Updated Environmental Impact Assessment

India: Chennai Metro Rail Investment Project
Corridor 4

Main Report

April 2024
Revision - 01

Prepared by the Chennai Metro Rail Limited (CMRL) for Project Lenders.

CURRENCY EQUIVALENTS

(as of 1st April 2024)

Currency unit – Indian Rupee (₹)
₹1.00 = $0.012
$1.00 = ₹83.39

ABBREVIATIONS

ADB	:	Asian Development Bank
AIIB	:	Asian Infrastructure Investment Bank
CBTC	:	Communication based Train Control
CGWB	:	Central Ground Water Board
C&D Waste	:	construction and demolition Waste
CMA	:	Chennai Metropolitan Area
CMDA	:	Chennai Metropolitan Development Authority
CMRL	:	Chennai Metro Rail Limited
CMWSSB	:	Chennai Metro Water Supply and Sewerage Board
CPCB	:	Central Pollution Control Board
CMP	:	Comprehensive Mobility Plan
CMBT	:	Chennai Mofussil Bus Terminus
CMFRI	:	Central Institute of Mining and Fuel Research
CRZ	:	Coastal Regulation Zone
DGC	:	District Green Committee
EHS	:	Environmental, Health, and Safety
EC	:	Environment Clearance
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
TNFD	:	Tamil Nadu Forest Department
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., FY2023 ends on 31 March 2023.

(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 8.65 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 the implementation of the 26.1 km of Chennai metro corridor 4 up to depot entry, which consists of 16.1 km of elevated section and 10.0 km of underground section. This line has 4 stations (namely Alwar Thirunagar, Valasaravakkam, Karambakkam and Alapakkam) in common with Corridor 5, offers interchange with Corridor 3, Phase I Metro and MRTS; it connects with suburban railway system. This alignment has been finalized after examining alternatives. The total capital cost of Corridor 4 is estimated to be USD 1,575 million for December 2018 including taxes and duties. It is estimated that the project will be commissioned 5 years from the award of civil contracts (i.e. 2021). CMRL will take full responsibility for the implementation of Corridor 4.

4. As per provisions of the Environmental Impact Assessment (EIA) Notification 2006 and its subsequent amendments by the Ministry of Environment, Forests and Climate Change (MoEF&CC), Railways and Metro Rail Projects are exempted from requirements of Environmental Clearance. However, part of the Light House to Kutchery Road section is l fall in Coastal Regulatory Zone (CRZ) II & IV B for which permission is required from NCZMA & TNCZMA Vide F.No 11- 13/2022-IA.III dated 22.04.2022. Subsequently Six monthly compliance report on the conditions stipulated in CRZ clearance has been submitted to Regional Office, MOEF&CC **(copy enclosed in Annexure 13)** as per CRZ Notification 2011.

5. This 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]. In accordance with proposed packaging of Corridor 4, underground stretch, elevated stretch, systems and depot will be financed by different MDB and constitute Associated Facilities to each package. The environmental impacts and mitigation measures of all 4 packages are analyzed in this report. Corridor 4 overall is expected to generate environmental and socio-economic benefits in terms of decreasing air pollution from

[1] Indian National Census, https://www.census2011 Based on the Second Master Plan, the current Metropolitan area is expected to have a population of 126 lakhs by 2026 (Source : Comprehensive Mobility Plan, 2019)

[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).

traffic congestion and serving the growing travel demand. As per the MDB's Environment and Social policies, the Corridor 4 has been categorized as "Category A" due to the significant impacts anticipated during construction. The EIA report comprising baseline data on existing conditions of physical and ecological environment including , the identified and anticipated environmental impacts and proposed mitigation measures, has been prepared in accordance with the GoI's legislative framework and MDBs' Environmental Safeguard requirements. This EIA report has been updated covering environmental impacts and mitigation measures associated with the changes in design of the Corridor - 4

6. Corridor 4 consists of 8 underground stations (Excluding common station of C3-Thirumayilai metro)from Lighthouse to Kodambakkam Flyover, 18 elevated stations from Kodambakkam Power House to Poonamalle Bypass and one depot at Poonamalle Bypass. The depot will have capacity for 31 trains of 6 cars for maintenance and repairs of the operational rolling stock. Standard Gauge (1435mm) will be adopted with a minimum track center distance of 4000 mm, 16-ton maximum axle load capacity and a design speed of 80 kmph. The elevated station is generally located on the road median 140 m long and 24 m wide and is a three level structure, with a minimum vertical clearance of 5.50 m under the concourse. To reduce physical and visual impact of the elevated station, stations have been made transparent with minimum walls on the sides. The underground station is two- or three-level station with entrances and ventilation shafts at the ground level, a concourse with ticketing and automatic fare collection system (AFCs) at the mezzanine level and finally 140 m long and 12 m wide island platforms at the lowest level. 25 kV AC traction system and Communication Based Train Control (CBTC) Signaling system shall be adopted for Corridor 4. 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, parking areas (wherever technically feasible), energy efficient air conditioning and lightning will be considered in station design.

7. The terrain along Corridor 4 alignment is primarily flat, no more than 3 m above mean sea-level. The Geotechnical Investigation is ongoing with the results showing that the soils are slightly alkaline with dominant types of sandy and clay. The section of alignment from Light House to Kutchery Road is located in CRZ II (length – 1.53 Km) and the tunnels (Length - 0.03 Km) between Kutchery Road to Thirumayilai station will be laid under 20m below the Buckingham canal falls under CRZ II & IVB. The total length of the CRZ area 1.56 Km and requires CRZ clearance from MOEF&CC. MoEF&CC issued CRZ clearance vide letter F.No 11-13/2022-IA.III dated 22nd April 2022 **(Copy enclosed in Annexure 13)**. Further, the requisite 707 trees were felled and 361 trees are transplanted along the corridor up to Poonamalle Bypass(as of December 2023).187 trees were felled and 42 trees were transplanted along the Poonamalle depot (as of December 2023). Two assets, namely, Rosary Church and Our Lady of Light Shrine are located on the underground section at distance within 100m from Corridor 4.

8. Despite the seemingly abundant sources of water, Chennai suffers continuously from water stress since the entire basin is dependent on rainfall. Water quality was sampled at 9 locations. Most of the parameters are well within the prescribed permissible limits as per the Bureau of Indian Standards IS 10500:2012except some parameters viz Turbidity, Total Dissolved Solids, Calcium, Total Hardness, and Chloride. Bacteriological contamination was found at 5 locations. Total Dissolved Solids (TDS) and Total Hardness at Santhome Church sampling location are higher than limits, this could be due to higher mineral content in the groundwater especially Calcium and Magnesium. The surface water in Porur Lake would be classified as 'D',

propagation of wildlife and fisheries, because of high amounts of Zinc and a large Biological Oxygen Demand.

9. Results of the air monitoring show that air quality was moderate, while the parameters of Sulphur Dioxide (SO_2) and Nitrogen Dioxide (NO_2) were within the permissible level of National Ambient Air Quality Standards (NAAQS) and World Health Organization (WHO) guideline. Particulate Matter (PM10 and PM2.5) was within NAAQS but exceeded WHO guideline. The concentration of Carbon Monoxide (CO) exceeded the permissible level of NAAQS in all the monitoring locations but was generally within WHO guidelines. The noise levels monitored at 8 locations along the alignment were above the national and international permissible limits. Noise levels were also monitored at 30 sensitive locations belonging to the silence zone, with 60% slightly exceeding Ambient Noise Standard of 50dB the daytime limit (23.3% per WHO guideline of 55dB), and 1 out of 30 exceeding 40 dB the night-time limit. The peak particle velocity baseline values to demonstrate the vibration level at 11 out of 13 monitored locations are found to exceed acceptable criteria for ground borne vibration prescribed by Federal Transit Administration (FTA) USA and Railway Design & Standards Organization (RDSO) India which are more valid for operation of this project. However, the observed levels at all 13 locations are well below the construction vibration damage criteria for blasting which are relevant only if blasting is undertaken during construction as per Central Institute of Mining and Fuel Research (CMFRI) India.

10. 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 of Corridor 4 include reduced use of private vehicle leading to reduction in pollutants; road safety improvements; increased accessibility and mobility, and a modest reduction in greenhouse gas emissions. The main residual negative impacts of Corridor 4 include fugitive and point source dust emission, surface noise and vibration from excavation and demolition, disturbance to road traffic, disposal of large quantities of construction and demolition wastes, and occupation and community health and safety, which are mainly temporary and localized. Initial noise and vibration modeling has been carried out under this EIA, during detailed design additional modeling will be conducted for each of the identified sensitive receptors.

11. 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 residential locations); and (iii) reuse of excavated material where feasible and disposal of construction waste in a regulated manner. Corridor 4 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. Several climate change considerations to be integrated into Corridor 4 design include: (i) installation of floodgates at stations with flooding risks; (ii) improving adaptability to seasonal thermal variations in the stations through the use of large open spaces for unrestricted air movement, cross-ventilation and ensuring that enclosed areas are well ventilated; (iii) designing for better adaptability to rising sea level/high tide/heavy flooding through the use of higher plinth levels and check valves for sewer lines in flood-prone areas and the use of resilient materials that can get wet and then dry out with minimal damage; (iv) using solar panels on station buildings parking areas and station and roofs to reduce the extensive use of grid-generated electricity supplied to the station for its operation and maintenance; and (v) through better station roof design, providing for rainwater harvesting by channeling rainwater through gutters and pipes to either harvesting pits in the ground or to recharge groundwater and (iii) using head-hardened rails of 1080 grade steel rails will result in

better mechanical properties in terms of stiffness, higher lateral resistance, and better transmission of thermal stresses, and higher durability; and reduced maintenance resulting from practically unchanged track geometry over time and at almost any operating speed.

12. 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 Corridor 4.

13. Meaningful consultations were carried out with various stakeholders during EIA preparation and will continue throughout Corridor 4 implementation. Women felt that Corridor 4 will provide (i) better access to higher levels of education, health services (especially in emergencies), and social interactions; (ii) better transport option; and (iii) increase in leisure time. Concerns voiced by Project Affected Persons (PAPs) and stakeholders have been incorporated in Corridor 4 design. Individual consultation of PAPs will also be carried out during implementation. Information disclosure will follow the procedure for MDBs' Category A projects.

14. Grievance Redress Mechanism (GRM) has been proposed constituted for Corridor 4 which 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 has been formed which 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.

15. 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-annual Environment Monitoring reports (EMR) will be prepared by GC and submitted to MDBs through CMRL. A third-party monitor will also supervise work independently and submit External Monitoring Report l (EMR) to CMRL and MDBs (ADB,AIIB,NDB). The preliminary estimated cost of the EMP including implementation and monitoring is USD 3.34 million (INR 243.62 million). This cost estimate is exclusive of land acquisition and resettlement & rehabilitation cost.

16. Benefits far outweigh negative impacts. Overall, the major social and environmental impacts associated with Corridor 4 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 on noise and vibration levels that will be generated during construction have been included in the Environmental Monitoring Plan (EMoP).. CMRL shall ensure that the EMP and EMoP are included in Bill of Quantity and forms part of bid document and civil works contract. The same shall be revised if necessary, during project implementation or if there is any change in the project design and with approval of MDBs.

17. 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 for Corridor 4 shall be recommended and implemented; (iii) Project description with enumeration of salient features of Corridor 4 which have bearing upon its environmental impacts; (iv) Environmental baseline of Corridor 4 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 of Corridor 4 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 Greater Chennai Corporation, Avadi Corporation, Tambaram Corporation, Kancheepuram Corporation, 12 Municipalities, 13Town Panchayats, 1 Special Grade Town Panchayat and 1321 Village and 22 Panchayat Unions. The extent of CMA is 5,904 sq. km. The CMA falls in five Districts of Tamil Nadu, viz. Chennai District, part of Tiruvallur District, Kancheepuram District, Chengelpet District, and part of Arakkonam Taluk of Ranipet District. (The Present extent of CMA is 5904 sq. km). In 2011, the resident population of CMA was 8.65 million, which is estimated to increase to 12.6 million in 2026. The last census was conducted in 2011, and the scheduled census for CMA in 2021 was postponed due to COVID-19.

2. Chennai, the capital city of the state of Tamil Nadu, 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 including Hyundai, Renault, Nissan, Daimler (Mercedes) operating their plants in the area. CMA also houses a growing number of software firms (including Infosys, TCS, Wipro etc.), financial services (KPMG, Deloitte, Price water house Coopers etc.) 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 Chennai Second Master Plan 2026 proposes to increase the public and private mode split to 70:30. 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 construction of for balance MRTS section from Velachery to St Thomas Mount is in process. Chennai Metro Phase 1 and Phase 1 Extension of 45 kms and 9 kms is in operation. Chennai suburban railway network supplements MRTS. A schematic diagram of urban mass rapid transit network is in Figure 1.1.

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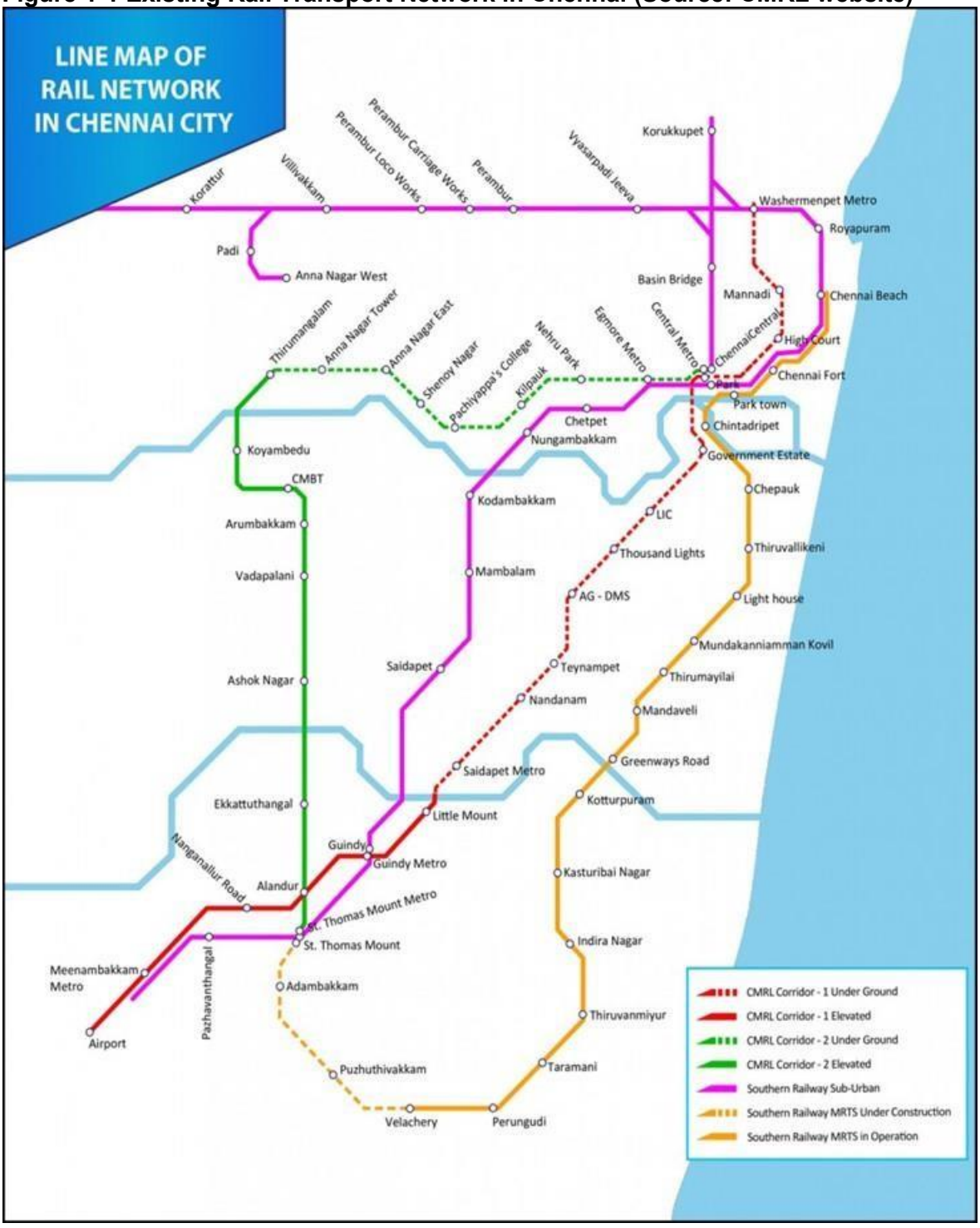
[1] Indian National Census, https://www.census2011.co.in/census/metropolitan/435-chennai.html The Census Organization of India, 2011.

[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 Existing Rail Transport Network in Chennai (Source: CMRL website)

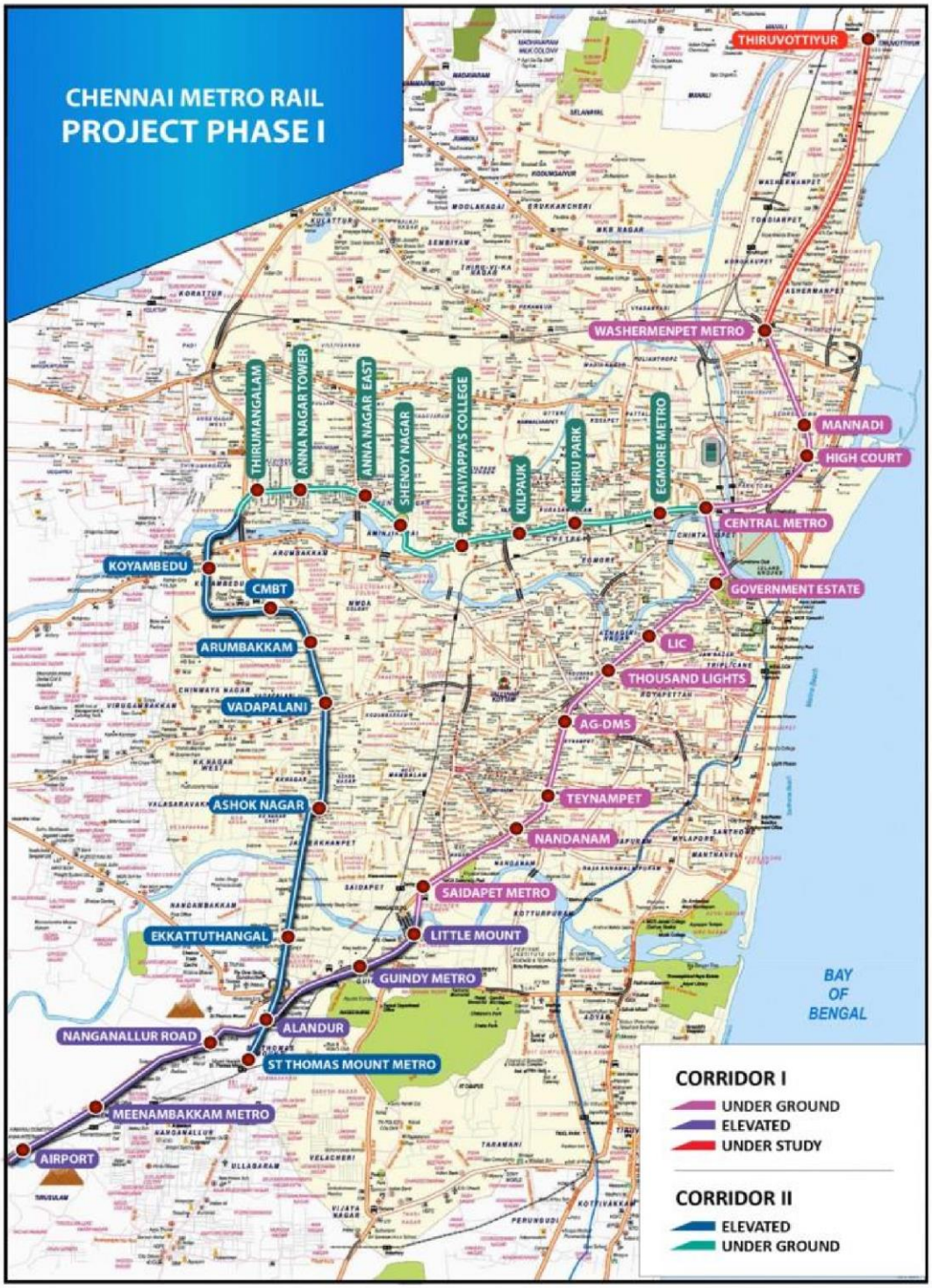


1.1.1. Chennai Metro Network

6. **Phase 1** of Chennai metro as shown in Figure 1.2 covers 54.05 km in two corridors - Corridor 1 (Blue line) from Washermanpet to Airport (23.09 Km), Corridor 2 (Green Line) starts

