, breathing apparatus | • Waste identification report<br>• Record sheet showing location and time of occurrence, number of personnel present and evacuated<br>• Geotagged photographs with date |
| Air pollution due to leakage and fire of flammable gases from C&D waste (muck) disposal site slope failure of muck stack at disposal site | Community and project workforce | • Even if grievous hurt and loss of life to workers and community and property is not caused, if incident occurred in public area posing a hazard, notify Police and alert Pollution Control Board.<br><br>• Use fire water | • Fire engines to dispense water and foam<br>• Portable extinguishers<br>• Fire protection suits<br>• Breathing apparatus, gas | Notification: Contractor to CMRL and Fire Department<br>CMRL to Pollution Control Board<br><br>Remedial Action by: Contractor | • Mock drills | • Gas sample test reports<br>• Record sheet showing location and time of occurrence, number of personnel present and evacuated<br>• Geotagged photographs with date |

| Emergency Situations | Community or individuals impacted | Response procedure | Equipment and resources | Responsibilities | Training need | Accident and emergency records |
|---|---|---|---|---|---|---|
| | | | detectors, helmets, goggles and face shield, first aid kits, stretchers, torches, ladders, Emergency lighting on standby power | | | |
| Failed launching of pre-cast girders or segments | Community and project workforce | • Administer first aid<br>• Organise lifting equipment and gas cutters<br>• Even if grievous hurt and loss of life to workers and community and property is not caused, but if collapse occurred in public area posing a hazard, notify Police. | • Lifting equipment and gas cutters<br>• First aid kits, stretchers, torches, ladders, emergency lighting on standby power | Notification: Contractor to CMRL CMRL to Police and district labour Commissioner Remedial Action by: Contractor | • Mock drills<br>• First Aid<br>• Search and Rescue | • Structural drawings of failed elements<br>• Record sheet showing location and time of occurrence, type of lifting equipment used, number of personnel present and evacuated<br>• Geotagged photographs with date |
| Collapse of temporary works such as scaffolding and excavation support | Community and project workforce | In case of injured worker suspended from his harness, wait for trained emergency personnel. | | Notification: Contractor to CMRL CMRL to Police and district labour Commissioner Remedial Action by: Contractor | • Mock drills<br>• First Aid | • Structural drawings of failed temporary works<br>• Record sheet showing location and time of occurrence, number of personnel affected<br>• Geotagged photographs with date |

| Emergency Situations | Community or individuals impacted | Response procedure | Equipment and resources | Responsibilities | Training need | Accident and emergency records |
|---|---|---|---|---|---|---|
| Service disruption and unplanned congestion due to failure of rolling stock doors | Metro Passengers | • As soon as duration of failure approaches disruption period allowed in station design, notify OCC and suspend boarding and alighting at affected station<br>• close entry of passengers into affected stations<br>• Trains arriving in affected duration will pass without stopping<br>• Affected trains will pass through to maintenance depot for attention | Maintenance equipment, spares and personnel | Notification: CMRL to Emergency Action Committee<br><br>Remedial Action by: CMRL | • Mock drills | • rolling stock usage log<br>• rolling stock maintenance reports<br>• Record sheet showing location and time of occurrence, number of services affected<br>• Geotagged photographs with date |
| Service disruption and unplanned congestion due to failure of traction power supply or signaling during operation of the metrorail | Metro Passengers | • In case of traction power failure, affected trains reach nearest station on battery.<br>• In case of signalling failure, stop affected trains at nearest station.<br>• Suspend operation of trains bound to pass through affected stations or section; stop trains at stations outside affected section<br>• Close entry of passengers into affected stations | Maintenance equipment, spares and personnel | Notification: CMRL to Emergency Action Committee<br><br>Remedial Action by: CMRL | • Mock drills | • TPS and S&T log<br>• TPS and S&T maintenance reports<br>• Record sheet showing location and time of occurrence, number of services affected<br>• Geotagged photographs with date |
| Unplanned congestion in stations due to failure of general power through grid | Metro Passengers | • As soon as standby supply is activated, notify OCC and suspend boarding and alighting in affected station; let trains pass through. | • Handheld 2 way radios and hailing loudspeakers<br>• Portable handheld lamps | Notification: CMRL to Emergency Action Committee<br><br>Remedial Action by: | • Mock drills | • Standby system maintenance reports<br>• Record sheet showing location and time of occurrence |