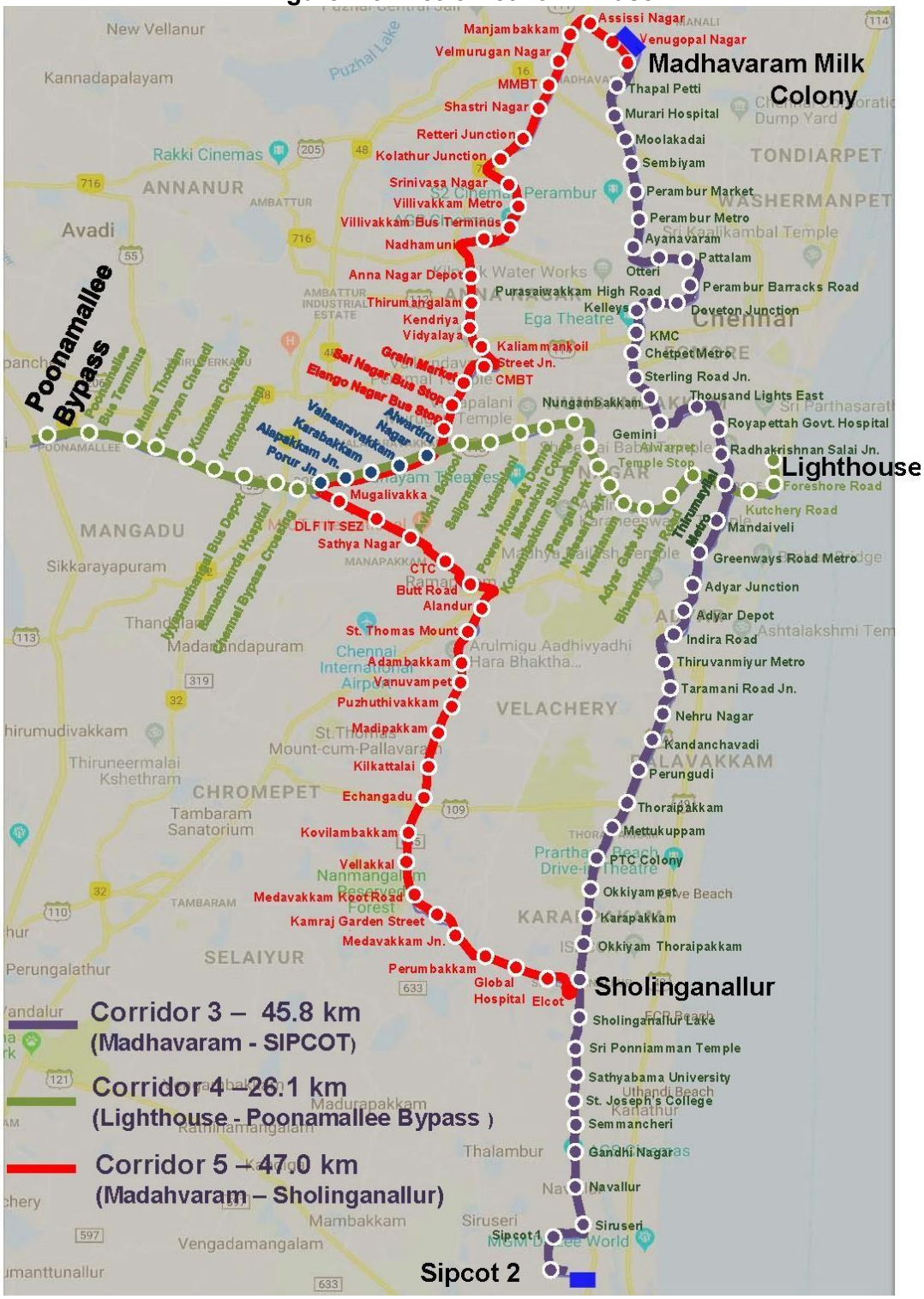
from Chennai Central to St. Thomas Mount (21.96 Km) via Koyambedu and extension from Washermanpet to Wimco Nagar (9.00 km) in Thiruvottiyur. As on August 2023, Phase 1 and Phase 1 Extension is in commercial operation. Phase 1 has been financed under a loan from JICA and does not form part of the proposed ADB/AIIB/NDB is financing for phase II.

Figure 1-2 Metro Network Phase 1 (Source: CMRL website)



7. **Phase 2** includes Corridor 3, 4 and 5 as shown in Figure 1.3. The final alignments will be decided based on engineering designs.

Figure 1-3: Metro Network Phase 2



Source: ADB

8. 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, shall be responsible for implementing, operating, and maintaining the city’s metro system. CMRL developed the Comprehensive Mobility Plan (CMP) 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.

9. This EIA covers **Corridor 4** of phase II. Corridor 4 runs from Lighthouse to Poonamallee bypass, length of the corridor is 26.1 km comprising 8 underground stations (excluding common station of C3- Thirumayilai) (Lighthouse to Kodambakkam Flyover) and 18 elevated stations (Kodambakkam Powerhouse to Poonamallee bypass). Corridor 4 has 4 stations (the latest alignment of Corridor 5 shows the Porur Jn station will be avoided by Corridor 5) in common with Corridor 5, offers interchange with Corridor 3, Phase I Metro and MRTS; it connects with suburban railway system. Civil construction of the underground section from Lighthouse to Kodambakkam Flyover (formerly called as Meenakshi College) commenced in December 2021 and completed by December 2025.System works are scheduled to be completed and the entire Corridor 4 is commissioned by December 2026.

10. Corridor 4 is being funded by MDBs AIIB, ADB and NDB. The MDB funding arrangement is as follows:

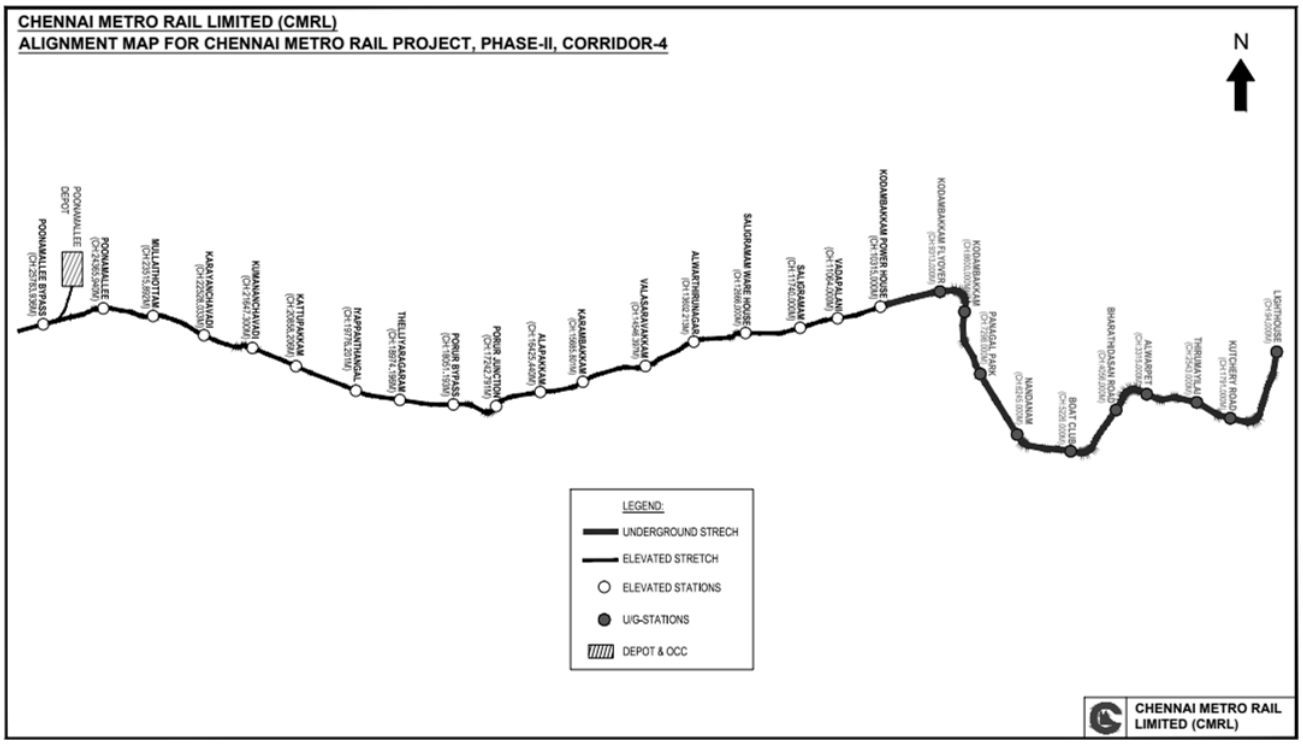
(i) Asian Development Bank (ADB): Alignment and formation/tunneling (10.0 km from Lighthouse to Kodambakkam Flyover), 8 underground stations structural civil cost.
(ii) Asian Infrastructure Investment Bank (AIIB): Alignment and formation (16.1 km from Kodambakkam Power House to Poonamallee bypass), 18 Elevated stations structural civil cost, General Consultancy.
(iii) New Development Bank (NDB): P. way, station building components VAC and TVS, E&M, Lifts and Escalators, Architectural finishes and MMI.

The government will finance the remaining components including Depot and Rolling Stock.

11. **Corridor 3 and corridor 5** of phase II are covered in separate EIAs, further details on those corridors can be found in the respective documents.

12. Figure 1.4 shows the alignment and station plan of Corridor 4.

Figure 1-4: Corridor 4 (Source: DPR of Corridor 4, Oct 2018)



1.2. Environmental Impact Assessment

1.2.1. Categorization

13. As per ADB's Safeguard Policy Statement (SPS) 2009, Category A is defined as if it is likely to have significant adverse environmental impacts that are irreversible, diverse, or unprecedented. These impacts may affect an area larger than the sites or facilities subject to physical works. An environmental impact assessment is required.

14. As per AIIB's Environmental and Social Framework (ESF) 2022, Category A is defined as if it is likely to have significant adverse environmental and social impacts that are irreversible, cumulative, diverse, or unprecedented. These impacts may affect an area larger than the sites or facilities subject to physical works and may be temporary or permanent in nature. The Bank (AIIB) requires the Client to conduct an environmental and social impact assessment (ESIA) or equivalent environmental and social assessment, for each Category A Project, and to prepare an environmental and social management plan (ESMP) or environmental and social management planning framework (ESMPF) (or other similar Bank-approved documentation), which is included in the ESIA report for the Project.

15. As per NDB's Environmental and Social Framework (ESF) 2016, A proposed project is classified as Category A if it is likely to have significant adverse environmental and social impacts

that are irreversible, diverse, or unprecedented. These impacts may affect an area larger than the sites or facilities subjected to physical works.

16. Considering the above policies of ADB ,AIIB and NDB the project (Corridor 4) has been categorized as Category A and the EIA report has been prepared and updated.

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1.2.2. Purpose of the EIA Report

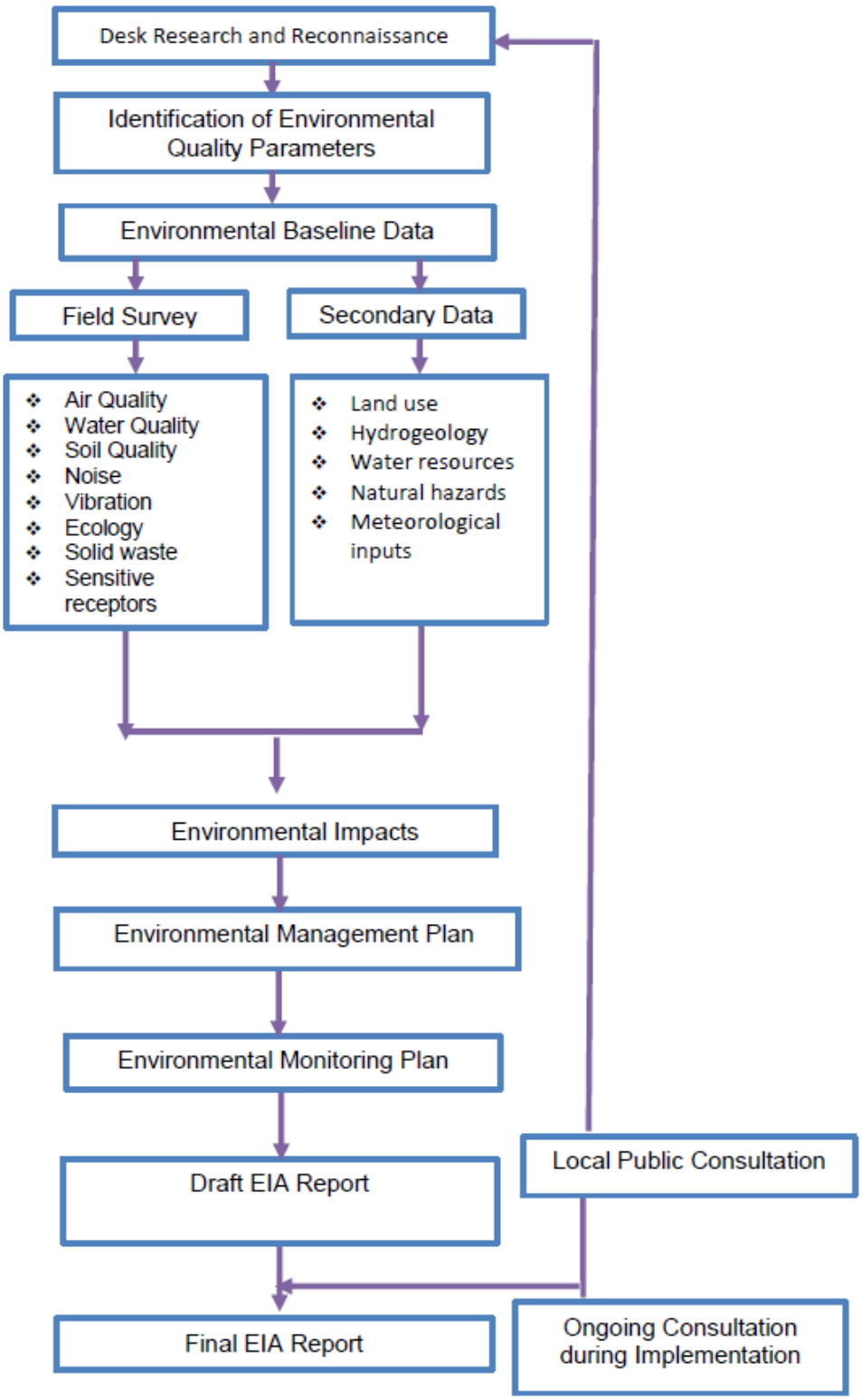
17. The main objective of this updated EIA report is to address the alterations in the construction design, specifically the incorporation of intergrade grade separators of 1.527 Km from Kattupakkam to Karayanchavadi.and also to identify and evaluate the resultant environmental impacts and proposing effective mitigation measures along the project alignment. This updated EIA report documents the environmental assessment of Corridor 4 and identifies the environmental issues to be considered preconstruction, construction and operation phase of the project. 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 national environmental management requirements of GoI and the MDBs environmental safeguard requirements. In general, the updated 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 shall be recommended and implemented;
- Provide information about the baseline environmental settings;
- Provide information on potential environmental impacts of Corridor 4 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.

18. Social Impact Assessment (SIA) with a Resettlement Action Plan (RAP) for implementation is presented as a separate Report.

1.2.3. Approach and Methodology

Figure 1-5: Methodology of Environmental Impact Assessment



19. As shown in Figure 1.5, the updated EIA followed a number of steps:

- Review of available baseline reports, and technical reports/studies related to Corridor 4;
- Conduct field visits to collect primary or secondary data relevant to Corridor 4 areas to establish the baseline[5];
- Assess the potential impacts on environmental attributes due to the location, design, installation and operation of Corridor 4 through field investigations and data analysis;
- Explore opportunities for environmental enhancement and identify measures;
- Updated the environment management plan (EMP) prepared earlier, covering the measures for mitigating the impacts identified including the institutional arrangements;
- Identify critical environmental parameters required to be monitored subsequent to the implementation of Corridor 4 and prepare an environmental monitoring plan;
- Carry out consultation with key stakeholders and administrative authorities to identify their perception on Corridor 4, introduce project components and anticipated impacts; and,
- Disclosure of the updated EIA Report on CMRL and lenders' website along with the EIA Executive Summary in Tamil and English languages.
- Disclose the draft EIA, including the Executive Summary in local language at CMRL and MDBs' websites to be made publicly available.

[5] The Baseline data for air, water and soil quality was collected in width 75m on either side of proposed center 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 center 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 the 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 their Environmental and Social Policies. This chapter will describe the applicability of the 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's, AIIB's 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. As per the EIA notification 2006, railway projects are not covered under the notification and hence environmental clearances related requirements do not envisage, this is applicable for metro rail projects as well. However, Corridor 4 will require Coastal Regulation Zone (CRZ) Clearance per the CRZ Notification 2011. Other relevant environmental legislations is mentioned in the Table 2.1.

2.1.1. Coastal Regulation Zone applicable to the Project

23. Alignment of the Corridor 4 passes through CRZ II and IV-B according to the CRZ Notification 2011. CRZ clearance needs has been obtained from Tamil Nadu Coastal Zone Management Authority (TNCZMA) and National Coastal Zone Management Authority (NCZMA). Under the regulation, GoI declared the coastal stretches of seas, bays, estuaries, creeks, rivers and backwaters which are influenced by tidal action (in the landward side) up to 500 metres from the High Tide Line (HTL) and the land between the Low Tide Line (LTL) and the HTL as CRZ with four categories.

24. As per CRZ Notification 2011, construction in CRZ IVB area, shall be permitted subject to a detailed marine or terrestrial or both environment impact assessment, to be recommended by TNCZMA and approved by the Ministry of Environment, Forest and Climate Change (MoEF&CC). Construction in CRZ II and IV B permission is required from TNCZMA and NCZMA. MoEF&CC issued CRZ clearance vide letter F.No 11-13/2022-IA.III dated 22nd April 2022. **(Attached as Annexure 13)**

2.1.2. Metro Rail Policy 2017

25. 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 an Unified Metropolitan Transport Authority shall be set up 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 (Community transport systems) promising.

2.1.3. Legislations Relevant to the Project

26. 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 to Corridor 4

Sl No.	Legislation	Objective	Responsible Institution
1.	Environment (Protection) Act (1986) and Rules (1986); National Conservation Strategy and Policy Statement on Environment and Development of 1992; National Environment Policy of 2006	To protect and improve the overall environment	MoEF&CC
2.	CRZ Notification, 2011	To ensure livelihood security to the fishing communities and other local communities living in the coastal areas; To conserve and protect coastal stretches and; To promote development in a sustainable manner based on scientific principles, taking into account the dangers of natural hazards in the coastal areas and sea level rise due to global warming	TNCZMA and NCZMA
3.	The Wildlife Protection Act (1972 and amended in 1993)	To protect wild animals and birds through the creation of National Parks and Sanctuaries	MoEF&CC
4.	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) and Tamil Nadu pollution Control Board (TNPCB)

Sl No.	Legislation	Objective	Responsible Institution
5.	Metro Rail Transit System, Guidelines for Noise and Vibrations, RDSO, Ministry of Railways, September 2015	Suggested mitigation measures for the prevention and control of noise and vibration during operation phase.	-
6.	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 / TNPCB
7.	The Tamil Nadu Water (Prevention and Control of Pollution) Rules, 1983 amended May 2009		Tamil Nadu Pollution Control Board (TNPCB)
8.	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)
9.	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 / TNPCB
10.	Solid Waste Management Rules, 2016	Provisions for collection, storage segregation, transportation, processing and disposal of municipal solid wastes	TNPCB / CPCB
11.	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	TNPCB / CPCB
12.	The Forest (Conservation) Act 1980 (Amended 1988) and Rules 1981 (Amended 2003); National Forest Policy of 1998	To protect and manage forests	Tamil Nadu Forest Department (TNFD) and MoEF&CC
13.	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) shall submit waste management plan and get appropriate approvals from the local authority before starting construction or demolition or remodeling work	TNPCB / CPCB
14	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	TNPCB / CPCB

Sl No.	Legislation	Objective	Responsible Institution
		concerned authorities shall examine the DEMOLITION PLAN submitted by the applicant to assess if there are any HW streams.	
15.	The Mines and Minerals (Development and Regulation) Act, 1957	To protect the environment from quarry operation	State Department of Geology and Mines
16.	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	Transport Commissionerate and State Transport Authority
17.	Indian Treasure Trove Act, 1878 (as modified up to September 1949); Ancient Monuments and Archaeological Sites and Remains Act (1958)	Conservation of Cultural and historical remains found in India Chance find during construction	Archaeological Survey of India (ASI)
18.	Annexure XXV, Special Rules for conservation of Heritage Buildings Vol II: Second Master Plan for Chennai Metropolitan Area 2026 amended May 2013	To protect heritage assets	Chennai Metropolitan Development Authority (CMDA)
19	National Policy on HIV/AIDS and the World of Work National Policy on Safety, Health and Environment at Workplace	To regulate the safety, health and environment at workplace	Department of Labour and Employment
20.	Building and Other construction workers (Regulation and the Employment and conditions of service) Act, 1996; Minimum Wages Act, 1948; Workmen's Compensation Act, 1923; The Contract Labour (Regulation & Abolition) Act, 1970 and Rules Employees State Insurance Act, 1948 (ESI); Minimum Wages Act, 1948, The Payment of Wages Act, 1936, amended in 2005; Maharashtra Labour Welfare Fund Act, 1953 (as amended) The Equal Remuneration Act 1976; Workmen's Compensation Act, 1923	To regulate the employment and conditions of service of building and other construction workers and to provide for their safety, health and welfare measures	Department of Labour and Employment
21.	Interstate Migrant Workers Act 1979	In case workers and labourers working at the project sites are migrants from other states during construction	Department of Labour and Employment

Sl No.	Legislation	Objective	Responsible Institution
22.	Child 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	Department of Labour and Employment
23.	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

27. As per GoI EIA Notification 2006, all railways and metro rail projects in India are exempted from Environmental Clearance (EC), this is applicable for Corridor 4 as well. Chennai being a coastal city, Light House to Foreshore Road falls under the coastal areas CRZ II and IVB prescribed in the CRZ Notification 2019 and requires CRZ clearance from TNCZMA and NCZMA.

28. Before the start of civil works for any section of Corridor 4, CMRL has obtained necessary clearances/permissions from statutory authorities such as MOEF&CC, TNPCB, CMDA, DGC etc. For implementation of Corridor 4, required clearances/ permissions related to environment, social and forests have been summarized in Table 2.2.

Table 2.2: Applicable Permissions and Clearances Required for Corridor 4

Sl. No.	Permissions/ Clearances	Acts/Rules/Notifications/ Guidelines	Concerned Agency	Responsibility
A. Pre-construction Stage				
1.	Permission for felling of trees	Forest Conservation Act, 1980 Tamil Nadu Government Order No 39 date 02.07.2021 and G.O No 66 dated 07.04.2022	District Green Committee and State Green Committee (DGC & SGC)	CMRL (Obtained Permission for tree felling and translocation)
2.	CRZ clearance for CRZ II CRZ permission for CRZ IVB	CRZ Notification, 2011	TNCZMA & NCZMA, MoEF&CC	CMRL (Obtained)
3.	Permission of construction near the National Shrine of St. Thomas Basilica, Santhome High Road; Rosary Church, Rosary Church Road and Our Lady of Light	The Ancient Monuments and Archaeological Sites and Remains (Amendment) Bill, 2018 Annexure XXV, Special Rules for conservation of Heritage Buildings Vol II: Second Master Plan for	Member Secretary Heritage Committee CMDA	Contractor and CMRL (Obtained)

Sl. No.	Permissions/ Clearances	Acts/Rules/Notifications/ Guidelines	Concerned Agency	Responsibility
	Shrine, Luz Church Road, which are located within 100m from the alignment of Corridor 4	Chennai Metropolitan Area 2026 amended May 2013		
4.	Building Permissions for an stations depots d	Second Master Plan for Chennai Metropolitan Area 2026 amended May 2013	CMDA	Contractor and CMRL (Obtained)
B. Implementation Stage				
5.	Consent to Establish and Consent to Operate for Batching Plant and Grouting Plant,STPs,Diesel Generators	Air (Prevention and Control of Pollution) Act 1981 The Water (Prevention and Control of Pollution) Act 1972 (Amended 1988) and Rules 1974	TNPCB	Contractor engaged by CMRL. (CTOs are obtained for construction plants,Batching, grouting plants , STP sand DG sets being utilized under corridor 4)
6.	Permission for dewatering of groundwater[6]	Environment (Protection) Act, 1986 Chennai Metropolitan Area Groundwater (Regulation) Act, 1987 as amended till 2008 Guidelines/Criteria for evaluation of proposals/requests for ground water abstraction (With effect from 16.11.2015)	Head of Municipal Area (Greater Chennai Municipal Corporation) and CGWA	Contractor engaged by CMRL (Not applicable as of now)- If required the contractor will obtain permission for the CGWA.)
7.	Consent to recharge groundwater with tunnel dewatering water	Water (Prevention and Control of Pollution) Act 1974 amended 1988, Environment (Protection) Amendment Rules, 2017 (Discharge Standard for Sewage Treatment Plants (STPs)), Model Groundwater (Control and Regulation) Bill 1970, amended in 1972, 1996 and 2005	CGWB/PWD	Contractor engaged by CMRL (Not applicable as of now)If required the contractor will obtain from the CGWA s)

[6] 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	Responsibility
8.	Authorization for storage (diesel) and disposal of Hazardous Waste	Hazardous and Other Wastes (Management& Transboundary Movement) Amendment Rules, 2019	TNPCB	Contractor engaged by CMRL(Obtained from TNPCB)
9.	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 STPs)	TNPCB	Contractor engaged by CMRL (Obtained from TNPCB)
10.	Pollution Under Control Certificate for various vehicles use for construction	Central Motor and Vehicle Act, 1988	Transport Commissionerate and State Transport Authority , GoTN authorized testing centers	Contractor engaged by CMRL (Obtained) .
11.	Employing Labour/ workers	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	District Labour Commissioner, GoTN	Contractor engaged by CMRL (obtained)
12.	Roof Top Rainwater Harvesting (RWH)	Central Groundwater Authority (CGWA) Guidelines and Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) NBC – Rainwater harvesting guidelines	CGWA / CMWSSB ,TNPCB,PWD	Contractor engaged by CMRL (Implemented))
13.	Permission for use of fresh water for construction and drinking purpose.	Environment (Protection) Act, 1986	Chennai Metropolitan Water Supply & Sewerage Board and CMWSSB	Contractor engaged by CMRL (Agreement made between contractor and CMWSSB)

Sl. No.	Permissions/ Clearances	Acts/Rules/Notifications/ Guidelines	Concerned Agency	Responsibility
14.	Permission for Quarry Operation	The Mines and Minerals (Development and Regulation) Act, 1957	State Department of Mines and Geology	Contractor engaged by CMRL (Obtained)
15.	Authorization for Disposal of Construction and Demolition Waste	Construction and Demolition Waste Management Rules, 2016	TNPCB	Contractor engaged by CMRL (Obtained)
16.	Heritage Assets (St. Thomas Basilica, Rosary Church and Our Lady of Light Shrine)	Annexure XXV, Special Rules for conservation of Heritage Buildings Vol II: Second Master Plan for Chennai Metropolitan Area 2026 amended May 2013	CMDA	Contractor engaged by CMRL (Obtained)
17.	Consent to Establish labour camps, precasting and material yards, hot mix plant, grouting plant crushers, batching plant, stations, depots	Air, Water and Noise Regulations	TNPCB	Contractor engaged by CMRL To be obtained (Obtained)
18.	Consent to muck/waste disposal	Construction & Demolition Waste Management Rules 2016 Solid Waste Management Rules 2016	TNPCB	Contractor engaged by CMRL (Obtained from the District Collector)
19.	Consent to Operate Depot and Compliance with discharge norms of wastewater	Water (Prevention and Control of Pollution) Act 1974 amended 1988; The Tamil Nadu Water (Prevention and Control of Pollution) Rules, 1983 amended May 2009; Environment (Protection) Amendment Rules, 2017 (Discharge Standard for Sewage Treatment Plants(STPs))	TNPCB	CMRL (Obtained)

Sl. No.	Permissions/ Clearances	Acts/Rules/Notifications/ Guidelines	Concerned Agency	Responsibility
20.	Installation and operation of DG sets at stations and depots	Air (Prevention and Control of Pollution) Act, 1981 amended 1987; CPCB Notification April 1994 of National Ambient Air Quality Standards and DG Guidelines Environmental Protection (Amendment) Rules, Noise Pollution (Regulation and Control) Rules, 2000	TNPCB	CMRL (Obtained)
21.	Transportation and Storage of Diesel (HSD) – Class B (No need of license for transport or storage if total quantity in possession at any one place does not exceed 2500 liters and none of it is contained in a receptacle exceeding 1000 liters in capacity)	Petroleum Rules, 2002	Petroleum and Explosives Safety Organization (PESO)	Contractor engaged by CMRL.(Not applicable current storage is less than 2500 liters)

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)**
The 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 MoEF&CC appraises these statements/ assessments and approves the project from the environmental angle.

33. **Tamil Nadu Pollution Control Board (TNPCB): The** 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 groundwater 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):** The NGT was 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 and 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

No.	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	Bonn convention - 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

No.	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

No.	Atmospheric emissions
1	UNFCCC (United Nations Framework Convention on Climate Change)
2	Kyoto Protocol
3	Vienna convention for Ozone Protection
4	Paris Agreement
5	UNCCD (United Nations Convention to Combat Desertification)
6	Montreal Protocol (on Ozone Depleting Substances)

D. Marine environment

No.	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) grievances. As a borrower, CMRL is entitled to ensure the implementation of the environmental and social framework and policies of the funding agencies.

2.3.1 Safeguard Policy Statement (SPS) July 2009 of ADB

40. The SPS 2009 is the policy set out by the ADB to address emerging environmental and social challenges of development in its developing member countries The objectives of ADB's safeguards are to: (i) avoid adverse impacts of projects on the environment and affected people, where possible; (ii) minimize, mitigate, and/or compensate for adverse project impacts on the

environment and affected people when avoidance is not possible; and (iii) help borrowers/clients to strengthen their safeguard systems and develop the capacity to manage environmental and social risks.

41. ADB's SPS 2009 sets out the policy objectives, scope and triggers, and principles for four key safeguard areas:

i. Safeguard Requirement 1: Environmental
ii. Safeguard Requirement 2: Involuntary Resettlement
iii. Safeguard Requirement 3: Indigenous Peoples
iv. Safeguard Requirement 4: Special Requirements for Different Finance Modalities.

42. 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 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.

2.3.2 Environmental and Social Framework (ESF) 2019 of AIIB

43. The AIIB's Environmental and Social Framework (ESF) is a system that supports the Bank and its clients in achieving environmentally and socially sustainable development outcomes. The objectives of this ESF are to:

40.1 Reflect institutional aims to address environmental and social risks and impacts in Projects (defined below in Section II, Definitions, of the ESP).
40.2 Provide a robust structure for managing operational and reputational risks of the Bank and its shareholders in relation to Projects' environmental and social risks and impacts.
40.3 Support the environmental and social soundness and sustainability of Projects.
40.4 Facilitate the integration of environmental and social aspects of Projects into the decision-making process by all parties.
40.5 Provide a mechanism for addressing environmental and social risks and impacts in Project identification, preparation,
40.6 and implementation.
40.7 Enable Clients (defined below in Section II, Definitions, of the ESP) to identify and manage environmental and social risks and impacts of Projects, including those of climate change.
40.8 Provide a framework for public consultation and disclosure of environmental and social information in relation to Projects.
40.9 Provide a grievance redress mechanism designed to enable Project-affected people to voice their concerns and grievances in connection with the environmental and social aspects of Projects.
40.10 Improve development effectiveness and impact to increase results on the ground, in both the short and long term.
40.11 Support Clients, through Bank financing of Projects, to strengthen their environmental and social management systems.
40.12 Support Clients, through Bank financing of Projects, to implement their obligations under national environmental and social legislation (including under international agreements adopted by the Member) governing these Projects, including commitments relating to climate change.
40.13 Support Clients, where feasible and appropriate, to mobilize resources for technical assistance for the preparation of environmental and social documents and capacity enhancement.

40.14 Facilitate cooperation on environmental and social matters with development partners.

44. ESF of AIIB comprises the following:

i. Environmental and Social Policy (ESP). This comprises mandatory environmental and social requirements for each Project

ii. Environmental and Social Standards (ESS). Three associated mandatory environmental and social standards (ESSs) set out more detailed environmental and social requirements relating to the following:

- ESS 1: Environmental and Social Assessment and Management;
- ESS 2: Involuntary Resettlement; and
- ESS 3: Indigenous Peoples.

2.3.3 Environment and Social Framework (ESF) 2016 of NDB

45. ESF of NDB comprises the Environmental and Social Policy and three Environment and Social Standards:

- ESS 1: Environment and Social Assessment: Screening, impact assessment, alternatives, management plan, consultations, grievance mechanism, information disclosure, monitoring.
- ESS 2:Land Acquisition and Involuntary Resettlement
- ESS 3: Indigenous Peoples.

2.4 Applied Standards

46. The project will follow national as well as international best practices and standards related to environment, health and safety including IFC/WB Environmental, Health, and Safety (EHS) General Guidelines (April 30, 2007) and Federal Transit Administration (FTA) USA vibration standards, whichever is more stringent.

3. DESCRIPTION OF THE PROJECT

3.1 Rationale

47. 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 2018.7 By 2030, Indian cities are projected to be home to another 250 million people. High technology and export-oriented manufacturing jobs are growing fastest in the outskirts of large metropolitan areas. The metropolitan areas are facing extremely high population densities and traffic congestion. Infrastructure development remains key to plan urban development taking into consideration economic activities, mobility, and environmental and social outcomes.

48. GoI has made efforts to reform the transport sector in recent years. To create safe, affordable, quick, comfortable, reliable, and sustainable urban transport systems for Indian cities, the Ministry of Housing and Urban Affairs (MoUHA) 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 November 2023, metro line services with a total length of 895 km are operational in India.[8]

49. Chennai, the capital city of the state of Tamil Nadu, is part of the CMA playing a vital role in the economy of South India. The CMDA devised the Chennai Second Master Plan 2026 and estimated that the population and daily passenger traffic would grow to 12.6 million people and 20.8 million in 2026, respectively.[9] 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 centres. 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.

50. 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. 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.[10] Chennai also recorded the highest number of road incidents in India, with a staggering 7,846 cases in 2016.[11]

51. CMRL, a joint venture of the GoI and GoTN with equal equity ownership, is responsible for implementing, operating, and maintaining the city's metro system. CMRL developed The Comprehensive Mobility Plan (CMP) 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.

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[7] https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=IN [11]
Urbanization Beyond Municipal Borders, The World Bank, 2013.
[8] Press Information Bureau, Ministry of Housing and Urban Affairs, Government of India,
[9] Second Master Plan for Chennai Metropolitan Area 2026, Chennai Metropolitan Development Authority, 2008.
[10] International Council for Local Environmental Initiative Study, 2012.
[11] Accidental Death and Suicides in India (ADSI), National Crime Records Bureau, 2016.

3.2 Description of the Corridor 4

52. The Phase I and Phase I Extension of the Chennai Metro Rail covers 54 km in two corridors, with 45 km in Phase I started its operations since 2015 and another 9 km of Phase I Extension commenced its operational from 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.

53. The Chennai Metro Corridor 4 from Lighthouse to Poonamalle Bypass has a length of 25.8 km, of which 15.8 km is elevated, and 10.0 km is underground, with 18 and 9 stations, respectively. Stations of Corridor 4 are depicted in Figure 3.1 and summarized in Table 3.1.

Figure 3-1: Corridor 4 (*Updated April 2021*)

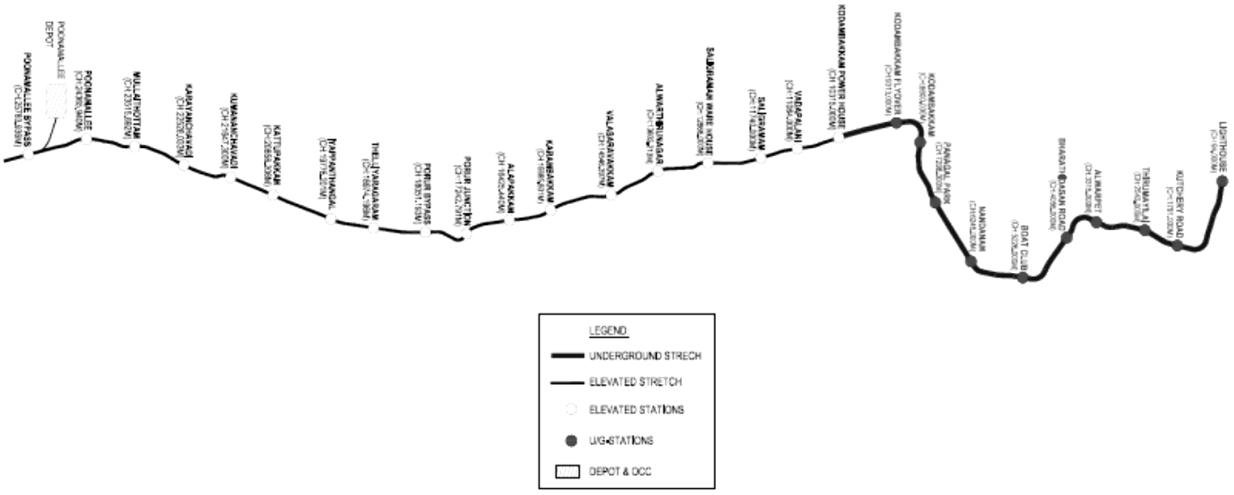


Table 3.1: List of Stations –Corridor 4

No	Station Name	Chainage (m)	Inter-station Distance(m)	Elevated/ Underground
1	Lighthouse	17	-	UG (190x21.80) 2L
2	Kutchery Road	1565	1548	UG (190x21.80) 2L
	Thirumayilai Metro (in Corriodor 3)	2271	706	UG (190x21.80) 2L
3	Alwarpet	3090	819	UG (190x21.80) 2L
4	Bharathidasan Road	3833	743	UG (190x21.80) 2L
5	Boat Club Metro (formerly Adyar Gate Junction)	5005	1172	UG (150x21.40) 3L

6	Nandanam	6029	1024	UG (150x21.40) ML
7	Panagal Park	7131	1102	UG (150x21.40) 2L with ext. concourse
8	Kodambakkam Metro	8529	1398	UG (150x21.40) ML
9	Kodambakkam Power House	10314	1785	Elevated (140x21.95)
10	Vadapalani	11065	751	Elevated (140x21.95)
11	Saligramam	11741	676	Elevated (140x21.95)
12	Saligramam Warehouse *(formerly Avichi School)*	12685	944	Elevated (140x21.95)
13	Alwarthiru Nagar	13592	907	Elevated (140x21.95)
14	Valasaravakkam	14559	967	Elevated (140x21.95)
15	Karabakkam	15731	1172	Elevated (140x21.95)
16	Alapakkam Junction	16426	695	Elevated (140x21.95)
17	Porur Junction	17243	817	Elevated (140x21.95)
18	Chennai Bypass Crossing	18050	807	Elevated (140x21.95)
19	Thielliyaragaram (*formerly Ramchandra Hospital*)	18976	926	Elevated (140x21.95)
20	Iyappanthangal Metro	19741	765	Elevated (140x21.95)
21	Kattupakkam	20858	1117	Elevated (140x21.95)
22	Kumanan Chavadi	21654	796	Elevated (140x21.95)
23	Karyan Chavadi	22527	873	Elevated (140x21.95)
24	Mullaithottam	23516	989	Elevated (140x21.95)

25	Poonamallee Metro *(formerly Poonamallee Bus Terminus)*	24366	850	Elevated (140x21.95)
26	Poonamallee Bypass	25772	1406	Elevated (140x21.95)

Source: Detailed Design Consultant, CMRL

3.2.1 Land Use

54. Land use along the alignment is summarized in Table 3.2.

Table 3.2: Land use abutting the Alignment.

Corridor	Section / Station	Land Use
Lighthouse to Poonamallee bypass	Lighthouse	Institutional + Open Space Reservation along seafront on either side *
	Santhome Church	Institutional
	Lighthouse to Santhome Church	CRZ II & IV-B
	Nandanam to Panagal Park	Commercial + Residential * ^
	Kodambakkam Flyover (formally Meenakshi college)	Institutional + Residential *
	Kodambakkam Powerhouse to Vadapalani	Commercial + Residential on either side * ^
	Porur lake	Water body *
	Thellliyaragaram metro Ramachandra Hospital	Institutional + Residential on either side *

***** Figure 4.4Landuse in CMA 2006, Master Plan 2026
@ Ecologically Sensitive Areas in CMA, Master Plan 2026
^ Land use away from alignment is residential

55. 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 52 bore holes were drilled all along the proposed Corridor 4 alignment. Also, since the proposed site is located in Seismic Zone III (Modrate- Risk Zone) of India, suitable seismic measures will be adopted in the design of the structures.