| Emergency Situations | Community or individuals impacted | Response procedure | Equipment and resources | Responsibilities | Training need | Accident and emergency records |
|---|---|---|---|---|---|---|
| supply for lighting, communication etc | | • Close entry of passengers into affected stations<br>• Switch on battery-powered high-power lamps which have been fixed to stations structure<br>• Use portable hailers to address passengers and employees<br>• Use portable lamps to locate and evacuate passengers and employees. | • Maintenance equipment, spares and personnel | CMRL | | • Geotagged photographs with date |
| Service disruption, Grievous hurt, loss of life due to natural disasters such as unanticipated earthquakes | Community and Metro Passengers | • Notify Operation Control Centre to suspend operation of trains bound to pass through affected stations or section; stop trains at stations outside affected section<br>• Administer first aid<br>• Notify nearby hospitals for ambulances and to standby<br>• Evacuate trains which have been stopped<br>• Close entry of passengers into affected stations<br>• Switch on battery-powered high-power lamps which have been fixed to station structure<br>• Disconnect grid and standby DG power supply with turnstiles in default open mode.<br>• Use portable hailers to address passengers and employees | • Trained rescue teams<br>• Emergency battery fixed lighting<br>• Hand torches<br>• First Aid Kits<br>• Safety helmets<br>• Ropes and safety harnesses<br>• Stretchers<br>• Ladders<br>• Ambulance<br>• Rail-cum-road Vehicles | Notification: CMRL to Emergency Action Committee, hospitals, Police, State Government, Commissioner Metro Rail Safety (CMRS) *<br><br>Remedial Action by: CMRL | • Mock drills<br>• First Aid<br>• Evacuation<br>• Search and Rescue | • Magnitude and epicenter of earthquake<br>• Seismic design adopted in design of structures<br>• Record sheet showing location and time of occurrence, number of persons affected<br>• Geotagged photographs with date |

| Emergency Situations | Community or individuals impacted | Response procedure | Equipment and resources | Responsibilities | Training need | Accident and emergency records |
|---|---|---|---|---|---|---|
| | | • Use portable lamps to locate and evacuate passengers and employees. | | | | |
| Unplanned congestion in stations due to terrorism or sabotage or law and order situations on Metro project or outside Metro project | Community, Metro Passengers and employees | • Notify Operation Control Centre to suspend operation of trains bound to pass through affected stations or section; stop trains at stations outside affected section<br>• Administer first aid<br>• Notify nearby hospitals for ambulances and to standby<br>• Evacuate trains which have been stopped<br>• Close entry of passengers into affected stations<br>. | • First Aid Kits<br>• Stretchers<br>• Ambulance | Notification: CMRL to Emergency Action Committee, hospitals, Police, State Government<br><br>Remedial Action by: CMRL | | • Record sheet showing location and time of occurrence, number of persons affected<br>• Geotagged photographs with date |
| Grievous hurt, loss of life and property due to terrorism or sabotage or law and order situations on Metro project | | | | Notification: CMRL to Emergency Action Committee, hospitals, Police, State Government, CMRS*<br><br>Remedial Action by: CMRL | • Mock drills<br>• First Aid<br>• Evacuation<br>• Search and Rescue | |
| Acts of suicide or murder or hurt | Perpetrators and victims | • Notify OCC and suspend operation of trains on affected platform; stop trains at stations outside affected section<br>• Administer first aid<br>• Notify nearby hospitals for ambulance and to standby | • First Aid Kits<br>• Stretchers<br>• Ambulance | CMRL to Emergency Action Committee, hospitals, Police, State Government, CMRS*<br><br>Remedial Action by: CMRL | • Mock drills<br>• First Aid<br>• Evacuation | |

***** *Metro Railway (Operations and Maintenance) Act, 2002 requires reporting of a) collision or derailment of trains or b) accidents attended or usually attended by loss of life or grievous hurt*

## 9.7. Training and Capacity Building Programs

397. CMRL's current capacity in monitoring of metro projects in adequate. However it is proposed to conduct a training program for CMRL as well as general consultant and contractors environmental, health and safety officials particularly on MDBs' monitoring and reporting requirements. External monitor will undertake training and capacity building activities. Training modules will be discussed and confirmed by CMRL and MDBs. A budget has been allocated in the EMP for the same.