3.2.2 Salient Design Features

56. The salient features of Corridor 4 Project are summarized in Table 3.3.

Table 3.3: Salient Features of Chennai Metro Corridor 4

Gauge(Nominal):	1435 MM
Route Length:	26.1 km (10.0 km Underground and 16.1 km Elevated)
Number of Stations:	26 (8 Underground and 18 Elevated)
Speed:	

1. Design Speed 80 kmph
2. Schedule(Booked)Speed 32 kmph

Train Operation Plan:

Particulars	2025	2035	2045	2055
Trains/hour (3 Car, 6 Car)	13 (13,0)	13 (6,7)	14 (3,11)	15 (0,15)
Head Way (Second)	277	277	257	240
Capacity (6p/m^2;8p/m^2)	9,958;12,675	15,628;19,878	19,634;24,969	23,640;30,060
Max. PHPDT Demand	11,707	18,944	23,816	29,940
Total Coach Requirement	78	129	156	186

Traction Power Supply:

1. Traction System Voltage 25 kV AC
2. Current Collection Overhead Electric Traction
3. Receiving Substations Two RSSs at Avichi School and Panagal Park stations (RSSs)

Power Demand (MVA):

Load	2025		2035		2045		2055	
	Normal	Emergency	Normal	Emergency	Normal	Emergency	Normal	Emergency
3 km from Kilpauk GSS-Panagal Park RSS (Chainage -255 to 7436) 7.691km								
Traction	2.45	8.39	3.62	12.41	4.40	15.10	5.36	18.38
Auxiliary	11.67	19.95	14.58	24.40	16.32	27.46	17.49	29.62
Total	14.12	28.34	18.20	36.81	20.72	42.56	22.85	48.00
3 .5 km from Koyambedu GSS-Avichi School RSS (Chainage -7436 to 25829) 1 8.38km								
Traction	5.94	8.39	8.79	12.41	10.70	15.10	13.02	18.38
Auxiliary	8.28	19.95	9.82	24.40	11.14	27.46	12.13	29.62
Total	14.22	28.34	18.61	36.81	21.84	42.56	25.15	48.00

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

Maintenance Facilities:

Maintenance depot has been proposed near Poonamalle Bypass station for 31 rakes of 6 cars for washing, maintenance and repairs of the rolling stock operation.

Signaling, Telecommunication and Train Control:

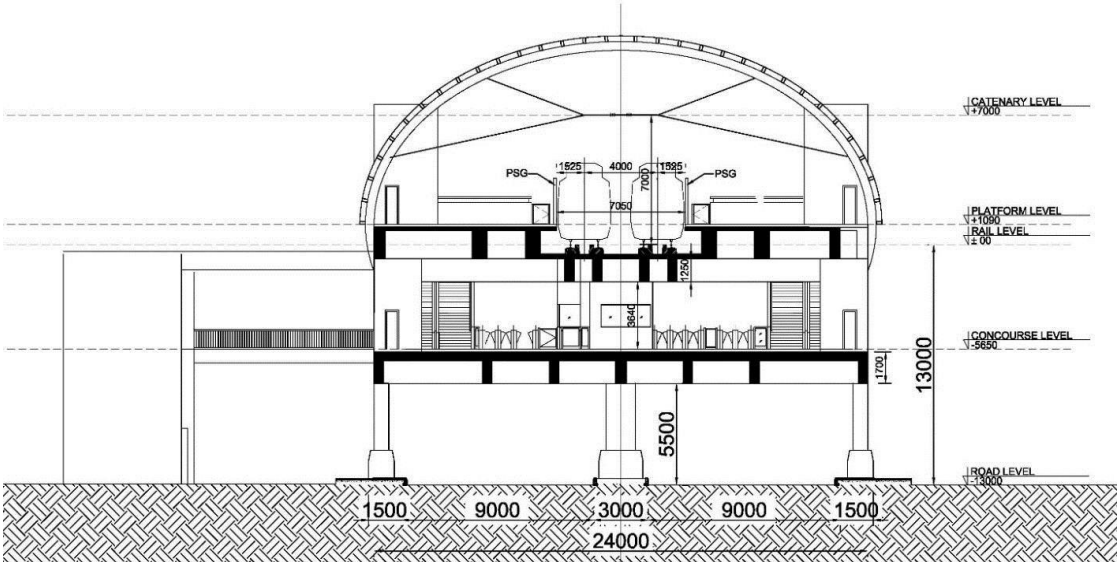
1. Type of Signaling — Communication based Train Control System (CBTC) with unattended train operation permitting an operational headway of 90 seconds.
2. Telecommunication — Integrated System with Optic Fiber cable, Supervisory Control and Data Acquisition (SCADA), Close Circuit Television (CCTV), Central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

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

3.2.3 Station Design

57. Elevated stations located at the median of existing roads will be 140 m long and 24 m wide. These elevated stations will be constructed using the cantilever method. The typical elevated station consists of three levels: ground, concourse and platform. Passenger facilities, operational and commercial areas are provided at the concourse level. Platforms will be at a level of 13 m and concourse floor at about 7 m above the road, with a minimum of 5.5 m of vertical clearance under the concourse. To reduce physical and visual impact, stations will be transparent with minimum walls on the sides. Figure 3.2 shows the typical elevated station.

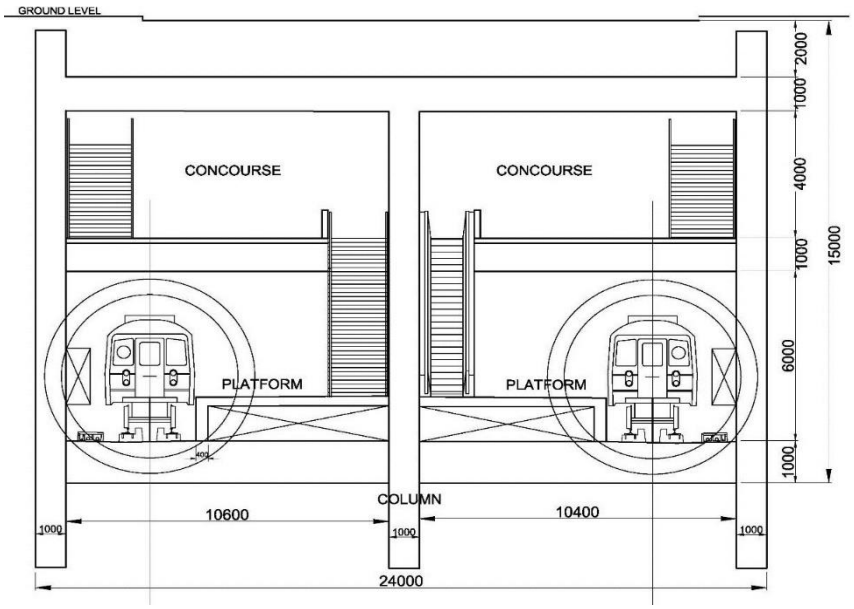
Figure 3-2: Typical Elevated Station



Source: Detailed Project Report for Chennai Metro Rail Phase II corridors, February 2017

58. The typical underground station is a two- or three-level station with entrances at ground level, a concourse with ticketing and passenger area, and platforms at the lowest level. Platforms will 140 m long and 12 m wide with easy accessibility features including escalators and elevators. Universal accessibility and green building features will be considered in the design. Two end concourses have been proposed, one at each end. The concourse is divided into paid and unpaid area. Since very limited space is available on the ground at station, all the over-ground structures are therefore, planned as and where space is available and are not necessarily grouped at ground level. The stations will be constructed using the cut and cover method. Figure 3.3 shows the typical underground station.

Figure 3-3: Typical Underground Station (2-level)



Source: Detailed Project Report for Chennai Metro Rail Phase II corridors, February 2017

3.2.4 Ventilation and Air-Conditioning System

59. The underground stations of the corridor are built in a confined space. A large number of passengers occupy concourse halls and the platforms, especially at the peak hours. The platform and concourse areas do not have adequate natural ventilation. It is therefore, essential to provide forced ventilation in the stations and inside the tunnel for the purpose of:

- Supplying fresh air for the physiological needs of passengers and the staff
- Removing body heat, obnoxious odors and harmful gases
- Removing large quantity of heat dissipated by the train equipment/fixtures
- Removing fumes and heat emitted by station equipment/fixtures

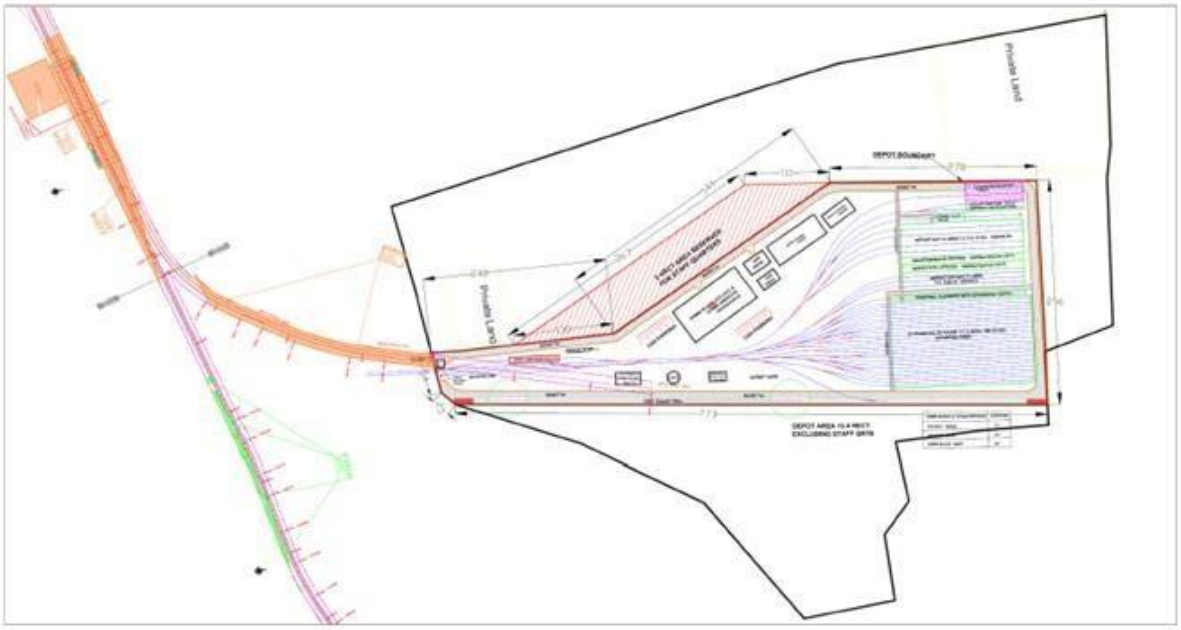
60. The tunnel ventilation shaft will be provided at each end of the station vertically from ground to concourse or platform level.

3.2.5 Depot

61. Major maintenance depot is proposed at Poonamalle Bypass. The depot comprises automatic coach washing plant, Operations Control Centre, maintenance infrastructure viz stabling lines, scheduled inspection lines, workshop for overhaul, unscheduled maintenance for the rolling stock and maintenance facilities for Civil – track, buildings, water supply; electrical – traction, E&M; signaling & telecommunication; automatic fare collection etc. Figure 3.4 shows the layout plan of Poonamalle Depot, which is proposed to have the following functions:

- Major overhauls of all the trains.
- All minor schedules and repairs.
- Lifting for replacement of heavy equipment and testing thereafter.
- Repair of heavy equipment.

Figure 3-4: Layout Plan of Poonamalle Depot



4

3.2.6 Labour Camp

62. The Contractor during the progress of work, will provide, erect and maintain necessary (temporary) living accommodation and ancillary facilities for labour. Contractor has established labor camps as part of the project. Emphasis was be given to use existing facilities (established under ongoing lines). However, locations of the camps was finalized after consultation with CMRL. The Contractor engaged by CMRL will also coordinate with the CMDA for land use clearance, TNPCB and Greater Chennai Corporation to establish the labour camps before construction. Selection of sites for labour camps must follow the guidelines for site selection as included in Annexure 10.

3.2.7 Construction Activities and Methodology

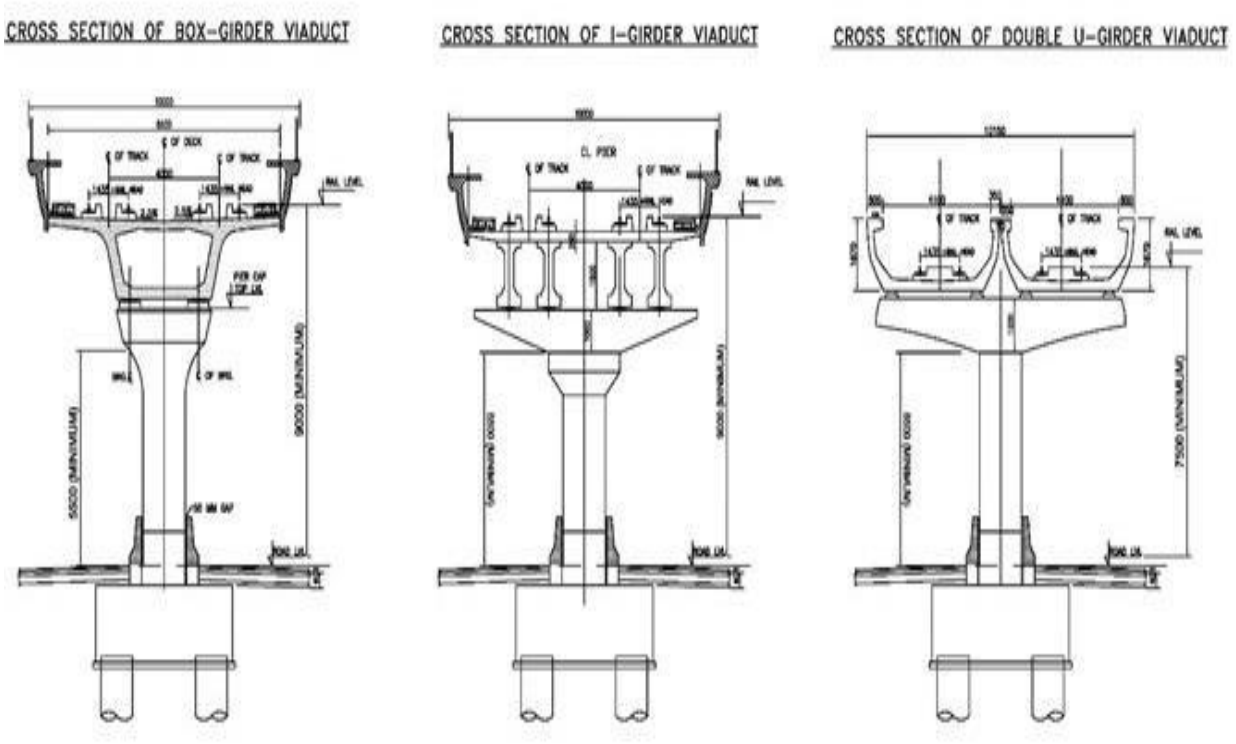
63. Main construction activities include demolition of structures (see Resettlement Plan) and ground clearing; Excavation and fill; Tunneling; Transport of construction materials, muck and waste; Casting of concrete elements and preparation of concrete and their transportation; Pile driving where cast-in-situ is not feasible, blasting in rock etc.

64. Elevated Sections. Substructure - open foundation, pile, pile caps, columns; station structure; earth retaining structures shall are 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 (minimum) is required for setting up each construction yard.

65. Underground Sections. Usually sections between underground stations are constructed by tunneling using Tunnel Boring Machine (TBM) while underground stations are built by cut-and-cover method. In the latter method, sidewalls of excavation at stations are supported in various ways. Between two stations tunnel is constructed by TBM. It will be launched from launching shaft. It is dragged in station area and continues from other side of station. Ground settlement analysis and monitoring is required during tunneling by TBM. Two separate tunnels are constructed by two different TBM. The initial plan is to enter two TBM's at Lighthouse Station, exit at Boat Club and the other four TBM's to enter at Panagal Park and exit at Boat Club (two TBM's) and Kodambakkam Flyover (two TBM's). Depending upon the soil/rock strata, suitable type of TBM shall be used for tunneling. Locations where deployment of TBM is not possible (tunneling of short length, cross passages, underground stations which are not possible by cut and cover method etc.) are tackled by New Austrian Tunneling Method (NATM). Excavated soil will be used as backfill where possible; it is estimated a surplus of 940,000 m^3 of soil needs to be disposed of (see paragraph 5.3.1).

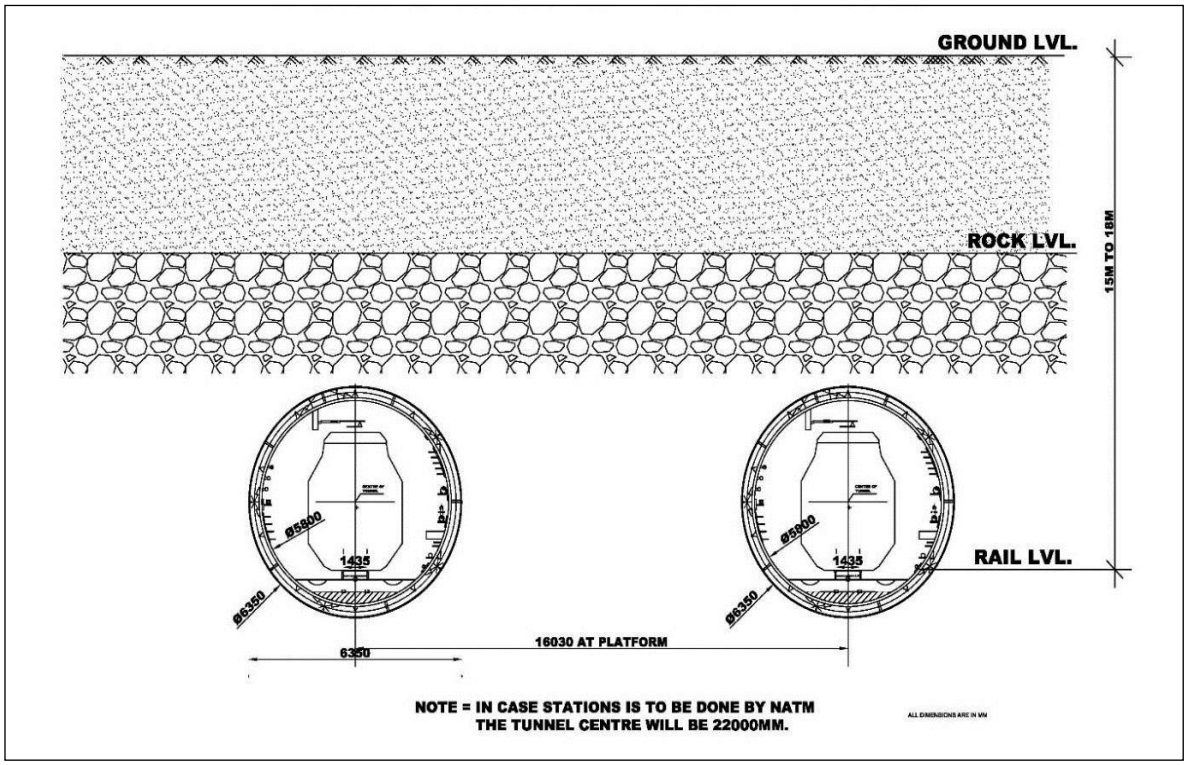
66. The typical viaduct and tunnel are shown in Figure 3.5 and 3.6.

Figure 3-5: Typical superstructure of viaduct



Source: Detailed Project Report for Chennai Metro Rail Phase II corridors, February 2017

Figure 3-6: Typical Twin Tunnel Section



Source: Detailed Project Report for Chennai Metro Rail Phase II corridors, February 2017

3.2.8 Integrated Grade Separator system at Kattupakkam

67. Tamil Nadu State Highways Department of GoTN proposed to construct a two-level Grade Separator comprising road at first level and Metro rail at Second level for a length of 2 kms at Kattupakkam. Kattupakkam Integrated Grade separator is located between P381 to P424 (48 piers) , overall length of integrated grade separator has been reduced to 1.527 Kms, which included of two stations such as Kumananchavadi and Karayanchavadi.In the 4th Steering committee meeting of Highways and Minor ports department, it was discussed and agreed to construct integrated structure supporting highways and Metro structures. Further, it was agreed that the design & construction will be carried out by CMRL. CMRL has prepared the DPR based on General Arrangement Drawing (GADs) approved by Highways Department(HD). The geographical representation of the grade separator layout are shown in Fig.3.7, Fig 3.8

Figure 3-7 Location of the Proposed Integrated Separator

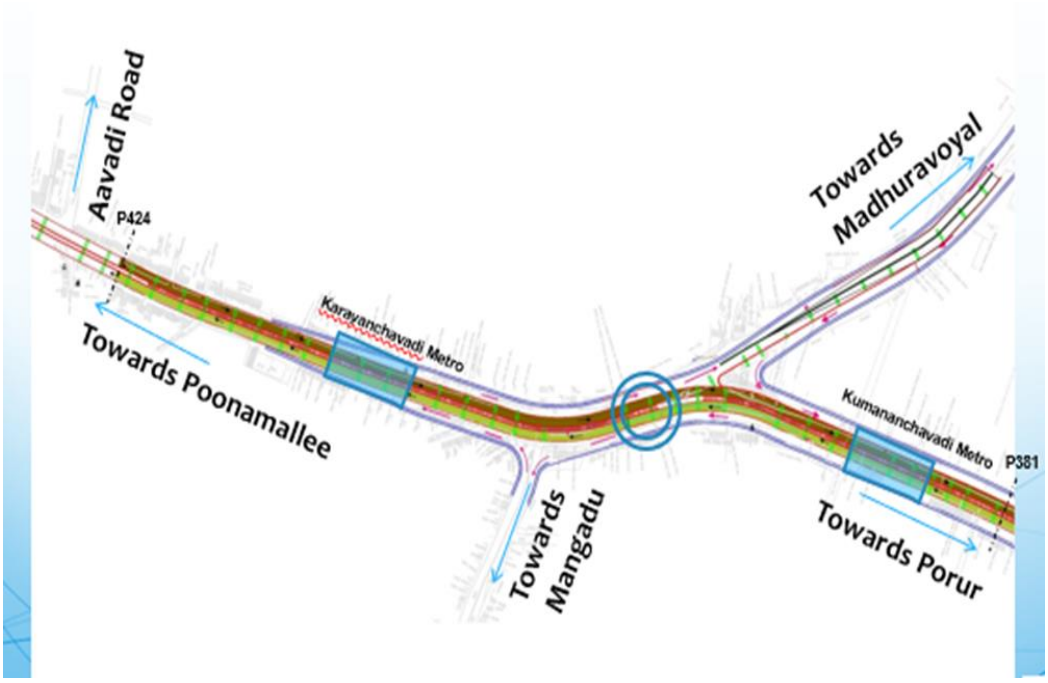
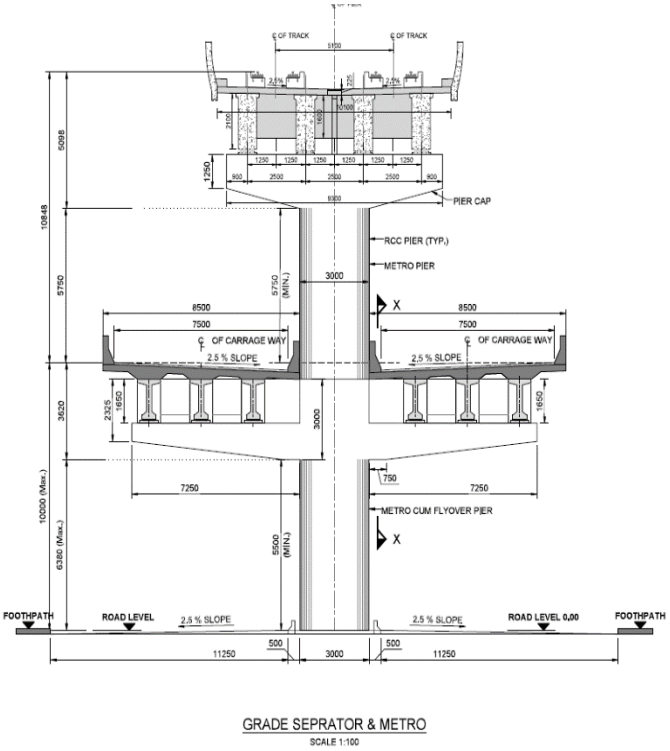
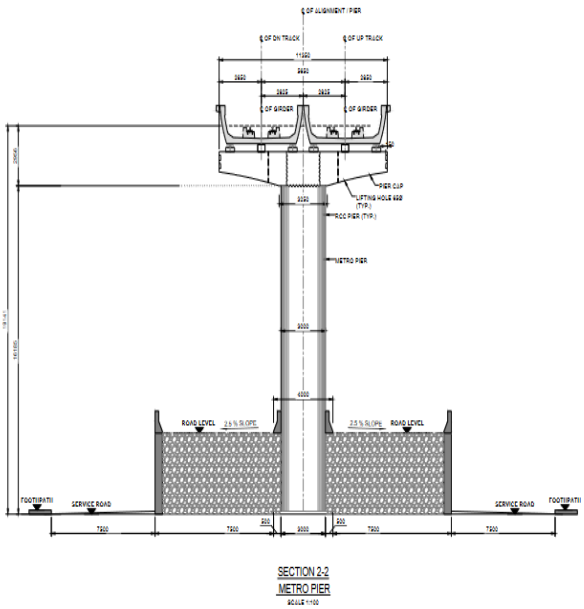
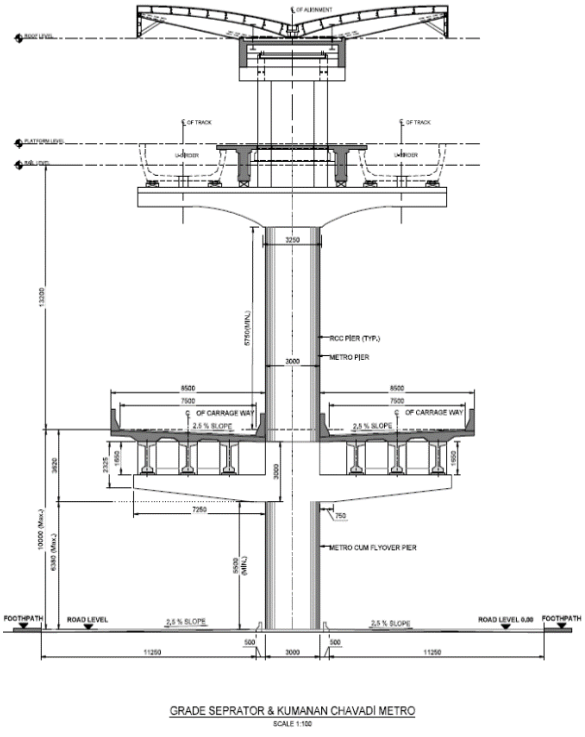


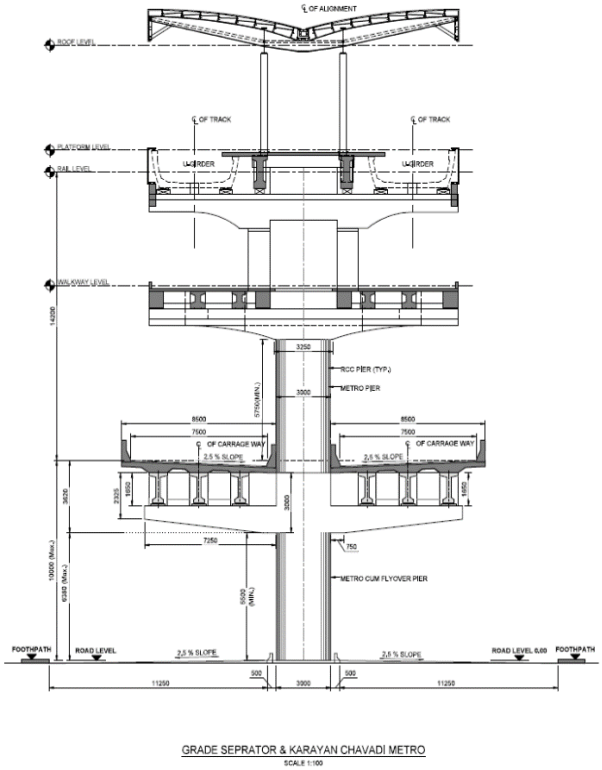
Figure 3-8 Typical Cross Section of Integrated Grade separator cum Via duct







Grade Separator at Kumananchavadi Metro



Grade Separator at Karayanchavadi Metro

3.3 Associated Facilities

68. As per ADB's SPS 2009, the 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; and (iii) necessary for the Project to be viable and would not be constructed or expanded if the Project did not exist.

69. Associated facilities for Corridor 4 are the power transmission/distribution system, existing grid substations (GSS) and water supply network. The construction and operation of Corridor 4 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, signaling & telecom, firefighting etc. and workshops, depots & other maintenance infrastructure 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.

70. 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, two Receiving Substations (RSS) are 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 for Corridor 4. M/s TANGEDCO has confirmed the availability of supply.

71. 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 Corridor4. Each elevated station shall be provided with an Auxiliary Substation with two 33kV/415V, 3phase, 500 kVA dry type cast resin transformers and the associated HT & LT switchgear. In addition, provision shall be made for one DG set at each station for emergency loads. Two transformers (33kV/415V, 3-phase) of 3.2 MVA at each underground ASS for the underground stations are proposed to be installed (one transformer as standby). In addition, it is proposed to provide standby DG set of 250 kVA at all elevated stations and 2 x 910 KVA capacity at underground stations to cater to all emergency loads. Power Demand is estimated in Table 3.3.

72. During construction, water consumption will be of the order of 492 KLD for construction and 780 KLD for labour camps. During operation, the water demand at depot and stations comprising train washing, drinking, toilet, cleaning and air conditioning in Chennai will be of the order of magnitude indicated in Table 3.4. The water requirement for the stations will be met through the public water supply system. i.e. through CMWSSB. CMWSSB water supply will be supplemented by rainwater harvesting at elevated stations. Source : CMRL Phase II DPR

Table 3.4: Water Requirement

S. No.	Particular	Water Demand at Each Station (KLD)	Total Water Demand (KLD)
1	In Underground stations with water softening plant	85.0	765
2	In Elevated stations without air conditioner	16.6	298.80
3	Depot	286	286
Total			**1,063.80**

73. In accordance with proposed packaging of Corridor 4, underground stretch, elevated stretch and depot will be financed by different MDB and constitute Associated Facilities to each package. The environmental impacts and mitigation measures of all packages are analyzed in this report.

3.4 Implementation Plan, Schedule and Cost

74. Corridor 4 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 stock etc. It is estimated that project will be commissioned 61 months from months from award of civil construction contracts. Table 3-5 shows the detailed schedule. The total capital cost of Corridor 4 is estimated to be USD 1,575 million for December 2018 including taxes and duties.

Table 3.5: Implementation Schedule of Corridor 4

S.N	DESCRIPTION	START	FINISH	REMARKS
1	LAND ACQUISITION	Jan-19	Jun-21	WIP
2	GEO TECH INVESTIGATION			
a	UNDER GROUND SECTION			
	Inviting the Tender for Geo tech Investigation, Evaluation & Awarding work	Aug-18	Dec-18	COMPLETED
	Geo Tech. & Survey Works (U.G Section)	Dec-18	May-19	COMPLETED
b	ELEVATED SECTION			
	Inviting the Tender for Geo tech Investigation, Evaluation & Awarding work	Jan-19	Jun-19	COMPLETED
	Geo Tech. & Survey Works (Elevated Section)	Jun-19	Jan-20	COMPLETED
3	DETAILED DESIGN CONSULTANT			
a	UNDER GROUND SECTION			
	Invite & Awarding tender for Detail Design Consultant Works	Aug-18	Mar-19	COMPLETED
	DDC -Execution of wok	Mar-19	Mar-25	COMPLETEDWIP
b	ELEVATED SECTION			
	Invite & Awarding tender for Detail Design Consultant Works	Dec-18	Jun-19	COMPLETED
	Detail Design Consultant Works	Jun-19	Jun-25	COMPLETEDWIP
4	GENERAL CONSULTANCY			
	Invite & Awarding tender for General Consultancy	Jan-20	Mar-21	COMPLETED
	GC works	Apr-21	Dec-26	COMPLETED
5	CONSTRUCTION OF UNDERGROUND STATIONS AND ASSOCIATED TUNNEL (C4-UG-01)- ADB			
	Inviting & Awarding Tender for Stations and associated Tunneling Works	Feb-21	Nov-21	COMPLETED
	Construction of Underground Stations and associated Tunneling Works	Dec-21	Dec-25	COMPLETED
6	CONSTRUCTION OF UNDERGROUND STATIONS AND ASSOCIATED TUNNEL (C4-UG-02)- ADB			

S.N	DESCRIPTION	START	FINISH	REMARKS
	Inviting & Awarding Tender for Stations and associated Tunneling Works	Feb-21	Nov-21	COMPLETED
	Construction of Underground Stations and associated Tunneling Works	Dec-21	Dec-25	COMPLETED
7	CONSTRUCTION ELEVATED STATIONS AND VIADUCT (C4-ECV-01)-aiibAIIB			
	Inviting & Awarding Tender for Stations and Viaduct Construction	Jul-20	Feb-21	COMPLETEDwip
	Construction of Elevated Stations and Viaduct	Mar-21	Dec-24	wip
8	CONSTRUCTION ELEVATED STATIONS AND VIADUCT (C4-ECV-02)- AIIB			
	Inviting & Awarding Tender for Stations and Viaduct Construction	Jul-20	Mar-21	COMPLETEDwip
	Construction of Elevated Station and Viaduct.	Apr-21	Dec-24	wip
9	CONTRUCTION OF DEPOT			
	Inviting & Awarding tender for Depot Construction	Jan-21	Aug-21	COMPLETED
	Construction of Depot	Sep-21	Sep-24	wip
d	Installation of Rails, turnout, fastening		Apr-26	
11	Systems works, testing, trial runs, commissioning		Dec-26	

wip: work in progress *Source CMRL Feb 2021*

The project progress status shall be presented in the monthly progress report (MPR), and quarterly progress report (QPR) under the Project.

4. DESCRIPTION OF THE ENVIRONMENT (BASELINE DATA)

75. 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 includes the characteristic of the 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, soil, ecology and biodiversity, and socioeconomic aspects. Secondary data were also collected from published sources and various government agencies.

4.1 Data Collection Methodology

76. The data on water, air, and noise were collected through field monitoring conducted in July 2016 and May 2017. The noise and vibration data were further elaborated in 2019 to include the sensitive receptors along the Corridor 4. Data on biodiversity was collected through field studies in May 2018. Meteorological data was collected from India Meteorological Department (IMD). 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 and Figure 4.2. 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	Physico-chemical parameters	17	Sampling/ Monitoring locations
Ambient Environment				
5.	Water Quality	Physical, Chemical and Biological parameters	17 (Groundwater) 1 (Surface)	Sampling/ Monitoring locations
6.	Ambient Air Quality	PM, SO_2, NO_2 and CO	26	Sampling/ Monitoring locations
7.	Noise	Noise levels in dB (A) Lmax, Lmin, Leq, L_{10}, L_{50}, L_{90}	26 by land use + 30 (Sample Sensitive Receptors)	Sampling/ Monitoring locations
8.	Vibration	Peak Particle Velocity in mm/s	13 (Sample Sensitive Receptors)	Sampling/ Monitoring locations
Ecological Environment				
9.	Flora and Fauna	Number	Once	Field Studies/

Sl. No	Attribute	Parameter	No. of Samples	Source
				Reconnaissance survey/ 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 the Sampling Locations to the Alignment (A: Air, W: Water; S: Soil, N: Noise)	Land Use**
4A	At Crossing of NH 4 Bypass & Poonamallee Flyover, 23m (A, W, S, N)	Commercial
4B	Near Kumunan chavadi Bus Stop, MSS Nagar 15m (A, W, S, N)	Residential
4C	Near Porur Lake, Padmavati Nagar, 27m (A, W, S, N)	Residential
5C***	Alwarthiru Nagar junction (A, W, S, N)	Residential
4D	Permal Street, Shradha Nagar, 16m (A, W, S, N)	Residential
4E	Vadapalani Junction, 54m (A, W, S, N)	Commercial
4F	Kodambakkam Meenakshi College, 75m (A, W, S, N)	Silence Zone
4G	Santhome Church, 36m (A, W, S, N)	Silence Zone
4H	Porur Lake (***water & soil only***), 58m (W, S)	Water body

Location Code	Distance from the Sampling Locations to the Alignment (A: Air, W: Water; S: Soil, N: Noise)	Test conducted	Land Use **
Baseline study (2021 - 2022)			
5A	Lighthouse	A,W,S,N	Commercial
5B	Kutchery Road	A,W,S,N	Commercial
5C	Thirumayilai Metro (in Corridor 3)		
5D	Alwarpet	A,W,S,N	Commercial
5E	Bharathidasan Road	A,W,S,N	Commercial
5F	Boat Club Metro (formerly Adyar Gate Junction)	A,W,S,N	Commercial
5G	Nandanam	A,W,S,N	Commercial
5H	Panagal Park	A,W,S,N	Commercial
5I	Kodambakkam Metro	A,W,S,N	Commercial
5J	Kodambakkam Flyover *(formerly Meenakshi College)*		
5K	Kodambakkam Power House	A,W,S,N	Commercial
5L	Vadapalani	A,W,S,N	Commercial
5M	Saligramam	A,W,S,N	Commercial
5N	Saligramam Warehouse *(formerly Avichi School)*	A,W,S,N	Commercial
5O	Alwarthiru Nagar	A,W,S,N	Residential+ commercial
5P	Valasaravakkam	A,W,S,N	Commercial
5Q	Karabakkam	A,W,S,N	Commercial

5R	Alapakkam Junction	A,W,S,N	Commercial
5S	Porur Junction	A,W,S,N	Commercial
5T	Porur Bypass crossing fromaly (Chennai Bypass Crossing)	A,,N,W	Commercial
5U	Thelliyaragram metro formaly Ramchandra Hospital	A,N	Commercial
5V	Iyappanthangal Bus Depot	A,N	Commercial
5W	Kattupakkam	A,N	Commercial
5X	Kumanan Chavadi	A,N	Commercial
5Y	Karyan Chavadi	A,N	Commercial
5Z	Mullaithottam	A,N	Commercial
6A	Poonamallee Metro *(formerly Poonamallee Bus Terminus)*	A,N	Commercial
6B	Poonamallee Bypass	A,N	Commercial

**Locations for noise and vibration at sensitive receptors are listed under Table 4.17 and Table 4.19 respectively.*
***As per CPCB guideline which is presented under Noise Section.*
****This sampling location is the shared alignment of Corridor 4 & 5.*

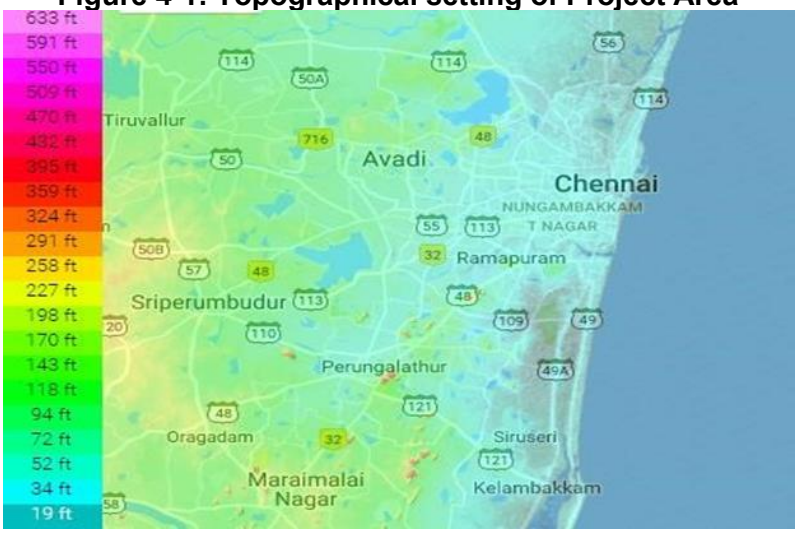
77. Sampling locations were selected to represent land uses along the alignment namely commercial, residential and silence zone (religious and educational uses). The baseline information is categorized as physical, ambient, ecological and socioeconomic environment with depiction in following sections.

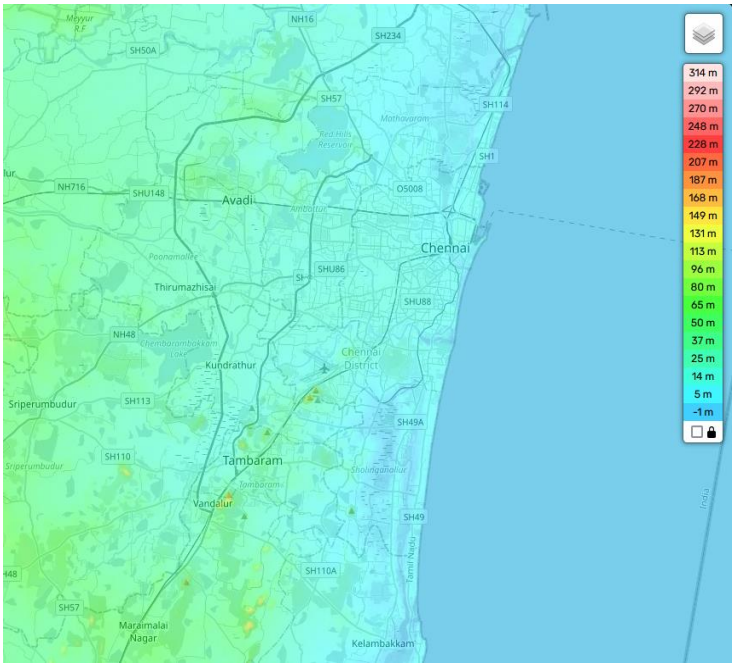
78. A further 270 environmentally sensitive receptors located within 200m on either side of alignment as listed in **Annexure 2** have been identified from site reconnaissance, comprising educational center's, religious places, hospitals and courts of law. To elaborate the baseline, a full set of baseline of air, water (surface and ground), soil, noise and vibration will be collected prior to the construction commencement.