398. Environmental Safeguards Specialist has been added to PIU: he will supervise work on all MDB corridors. The CMRL core Environment Safeguards team will be responsible for all corridors: it will be supported during construction by 2 junior CMRL environmental engineers who are assigned and charged to each corridor, assisted by safety, environmental, traffic, labor welfare professionals deployed by GC. During operation of metro, the core team will continue to monitor implementation of EMP by the metro operations contractors and EMoP by external environment monitoring agencies.

## 9.8. Environmental Management Budget and Resources

399. The cost of all compensation and rehabilitations works will be an integrated part of the overall project cost, which will be borne by the project. The preliminary estimated cost of the environmental and social management plan is estimated as below. This cost estimate is exclusive of land acquisition and resettlement & resettlement cost.

**Table 9-6: Cost of EMP and EMoP Implementation – MDB Corridor 3***

| SN. | Item | Amount (Rs in lakh) |
|---|---|---|
| 1. | Compensatory Afforestation | 72.95 |
| 2. | Diversion of Forest Land | 0 |
| 3. | Noise Barriers | 117.6 |
| 4. | Rainwater Harvesting including Depot | 350.29 |
| 5. | Sewage Treatment Plant (STP) | 0 |
| 6. | Effluent Treatment Plant (ETP) | 0 |
| 7. | Environmental Monitoring | 149.85 |
| 8. | Training and Extension | 12.6 |
| 9. | Environment Division | 171.46 |
| 10. | Solar System | 885 |
| | **Total** | **1759.75** |

***** *Does not include cost of monitoring of building condition survey during construction and plantation monitoring. The additional costs for Covid-19 measures and PPEs will be part of civil work cost. In addition, as a noise embedded measure and as a part of civil work cost, Ballast less track(P-way) and Green Building have also been considered as follows:*

| SN. | Item | Amount (in Crores) |
|---|---|---|
| 1. | Ballast less track (P-Way) | 541.60 |
| 2. | Cost for Green Building concept (Lumpsum) | 10.0 |

## 10. CONCLUSION AND RECOMMENDATION

400. The alignment of the proposed Chennai Metro Corridor 3 is not located in any protected area or near a site of historical/cultural significance. Some impact is anticipated due to cutting of about 164 public trees along existing roads.

401. Significant adverse impacts of `medium to high` risk and `likely to definite` likelihood are a) social impacts due to involuntary resettlement, b) loss of trees, c) utility diversion, d) air, noise, vibration, C&D waste (muck) disposal, labour safety, water demand, e) likely climate vulnerability. Measures to mitigate adverse impacts have been recommended.

402. After mitigation some residual impacts are expected, predominantly due to noise, vibration, visual intrusion and health and safety risks.

403. Benefits include reduced air pollution and road accident, increased benefits to economy and commuters on metro and road. Major roads along the proposed alignments are forecast to function beyond respective design service volume in year 2035 in absence of the project lines. BRT has significantly lower unit life cycle cost but likelihood of rapid development on this corridor suggests connectivity to metro under implementation from Madhavaram to Sholinganallur.

404. Public consultations highlighted opinions of participants on benefits of Metro in terms of easing connectivity, pollution, congestion, accidents and travel on roads. Public consultations during construction and operation will form part of periodic reports sent by CMRL to MDBs. These consultations will focus on the efficacy of mitigation measures being implemented.

405. Grievance Redress Mechanism will be developed to assist the citizens, users of the Metro and other stakeholders communicate their queries, complaints and suggestions in connection with implementation of EMP and EMoP. GRM for both workers and communities will be instituted during pre-construction phase to continue through different phases.

406. Institutional arrangement, EMP, reporting and record keeping, emergency response and environment monitoring plan have been developed. Budgetary cost estimate to implement the EMP and EMoP has been prepared.

407. Best available technology and best management practices are built-in to the project design. All project components will be implemented and monitored in line with the MDBs' applicable policies and standards. A semi-annual environmental and social monitoring report will be submitted to MDBs and will be disclosed publicly at the MDBs' websites. Environmental and social benefits of the project and long-term investment program objectives outweigh the temporary negative impacts.