4.2 Physical Environment

4.2.1 Physiography

Figure 4-1: Topographical setting of Project Area

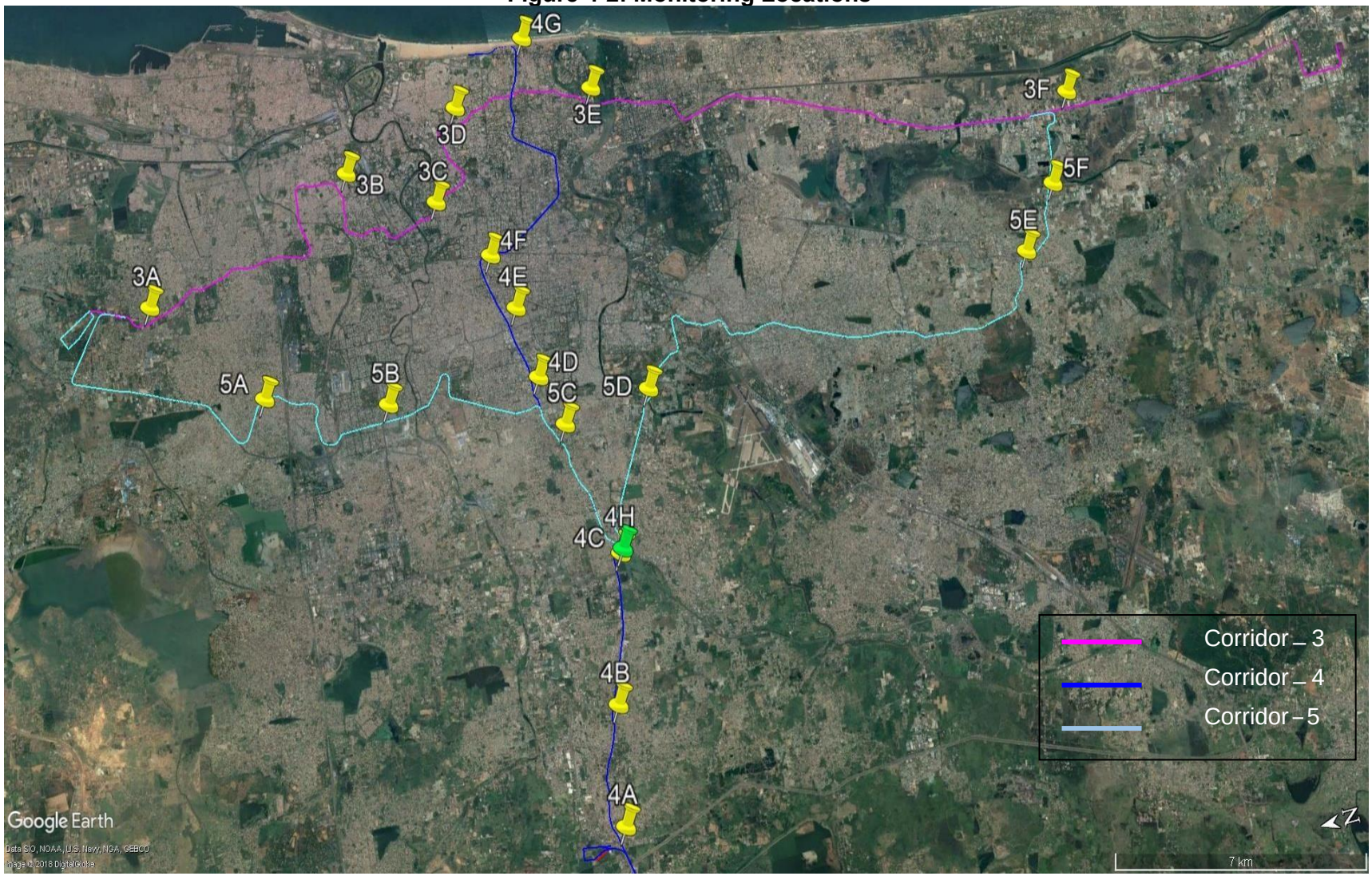




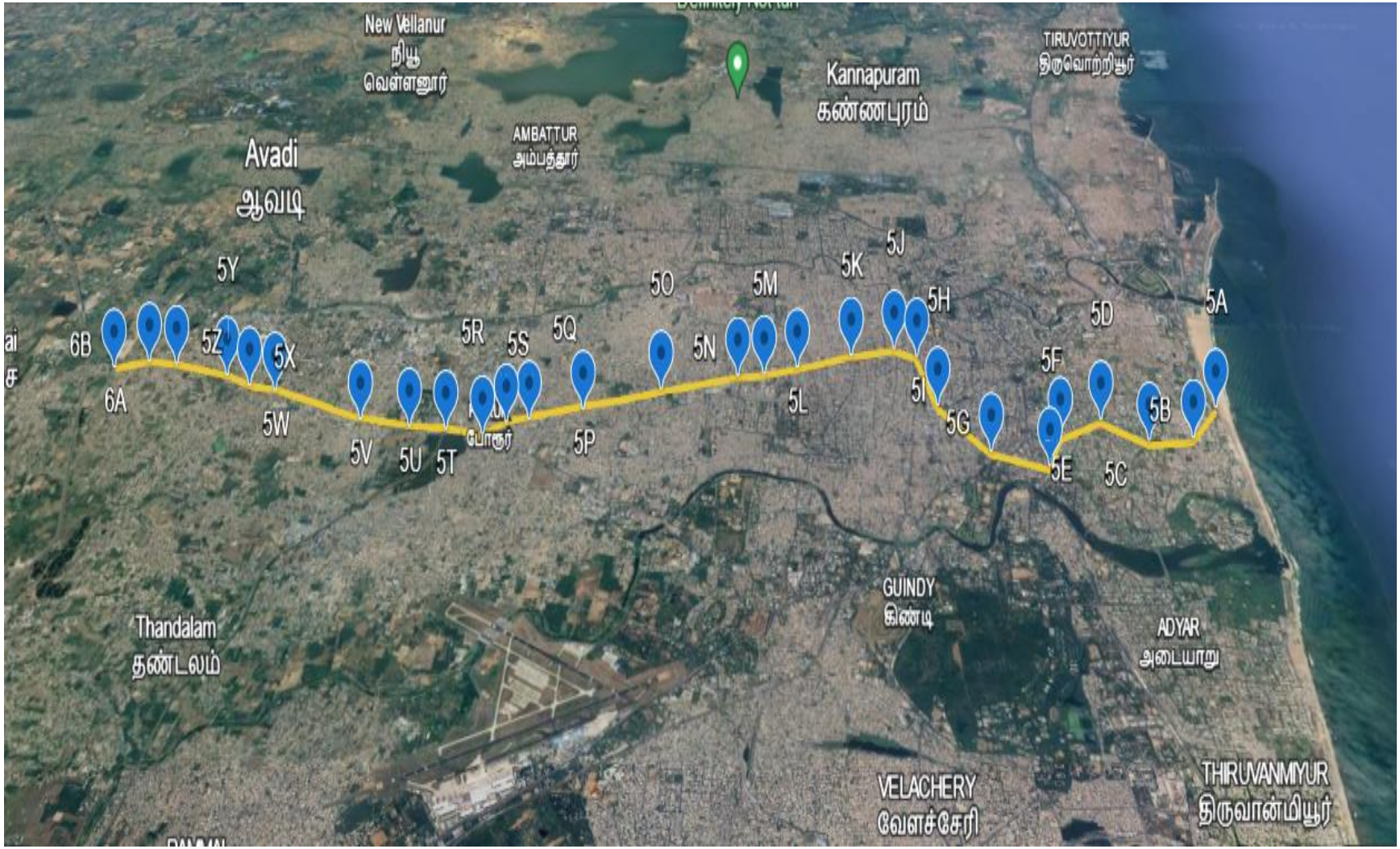
Source: https://en-gb.topographic-map.com/map-qjlf3/Chennai/?center=13.13766%2C79.9367&zoom=13

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 the project area is shown in Figure 4.1.

Figure 4-2: Monitoring Locations



Monitoring Locations – Soil, Air, Water & Noise by Land Use



Locations 5A to 6B; Field Survey: 2021- 2022

Table 4.3: Results of Laboratory Analysis of Soil Sample

S. No.	Parameter	Unit	Corridor 4									Soil Standards
			4A	4B	4C	5C	4D	4E	4F	4G	4H	
1	pH (at 25^0C)	-	8.24	8.2	8.05	7.11	7.98	7.23	7.10	7.02	8.14	6.0*
2	Conductivity (1:2 soil water sus.)	mS/cm	0.36	0.32	0.24	0.19	0.29	0.12	0.17	0.28	0.27	1*
3	Chloride	mg/kg	142.31	1223.09**	359.93	24.79	262.50	33.37	29.87	47.67	97.67	-
4	Total Zinc as Zn	mg/kg	72.13	68.36	69.14	12.35	70.54	14.32	13.28	14.22	57.49	-
5	Manganese as Mn	mg/kg	262.50	108.56	141.38	166.32	196.43	200.01	199.12	179.42	52.79	-
6	Total Lead as Pb	mg/kg	BDL	BDL	BDL	9.65	BDL	10.75	10.69	10.23	BDL	-
7	Total Copper as Cu	mg/kg	19.50	15.10	14.80	14.82	16.20	20.02	18.27	19.25	13.20	-
8	Organic Carbon	%	0.35	0.33	0.35	0.73	0.36	0.59	0.62	0.69	0.40	-
9	Water Soluble Sulphate	mg/kg	36.45	26.58	40.16	20.12	36.48	27.29	20.88	20.23	38.50	-
10	Boron	mg/kg	1.48	1.84	1.66	1.86	1.86	2.38	1.98	2.66	1.78	-
11	Iron	mg/kg	1343.34	1258.05	1299.51	420.37	1351.19	444.35	412.65	368.24	1210.29	-
12	Nickel	mg/kg	BDL	BDL	BDL	18.27	BDL	12.35	12.93	12.79	BDL	130
13	Bicarbonate	mg/kg	168.40	135.63	168.44	125.69	125.48	148.68	142.62	150.13	128.28	-
14	Calcium	mg/kg	665.33	625.25	480.96	140.09	384.77	108.16	145.06	136.29	436.87	-
15	Magnesium	mg/kg	34.05	102.14	41.34	27.28	89.98	28.12	20.36	28.13	38.91	-
16	Sand	%	22.41	32.53	32.97	34.93	38.86	34.09	34.45	33.45	36.54	-
17	Silt	%	59.37	59.19	59.34	38.88	56.04	39.67	38.88	40.05	59.56	-
18	Clay	%	18.22	8.28	7.69	28.19	5.10	24.27	26.67	26.50	3.90	-
19	Sodium	mg/kg	23.70	2.97	129.33	56.45	164.02	42.10	51.85	75.70	24.32	-
20	Potassium	kg/hec	176.98	372.97	271.60	70.18	249.50	97.16	88.38	98.92	200.49	-

S. No.	Parameter	Unit	Corridor 4									Soil Standards
			4A	4B	4C	5C	4D	4E	4F	4G	4H	
21	Sulphur	mg/kg	38.19	36.98	42.55	29.18	48.55	22.87	30.23	29.56	36.22	-
22	Organic Matter	%	0.60	0.57	0.60	1.26	0.62	1.02	1.08	1.19	0.69	-
23	Orthophosphate	mg/kg	12.40	10.12	5.80	70.65	16.54	67.09	59.54	68.98	16.54	-
24	Carbonate	mg/kg	5.65	16.54	10.20	2.99	4.20	5.10	4.92	4.36	6.40	-
25	Arsenic	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	32
26	Mercury	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	1
27	Cadmium as Cd	mg/kg	BDL	BDL	BDL	1.24	BDL	1.72	1.32	1.68	BDL	10
28	Molybdenum	mg/kg	BDL	BDL	BDL	0.60	BDL	0.69	0.76	0.80	BDL	-
29	Available Nitrogen	Kg/hec	140.86	146.54	172.50	199.97	158.40	304.51	269.61	308.12	189.80	-

** 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)*

*** As per the Geo-investigation report 2020, the Chloride as Cl ranges from 19.83 to 277.69 mg/kg.*

In 2021 - 2022, before the initiation of the construction activity, Soil samples were collected in 17 locations and tested for 16 parameters, and the results are recorded as shown in Table. 4-4

Table 4.4 Results of Laboratory Analysis of Soil Sample (2021 - 2022)

S. No.	Parameter	Unit	Corridor 4																	Soil Standards
			5A	5B	5D	5E	5F	5G	5H	5I	5K	5L	5M	5N	5O	5P	5Q	5R	5S	
1	pH value @ 25ºC	-	6.14	6.91	6.82	7.28	6.08	6.03	6.71	7.12	8.05	7.56	8.16	8.10	7.99	7.45	7.86	7.65	7.76	6.0*
2	Water Soluble Salts Electrical Conductivity @	µS/cm	320	508	494	646	125	142	458	704	121	134	470	128	115	117	112	131	119	1*
3	Organic Matter	%	0.41	0.66	0.64	0.83	0.14	0.16	0.57	0.89	2.42	2.68	1.8	2.62	2.3	2.35	2.29	1.9	1.4	-
4	Moisture Content @105º C	%	3.94	6.25	6.07	7.96	1.51	1.72	5.61	8.75	6.52	7.22	10.2	6.90	6.2	6.30	6.03	5.85	5.1	-
5	Chloride (as Cl-)	meq/L	0.83	1.31	1.27	1.67	0.32	0.37	1.20	1.86	1.16	1.28	1.5	1.21	1.1	1.11	1.06	1.017	1.51	-
6	Sulphates	mg/kg	0.11	0.17	0.16	0.21	0.04	0.04	0.13	0.19	4.82	4.86	18.3	4.64	6.2	4.24	4.06	3.93	2.71	-
7	Manganese (as Mn)*	mg/kg	2.97	4.69	4.41	5.98	1.18	1.36	4.22	6.63	13.4	14.8	52.4	14	12.7	12.9	12.3	10.8	8.1	-
8	Copper (as Cu)*	mg/kg	0.13	0.2	0.18	0.26	0.04	0.05	0.16	0.25	12.7	14.1	11.4	13.5	12.1	12.3	11.8	11.4	7.00	-
9	Cadmium (as Cd)*	mg/kg	0.08	0.13	0.11	0.16	0.03	0.02	0.10	0.14	0.21	0.23	0.6	0.21	0.2	0.2	0.19	0.18	0.12	-
	Lead (as Pb)*	mg/kg	0.16	0.24	0.21	0.32	0.04	0.05	0.18	0.26	1.96	2.16	2.93	2.1	1.86	1.89	1.81	1.78	1.22	
10	Chromium (as Cr)*	mg/kg	1.10	1.65	1.41	2.20	0.35	0.42	1.59	2.32	3.38	3.74	6.25	3.56	3.21	3.26	3.12	3.02	1.76	-
11	Selenium (as Se)*	mg/kg	1.51	2.27	2.20	3.03	0.46	0.58	2.17	3.17	0.11	0.12	0.15	0.1	0.10	0.1	0.1	0.12	0.19	-
12	Arsenic (as As)*	mg/kg	0.62	0.93	0.9	1.24	0.19	0.24	0.88	1.31	0.22	0.24	0.36	0.23	0.21	0.21	0.2	0.19	0.13	130
13	Nickel (as Ni)*	mg/kg	0.39	0.58	0.56	0.78	0.11	0.15	0.53	0.78	2.48	2.74	4.1	2.31	2.36	2.39	2.29	1.96	1.34	-
15	Boron (as B)*	mg/kg	0.80	1.19	1.14	1.61	0.23	0.31	1.08	1.61	3.38	3.47	3.8	3.29	3.21	3.01	2.88	2.78	1.91	-
16	Zinc (as Zn)*	mg/kg	1.17	1.72	1.63	2.35	0.36	0.45	1.60	2.34	9.15	10.1	8.2	9.63	8.7	8.81	8.43	8.16	5.62	-

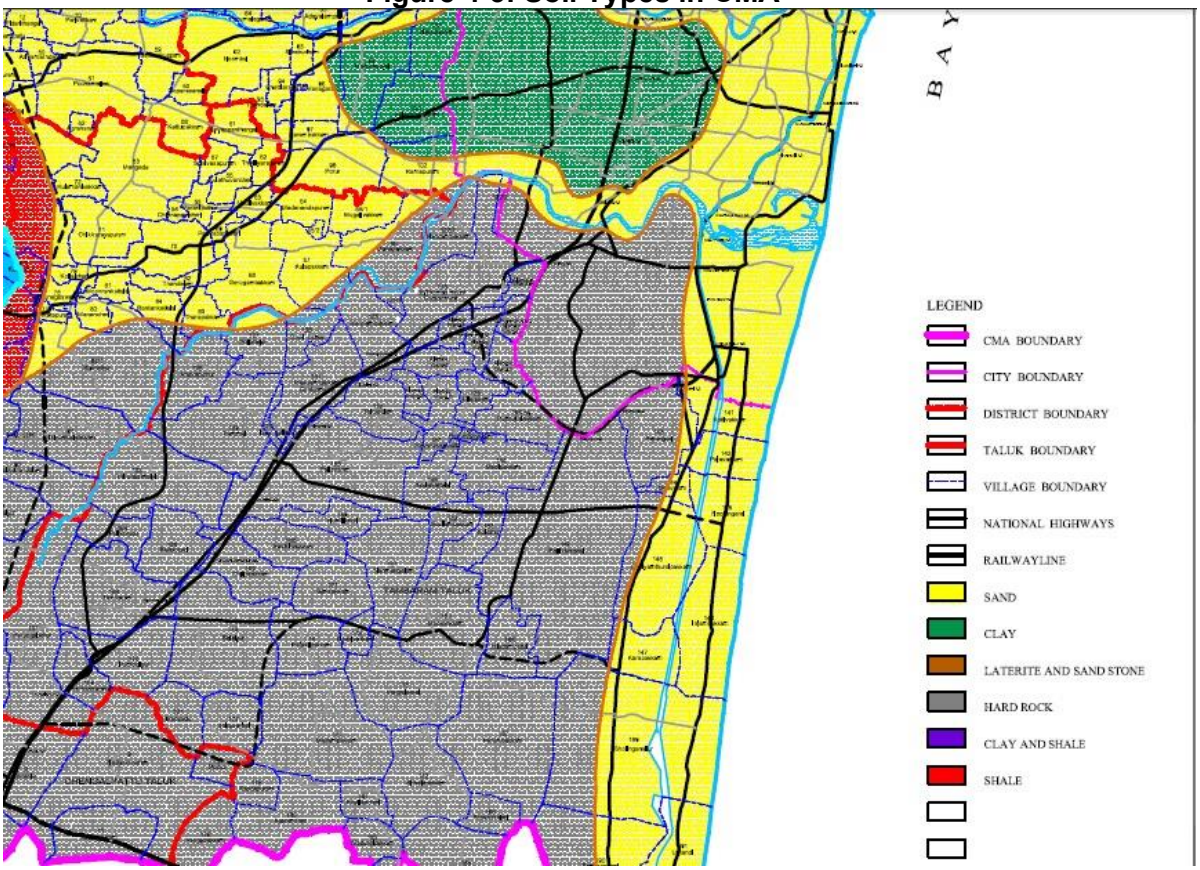
4.2.2 Soil

79. The sandy soil (Entisols) is immature soils and is predominant in the city and it occurs in small patches. The major soil in this region belongs to Alfisols and Entisols. Inceptisols and Vertisols are found in a very limited area only. These soils are generally poor in soil nutrients. They have medium to high permeability. They have low water holding capacity except in patches of clayey soils. The laboratory analysis results for soil are reported in Table 4.3. The soils are slightly alkaline in nature. Organic matter content in soils varies from 0.57% to 1.26%. The soil types found along the alignments, as recorded in the Master Plan 2026 for CMA are presented in Table 4.5 and Figure 4.3, subject to more specific findings from geotechnical investigations.

Table 4.5: Soil Types along alignment

Corridor / Section	Type of soil
Corridor 4	
Lighthouse to Nandanam	Sandy
Nandanam to Porur	Clay
Porur to Poonamallee bypass	Sandy

Figure 4-3: Soil Types in CMA



Second Master Plan for Chennai Metropolitan Area 2026, CMDA

80. The pH of the soil samples across all the sampling locations are observed to be alkaline. The conductivity of the soil is observed less than 1 mS/cm. The concentration of Zinc, Manganese, lead, copper, Nickel, Sulphur, Arsenic, Mercury, Cadmium (Cd) and Molybdenum are observed to be well within the limits (IS as well as ISO Soil standards). The recorded available

Nitrogen has been observed within medium range (in comparison with soil rating chart[15]) for samples collected at 4E, 4F and 4G, for other locations it is less than the stipulated limit of < 240Kg/ha.

4.2.3 Geology and Minerals

81. The geological formations in the region are from the Archaeans to the recent Alluvium (Table 4.6). 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. It is more than 130 m at Porur and Koyembedu whereas it exceeds 25 m in Ashok Nagar and 60 m in Sterling Road. The highly variable nature of Gondwana sediments indicated the irregularly eroded crystalline basement, over which the Gondwana sediments are deposited.

Table 4.6: Geological Formation in the Project Area

Geological succession in Chennai district Group	System	Age	Lithology	Aquifer Characteristics
Quaternary	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

82. While there is no great increase in extent of lands zoned for urban activities, the intensity of development is likely to increase in sparsely developed and less developed areas to optimum levels thus increasing the efficiency of urban form. Restricting reclassification and open layout developments would prevent urban sprawl beyond the area zoned for urban development.

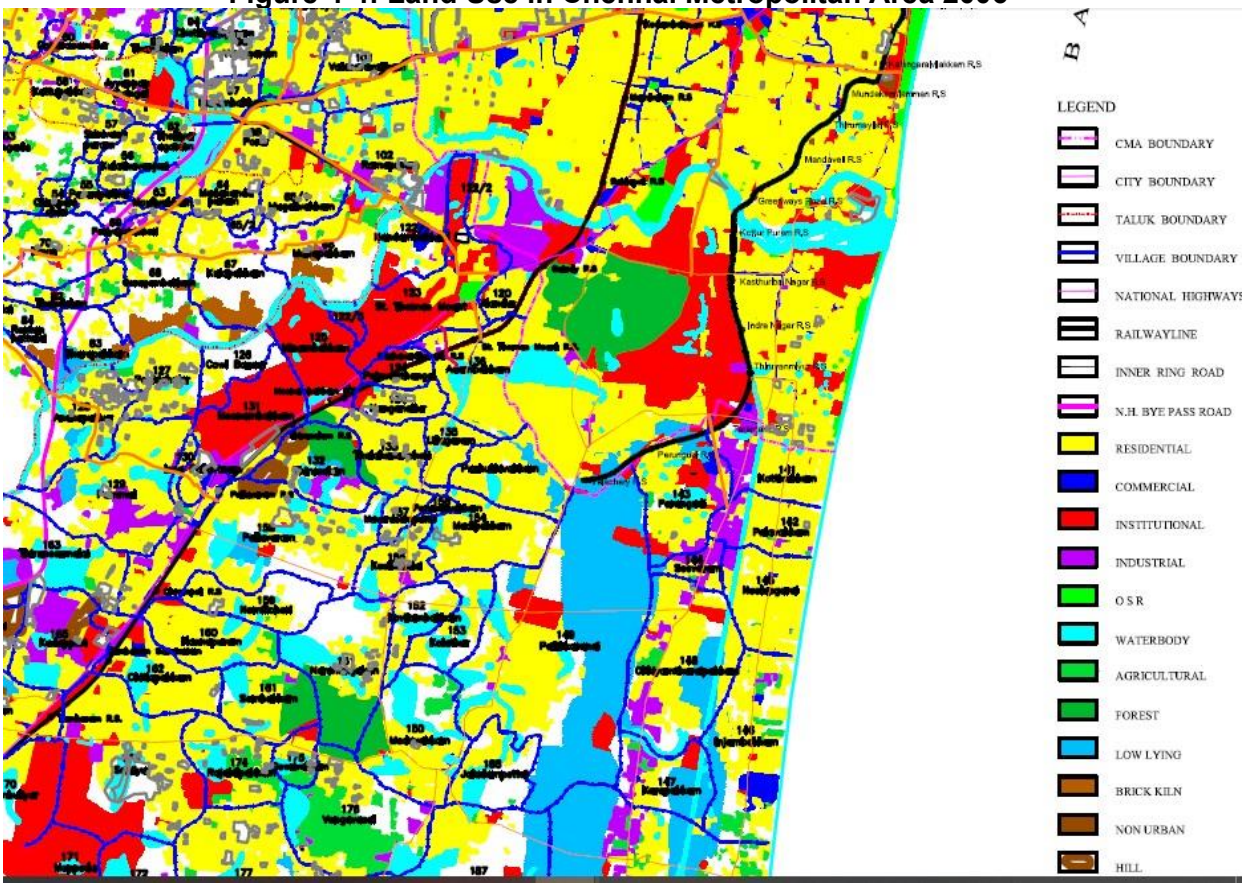
83. In the North, large industrial units are located at Ennore, Thiruvottiyur and Manali; industrial estates are located at Madhavaram, Kodungaiyur and Gummipoondi. In the West

[15] http://agritech.tnau.ac.in/agriculture/agri_soil_soilratingchart.html

important industrial locations include Ambattur, Padi and Sembiam. ICF Perambur and HVF Avadi are important industries under public sector. Many small and medium scale industries are located at Ambattur, Villivakkam, Thirumazhisai, Poonamallee and Noombal. Thermal power plant is located at Basin bridge. Hyundai car factory at Sriperumbudur, Hindustan Earth Movers at Tiruvallur and automobile industries at Irugattukottai are other important industries. In the south most of the industries are located along the G.S.T Road (NH45). Simpson, Addison and TVS industries are located in the heart of the City along Anna Salai. Madras Export Processing Zone (MEPZ) spread over an area of 105 hectares is located at Tambaram. Leather tanneries and leather-based industries are located near Tambaram.

84. Large-scale automobile engineering, glass and ceramic industries are located at Maraimalai Nagar. Mahindra Industrial Park developed over an area of 520 hectares is located near Chengalpattu along the GST Road. The highlights of land use in CMA are residential use and water bodies. Land use in year 2006 is depicted in Figure 4.4 and classified in Table 4.7. Maps with planned landuse for 2026 can be found at CMDA's website (*http://cmdalayout.com/landusemaps/landusemaps.aspx).* The predominant land use pattern along the corridor 4 is dominated by industrial, residential and commercial use. The buildings along the alignment of Corridor 4 are majorly low rise varying from 4 to 6-storey.

Figure 4-4: Land Use in Chennai Metropolitan Area 2006



Source: Second Master Plan for Chennai Metropolitan Area, 2026

Table 4.7: 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	9,523	22,877	8,342	45,593
Commercial	1,245	390	714	880
Industrial	908	6,563	822	10,690
Institutional	3,243	3,144	2,868	3,888
	Land use 2006		**Land use 2026**	
Open Space and Recreational	366	200	1,000	392
Agricultural	99	12,470	Nil	7,295
Non-urban	82	2,433	113	2,333
Others	2,087	56,507	3,754	28,147
Urbanisable	Nil	Nil	Nil	2,075
Total	17,553	104,584	17,613	101,293

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

4.2.5 Seismicity

85. As per seismic zoning map of India shown at Figure 4.5, Tamil Nadu and Chennai are located in Moderate Seismic Zone (Zone III–BIS: 1893 (2001)). A study of seismic hazard for representative locations in Chennai (Seismic Hazard Assessment of the city of Chennai, India, Subhadeep Banerjee and A Boominathan, ASEM, Aug-Sept 2017) concluded that Santhome falls in class D; Vadapalani and Alwarpet fall in class C. Out of 5 classes (A, B, C, D and E) of soil that have been defined (NEHRP, USA) to rate building shaking due to seismic events, class A is the least vulnerable and class E is most vulnerable. Another micro zonation study (First level seismic micro zonation map of Chennai city - A GIS approach, Ganapathy, Natural hazards and earth system sciences 11(2) · February 2011) concluded that hazard for Santhome to Nandanam section except Alwarpet is low and Nandanam to Alwarthiru nagar section is moderate as depicted in Figure 4.6.

Figure 4-5: Seismic Zone Map of India

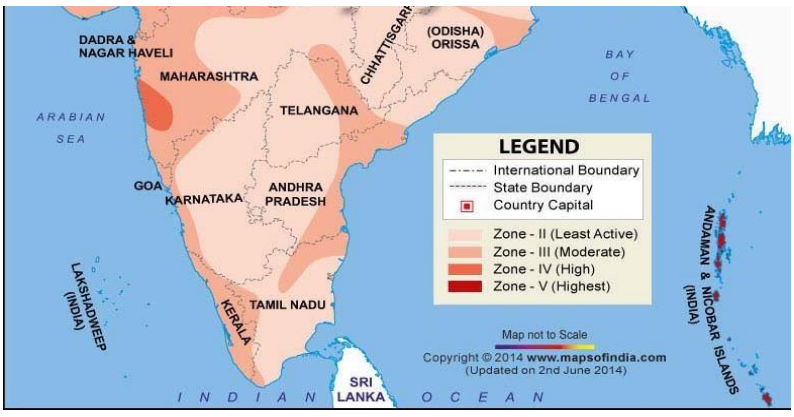
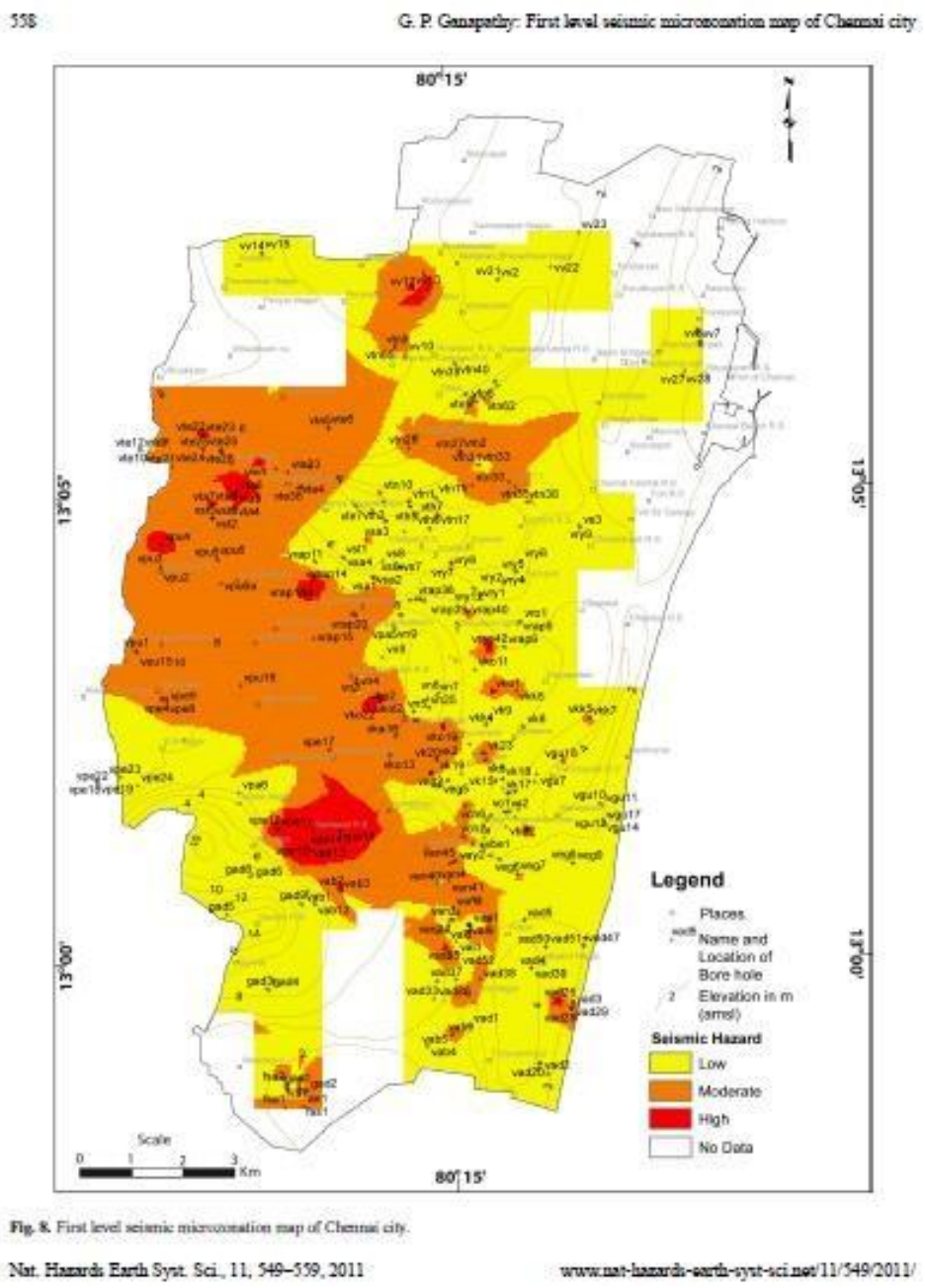


Figure 4-6: Seismic micro zonation of Chennai



First level seismic micro zonation map of Chennai city - A GIS approach, Ganapathy, Natural hazards and earth system sciences 11(2) · February 2011

86. 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.

87. The known faults and shear zones of the peninsular shield closely follow the pattern of major rivers. The fault details around Chennai city are listed in Table 4.8 which shows that none of them passes through the project site.

Table 4.8: Seismic Faults

Table 1. *The details of faults and seismicity in the vicinity of Chennai city.*

Sl. no.	Name of fault	Fault length L (km)	Distance (km)	Hypocentral distance, R (km)	Moment magnitude (M_w)	PGA (g)
1	Fault 15d	40	10	14	4.0	0.066
2	Fault 24	365	10	14	4.4	0.106
3	Fault 53	137	32	34	4.1	0.029
4	Kilcheri fault	26	33	34	4.0	0.025
5	Fault 15a	105	46	47	4.5	0.032
6	Neotectonic fault	105	48	49	3.8	0.013
7	Palar fault	85	59	60	4.0	0.013
8	Tambaram fault	10	59	60	4.4	0.021
9	Fault 15	96	61	62	3.7	0.009
10	Fault 52	115	67	68	3.6	0.007
11	Fault 15e	50	68	69	4.5	0.020
12	Fault 54	129	70	71	3.8	0.009
13	Mahapalipuram fault	5	75	76	4.0	0.010
14	Kalkulam fault	36	82	83	3.6	0.005
15	Muttukadu fault	11	95	96	3.5	0.004
16	Fault 26d	160	96	97	4.5	0.013
17	Fault 56e	75	97	98	4.5	0.013
18	Fault 26	1000	98	99	4.5	0.013

(*Source: Seismic hazard assessment of Chennai city considering local site effects A Boominathan*, G R Dodagoudar, A Suganthi and R Uma Maheswari, J. Earth Syst. Sci. 117, S2, November 2008*)

4.2.6 Meteorology

4.2.6.1 Temperature

88. 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 2014 to Dec 2023 collected from Indian Meteorological Department (IMD). Table 4.9 and Table 4.10 depicts that the hottest part of the year is in the month of May with maximum temperature varies 41.0°C to 43.0°C. The coolest part of the year is in the month of January, with minimum temperature varies 18.7°C to 20.6°C.

Table 4.9: Monthly Highest Maximum Temperature (Deg C)

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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	33.0
2018	31.1	32.8	35.6	36.6	39.1	39.8	38.1	37.8	37.3	36.4	32.7	31.3
2019	30.8	34.0	35.6	36.8	41.5	41.5	40.4	38.3	36.8	34.4	35.1	31.0
2020	32.2	33.0	34.4	36.2	41.8	40.6	38.3	36.5	36.6	37.1	33.3	31.2
2021	32.0	33.5	38.3	41.2	40.3	39.9	37.2	36.8	36.6	35.9	32.2	32.4
2022	32.2	33.5	37.6	36.0	39.8	40.1	36.6	37.2	37.5	35.1	31.8	31.9

2023	31.1	34.1	34	38.1	41.8	42.3	37.6	38.2	36.4	36.5	32.6	32.2

Source: Regional Meteorological Centre, Chennai

Table 4.10: Monthly Lowest Minimum Temperature (Deg C)

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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
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	21.0
2018	19.0	19.0	21.0	25.4	26.6	25.2	22.4	23.2	22.4	23.8	22.6	20.0
2019	19.7	21.0	23.6	26.4	28.4	23.4	23.8	23.2	22.9	23.9	22.8	22.0
2020	18.7	20.3	23.7	23.1	27.9	25.4	24.2	24.6	24.0	23.6	20.8	20.7
2021	20.6	20.4	22.6	23.1	24.6	24.4	23.8	23.6	24.0	24.2	20.8	19.2
2022	20.6	20.4	22.2	26.4	24.7	22.8	24.7	23.9	25.0	22.2	21.3	19.8
2023	19.5	20.0	22.0	24.7	25.0	24.5	24.6	22.8	23.8	23.3	23.3	20.6

Source: Regional Meteorological Centre, Chennai

4.2.6.2 Rainfall

89. Chennai 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. The highest annual rainfall recorded is 1,049.3mm in November 2015, the highest recorded since November 1918 when 1,088 mm of rainfall was recorded. The monthly rainfall is given in Table 4.11.

Table 4.11: Monthly Rainfall (mm)

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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	1049.3	454.7
2016*	0.4	0.0	0.0	0.0	216.8	133.1	41.3	24.5	264.7	16.4	73.8	219.9
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
2018	1.9	1.0	2.9	0.0	0.0	63.1	117.0	191.5	60.7	162.2	190.7	35.8
2019	0.2	4.0	0.0	0.0	0.0	44.7	142.9	120.9	184.1	318.2	108.2	178.8
2020	67.8	0.8	0.0	25.6	0.0	41.8	69.2	69.4	113.0	318.5	525.9	189.1
2021	166.2	8.5	0.0	24.4	16.8	54.7	242.8	168.2	92.1	216.4	1044.3	224.1
2022	90.3	0.0	0.0	0.0	39.5	167.1	107.2	102.2	121.2	171.0	526.2	263.1
2023	4.1	0.8	52.7	1.5	44.9	210.8	56.3	56.3	200.6	109.5	564.7	594.6

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

4.2.6.3 Humidity

90. Mean Relative Humidity is presented in Table 4.12 and Table 4.13. It varies 56% to 100% at 08:30 hrs and 57% to 87% at 17:30 hrs. 2016 and 2017 data were collected at different time slots.

Table 4.12: Monthly Mean Relative Humidity at 08:30 hrs (%)

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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
2018	78	79	81	74	68	62	64	71	78	81	82	83
2019	82	79	77	78	75	66	74	72	83	86	87	86
2020	86	83	85	84	76	63	82	81	81	79	85	83
2021	85	76	77	74	66	67	76	79	82	85	94	84
2022	87	72	84	83	78	72	75	73	73	81	87	87
2023	82	82	79	73	72	66	69	76	75	80	90	86

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

Table 4.13: Monthly Mean Relative Humidity at 17:30 hrs (%)

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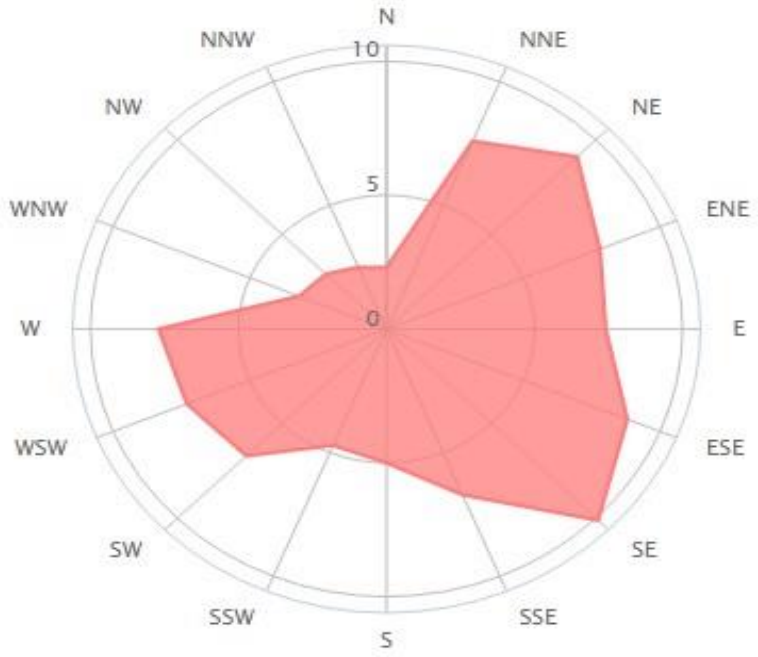
YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014	69	67	64	68	68	66	65	74	75	80	77	76
2015	73	71	67	69	69	65	70	71	75	78	87	78
2016*	38	30	29	30	30	37	37	33	37	30	27	27
2017*	35	24	38	23	25	16	33	42	47	36	43	40
2018	68	67	68	70	69	60	56	67	73	76	74	73
2019	66	68	67	74	80	70	70	65	78	78	79	80
2020	74	75	76	80	75	64	75	77	77	76	80	73
2021	74	63	65	69	68	65	65	72	76	80	88	73
2022	74	60	71	77	77	69	68	65	71	71	80	77
2023	65	62	67	66	67	67	51	70	73	73	84	77

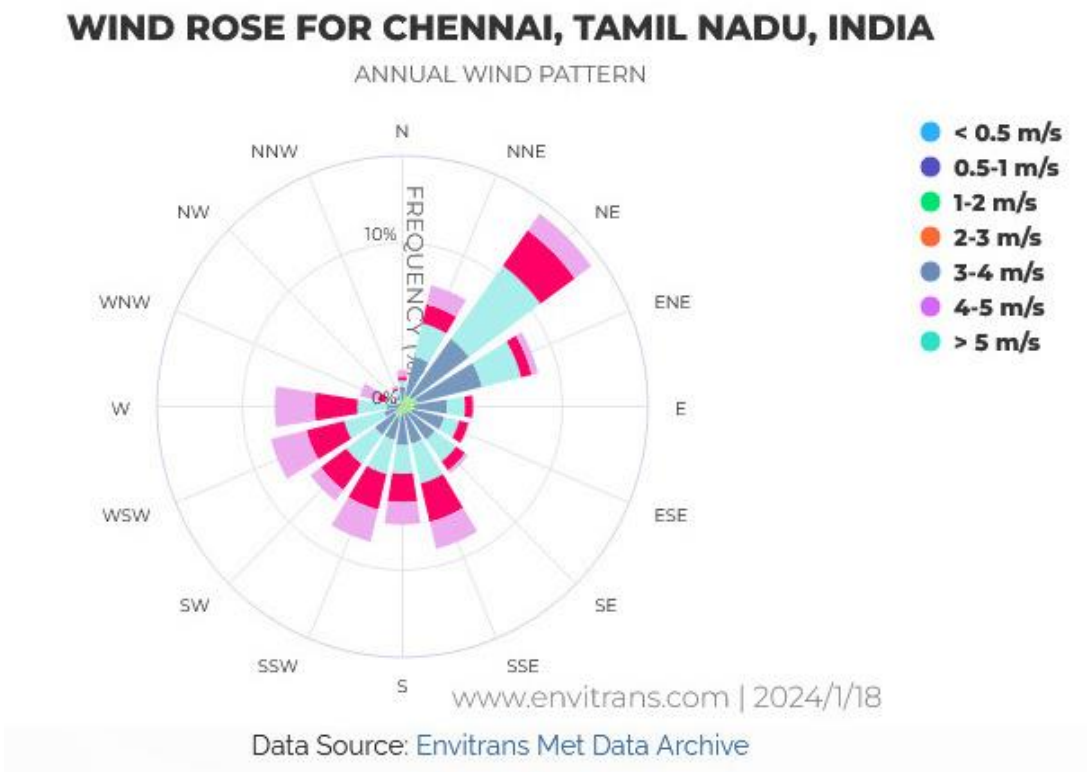
*Source: Regional Meteorological Centre, Chennai, *at 14.30 hrs(www.timeanddate.com)*

4.2.6.4 Wind

91. 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





Source : www.envitrans.com

4.3 Ambient Environment

92. In order to assess the impact on existing ambient environment due to Corridor 4, it is necessary to have baseline status of ambient environmental parameters.

4.3.1 Water Resources

93. As the city lacks a perennial water source, catering the water requirements of the population has remained an arduous task. Groundwater levels from Jan 2022 to Jan 202were up to 10m below ground in pre-monsoon as well as post-monsoon seasons and rise in water level of up 2 to 4m in all observation wells in Chennai district between pre-monsoon and post-monsoon months. From May 2016 and May 2022, the groundwater levels were up to 4m in77% of observation wells (*Groundwater Yearbook of Tamil Nadu and UT Puducherry, 2022 - 2023 Central Groundwater Board*).

94. As per data provided by Chennai water authority, CMWSSB in Jan 2024, the combined water level in the five reservoirs namely Red Hills, Cholavaram, Chembarambakkam , Kandigai ,and Poondi lakes was 11757mcft or. In May 2019 the combined storage level 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*).

95. 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 400MLD supplements these sources; and other water sources, including abandoned stone quarries, agriculture wells and Neyveli Corporation mines. (*Down to Earth 22 May 2019*).

4.3.2 Drainage

96. 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.

97. Cooum or Koovum (sometimes called as Triplicane River) 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 Tiruvallur 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.

98. Otteri nala 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

99. The analysis of water samples is presented in Table 4.14. Laboratory analysis of water sample depicts that most of the parameters are well within the prescribed permissible limits as per the Bureau of Indian Standards except some parameters viz Turbidity at 4A, and 5C, Total Dissolved Solids, Calcium, Total Hardness, and Chloride at 4G, Lead at 4E exceed the permissible limit. Bacteriological contamination found at 4A, 4B, 4C, 4D and 4H. Total Dissolved Solids (TDS) and Total Hardness at Santhome Church sampling location are higher than limits, this could be due to higher mineral content in the groundwater especially Calcium and Magnesium. Laboratory analysis of water sample depicts at most locations that TDS, hardness and coliform are more than prescribed desirable limits for drinking water. The analysis of water samples is presented in Table 4-15. Laboratory analysis of water samples depicts that most of the parameters are well within the prescribed permissible limits as per the Bureau of Indian Standards except some parameters viz Turbidity at 5D,5E,5L,5M,5N and 5O Aluminium at 5L,5M,5N,5O,5P,5Q,5R Manganese at 5L,5M,5N,5O,5P,5Q, Boron at 5L, 5O exceed the permissible limit. Bacteriological contamination found at all locations is higher than the permissible limit. Due to higher mineral content in the groundwater, especially aluminum and Manganese. At most locations, laboratory analysis of water samples shows that Turbidity and coliform are more than the prescribed desirable limits for drinking water.

100. 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. Table 4-14 shows that the water in Porur Lake (sample 4H) would be classified as ‘D’, propagation of wildlife and fisheries, because of high amounts of Zinc and a large Biological Oxygen Demand.

Table 4.14: Results of Laboratory Analysis of Water Sample

S. N	Parameter	Unit	Corridor 4									Acceptable/ Permissible Limit for drinking water IS 10500	Effluent standards IFC/WBG for treated sanitary effluent in mg/l	Surface water criteria *				
			4A	4B	4C	5C	4D	4E	4F	4G	4H			A	B	C	D	E
1	pH at 25^{O}C	-	6.87	6.77	6.62	7.13	7.21	7.49	6.56	7.31	7.45	6.5-8.5/no relaxation	6.0-9.0					
2	Turbidity	NTU	**59.2**	<0.1	<0.1	**67.3**	<0.1	5.5	<1	<1	<1	1/5 max						
3	Total Dissolved Solids	mg/L	1186	1104	675	1826	612	1412	56	**4510**	418	500/2000 max						
4	Aluminium as Al	mg/L	BDL	BDL	BDL	BDL	BDL	0.05	BDL	BDL	BDL	0.03/0.2 max						
5	Free Ammonia (as NH_3)	mg/L	<0.1	>0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	-						
6	Barium (as Ba)	mg/L	BDL	BDL	BDL	0.13	BDL	0.058	BDL	0.099	BDL	0.7 max/ no relaxation						
7	Boran (as B)	mg/L	BDL	BDL	BDL	0.004	BDL	BDL	BDL	BDL	BDL	0.5/1						
8	Calcium as Ca	mg/L	100.2	116.2	76.2	82.6	48.1	57.8	2.1	**289**	32.1	75/200						
9	Chloride as Cl	mg/L	207	182.3	123.2	670.1	98.6	409	14.8	**2118.8**	113.3	250/1000		250		600		600
10	Copper as Cu	mg/L	0.0021	0.0023	BDL	BDL	0.0021	BDL	BDL	0.007	BDL	0.05/1.5		1.5		1.5		
11	Fluoride as F	mg/L	>1	>1	>1	>1	>1	>1	<0.1	>1	<1	1.0/1.5		1.5	1.5	1.5		
12	Iron as Fe	mg/L	BDL	BDL	BDL	0.15	BDL	BDL	BDL	BDL	BDL	0.3/ no relaxation		0.3		50		
13	Magnesium (as Mg)	mg/L	58.4	31.7	19.5	52.7	17	42.6	1.3	95.3	14.6	30/100						
14	Manganese as Mn	mg/L	1.16	0.003	BDL	0.54	0.002	0.35	BDL	0.137	0.003	0.1/0.3						
15	Nitrate as NO_3	mg/L	BDL	70.8	21.6	BDL	1.2	5	BDL	11.3	BDL	45/ no relaxation		20		50		
16	Phenolic Compounds	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.001/0.002						
17	Seleniem (as Se)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01/ no relaxation						
18	Silver (as Ag)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01/ no relaxation						
19	Sulphate as SO_4	mg/L	312.7	196	50.8	46.1	85	61.7	BDL	224.2	BDL	200/400		400		400		1000
20	Sulphide (as S)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	27.4	0.05/ no relaxation						

S. N	Parameter	Unit	Corridor 4									Acceptable/ Permissible Limit for drinking water IS 10500	Effluent standards IFC/WBG for treated sanitary effluent in mg/l	Surface water criteria *				
			4A	4B	4C	5C	4D	4E	4F	4G	4H			A	B	C	D	E
21	Total Alkalinity as $CaCO_3$	mg/L	223.3	396	310	460.6	467	539	9.8	372.4	BDL	200/600						
22	Total Hardness as $CaCO_3$	mg/L	490	420	270	422.3	190	319.3	10.3	**1112.4**	152.3	200/600						
23	Zinc as Zn	mg/L	BDL	BDL	BDL	BDL	BDL	0.027	0.14	0.034	140	5/15		15		15		
24	Cadmium (as Cd)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.003/ no relaxation						
25	Cyanide (as CN)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05/ no relaxation						
26	Lead as Pb	mg/L	BDL	BDL	BDL	BDL	BDL	**0.045**	BDL	BDL	BDL	0.01/ no relaxation						
27	Mercury (as Hg)	mg/L	BDL	0.0008	0.00093	0.006	0.00025	BDL	BDL	0.00045	BDL	0.001/ no relaxation						
28	Nickel	mg/L	BDL	BDL	BDL	BDL	BDL	0.0025	BDL	BDL	BDL	0.02/ no relaxation						
29	Total Arsenic as As	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.004	BDL	0.01/0.05						
30	Total Chromium (as Cr)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05 max/no relaxation						
31	Total Suspended Solids	mg/L	29.0	9	7	21	7	9	3	8	8	-	50	500		1500		2100
32	Vanadium (as V)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	-						
33	Amonical Nitrogen (as N	) mg/L	<0.1	>0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5/No relaxation						
34	Total Kjeldahl Nitrogen (as N)	mg/L	BDL	89	27.8	0.2	1.5	11.6	0.1	14.2	1.12	-						
35	Chromium (as Hexavalent Cromium)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	-						
36	Oil and Grease	mg/L	<5	<5	<5	<1	<5	<1	<1	<1	<5	-	10					

S. N	Parameter	Unit	Corridor 4									Acceptable/ Permissible Limit for drinking water IS 10500	Effluent standards IFC/WBG for treated sanitary effluent in mg/l	Surface water criteria *				
			4A	4B	4C	5C	4D	4E	4F	4G	4H			A	B	C	D	E
37	Dissolved Oxygen	mg/L	6	6.8	6.6	4.6	6.7	4.4	6.1	4.9	5.7	-		6	5	4	4	
38	Chemical Oxygen Demand	mg/L	32	24	16	64	20	64	Nil	52	56	-	125					
39	Biochemical Oxygen Demand (3 day 27^0C)	mg/L	13	9	6	23	8	20	Nil	19	20	-	30	2	3	3		
40	Total Phosphate as P	mg/L	0.1	3.3	1.3	0.9	2.4	1.2	BDL	1.4	0.18	-	2					
41	Dissolved Phosphate (as P)	mg/L	0.1	3.3	1.3	0.9	2.4	1.2	BDL	1.4	0.18							
42	Sodium as Na	mg/L	135	137.5	110	575	165	455	10.9	925	75	-						
43	Potassium as K	mg/L	5.8	47	24.3	15	24.8	29	BDL	61	12	-						
44	Nitrate Nitrogen	mg/L	BDL	16	4.9	BDL	0.27	1.13	BDL	2.6	BDL	-						
45	Total Nitrogen	mg/L	BDL	89	27.8	0.2	1.5	11.6	0.1	14.2	1.12	-	10					
46	Organic Phosphorus	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.002 max						
47	Coliform Count	MPN/100 ml	**160**	**20**	**40**	<1	**90**	<1	<1	<1	**90**	Absent						
48	Fecal Coliform	MPN/100 ml	**50**	**10**	**10**	<1	**30**	<1	<1	<1	**20**	Absent						
49	Total Coliform Organism	MPN/100 ml	**250**	**69**	**80**	<1	**230**	<1	<1	<1	**200**	Absent	400	50	500	5000		

* Surface Water Quality Standards CPCB for Best Designated Usage

Table 4.15 : Results of Laboratory Analysis of Water Sample

S.No	Parameters	Units	5A	5B	5D	5E	5F	5G	5H	5I	5K
1	Turbidity	NTU	0.9	BDL(DL:0.5)	**56.0**	**31.1**	BDL(DL:0.5)	1.0	BDL(DL:0.5)	BDL(DL:0.5)	1.0
2	pH Value @ 25 °C	-	7.33	6.83	6.99	7.29	6.93	7.59	6.82	7.11	7.83
3	Electrical Conductivity @ 25°C	µS/cm	985	1403	1365	1798	456	577	1013	1997	2440
4	Total Dissolved Solids @ 180°C	mg/L	644	920	894	1173	294	382	655	1304	1580
5	Total Suspended Solids @ 105°C	mg/L	BDL(DL:2.0)	BDL(DL:2.0)	27.0	76.4	BDL(DL:2.0)	BDL(DL:2.0)	BDL(DL:2.0)	BDL(DL:2.0)	BDL(DL:2.0)
6	Oil & Grease	mg/L	BDL(DL:5.0)	BDL(DL:5.0)	BDL(DL:5.0)	BDL(DL:5.0)	BDL(DL:5.0)	BDL(DL:5.0)	BDL(DL:5.0)	BDL(DL:5.0)	BDL(DL:5.0)
7	Total Phosphorous (as P)	mg/L	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)
8	Total Nitrogen (as N)	mg/L	11.3	21.4	18.6	18.1	6.26	8.5	10.2	20.6	7.3
9	Volatile Organic Compound (VOC)	mg/L	BDL(DL 1.0)	BDL(DL 1.0)	BDL(DL 1.0)	BDL(DL 1.0)	BDL(DL 1.0)	BDL(DL 1.0)	BDL(DL 1.0)	BDL(DL 1.0)	BDL(DL 1.0)
10	Dissolved Oxygen (as DO)	mg/L	6.8	7.1	6.7	6.6	7.1	6.2	6.7	7.2	6.7
11	Manganese (as Mn)	mg/L	BDL(DL:0.05)	BDL(DL:0.05)	BDL(DL:0.05)	BDL(DL:0.05)	BDL(DL:0.05)	BDL(DL:0.05)	BDL(DL:0.05)	BDL(DL:0.05)	**0.74**
12	Selenium (as Se)	mg/L	0.10	0.08	0.06	0.12	BDL(DL:0.01)	0.05	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)
13	Barium (as Ba)	mg/L	BDL(DL:0.05)	BDL(DL:0.05)	BDL(DL:0.05)	0.07	BDL(DL:0.05)	BDL(DL:0.05)	0.12	**2.16**	0.44
14	Silver (as Ag)	mg/L	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)

15	Aluminium (as Al)	mg/L	0.06	0.05	0.04	0.09	0.03	0.27	0.05	0.13	**1.57**
16	Boron (as B)	mg/L	BDL(DL:0.05)	0.11	0.09	0.15	BDL(DL:0.05)	BDL(DL:0.05)	BDL(DL:0.05)	0.20	0.46
17	Copper (as Cu)	mg/L	BDL(DL:0.01)	0.02	BDL(DL:0.01)	0.04	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	0.05
18	Zinc (as Zn)	mg/L	0.03	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	0.10
19	Cadmium (as Cd)	mg/L	BDL(DL:0.001)	BDL(DL:0.001)	BDL(DL:0.001)	BDL(DL:0.001)	BDL(DL:0.001)	BDL(DL:0.001)	BDL(DL:0.001)	BDL(DL:0.001)	0.01
20	Cyanide (as CN)	mg/L	BDL(DL:0.02)	BDL(DL:0.02)	BDL(DL:0.02)	BDL(DL:0.02)	BDL(DL:0.02)	BDL(DL:0.02)	BDL(DL:0.02)	BDL(DL:0.02)	BDL(DL:0.02)
21	Lead (as Pb)	mg/L	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	0.02	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	0.27	0.10
22	Mercury (as Hg)	mg/L	BDL(DL:0.001)	BDL(DL:0.001)	BDL(DL:0.001)	BDL(DL:0.001)	BDL(DL:0.001)	BDL(DL:0.001)	BDL(DL:0.001)	BDL(DL:0.001)	0.35
23	Nickel (as Ni)	mg/L	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	0.16
24	Arsenic (as As)	mg/L	0.13	0.24	0.21	0.33	BDL(DL:0.001)	0.06	BDL(DL:0.001)	BDL(DL:0.001)	0.04
25	Total Chromium (as Cr)	mg/L	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	0.59
26	Escherichia coli (MPN)	Present/Absent	Present	Present	Present	Present	Present	Present	Present	Present	Present

S.No	Parameters	Units	5L	5M	5N	5O	5P	5Q	5R	5S	A
1	Turbidity	NTU	**177**	**136**	**14.8**	**106**	1.0	BDL(DL:0.5)	0.8	1.0	BDL(DL:1.0)
2	pH Value @ 25 ^{o}C	-	6.41	6.65	7.19	6.52	7.26	6.55	7.02	6.86	7.67
3	Electrical Conductivity @ 25^{o}C	µS/cm	1935	2590	1157	1246	1926	1493	1187	1435	-
4	Total Dissolved Solids @ 180^{o}C	mg/L	1258	1680	752	814	1271	973	772	947	756
5	Total Suspended Solids @ 105^{o}C	mg/L	38.0	6.67	BDL(DL:2.0)	38.30	BDL(DL:2.0)	BDL(DL:2.0)	40.0	BDL(DL:2.0)	-
6	Oil & Grease	mg/L	BDL(DL:5.0)	BDL(DL:5.0)	BDL(DL:5.0)	BDL(DL:5.0)	BDL(DL:5.0)	BDL(DL:5.0)	BDL(DL:5.0)	BDL(DL:5.0)	-
7	Total Phosphorous (as P)	mg/L	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	-
8	Total Nitrogen (as N)	mg/L	10.1	6.59	9.1	2.47	5.87	37.0	13.8	7.60	-
9	Volatile Organic Compound (VOC)	mg/L	BDL(DL 1.0)	BDL(DL 1.0)	BDL(DL 1.0)	BDL(DL 1.0)	BDL(DL 1.0)	BDL(DL 1.0)	BDL(DL 1.0)	BDL(DL 1.0)	-
10	Dissolved Oxygen (as DO)	mg/L	BDL(DL 1.0)	4.8	7.7	7.5	6.9	8.7	6.6	7.1	6.5
11	Manganese (as Mn)	mg/L	**15.7**	**5.32**	**12.9**	**9.86**	**12.1**	**0.56**	0.37	**3.85**	BDL(DL:1.0)
12	Selenium (as Se)	mg/L	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	0.03	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.005)
13	Barium (as Ba)	mg/L	0.42	0.16	0.12	0.07	0.33	0.05	0.05	0.31	BDL(DL:0.05)
14	Silver (as Ag)	mg/L	0.19	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	0.02	0.14	BDL(DL:0.01)

15	Aluminium (as Al)	mg/L	**5.19**	**4.99**	**2.38**	**11.7**	**3.03**	**1.78**	**2.45**	**3.9**	BDL(DL:0.5)
16	Boron (as B)	mg/L	**1.52**	BDL(DL:0.05)	0.69	**2.43**	1.18	0.50	0.72	**1.14**	BDL(DL:0.1)
17	Copper (as Cu)	mg/L	0.05	BDL(DL:0.01)	1.62	BDL(DL:0.01)	0.05	BDL(DL:0.05)	BDL(DL:0.01)	0.05	BDL(DL:0.3)
18	Zinc (as Zn)	mg/L	2.82	1.47	6.41	0.34	1.19	0.31	BDL(DL:0.01)	2.12	BDL(DL:0.02)
19	Cadmium (as Cd)	mg/L	BDL(DL:0.001)	0.01	0.01	BDL(DL:0.001)	BDL(DL:0.001)	0.001	0.01	BDL(DL:0.001)	BDL(DL:0.01)
20	Cyanide (as CN)	mg/L	BDL(DL:0.02)	BDL(DL:0.02)	BDL(DL:0.02)	BDL(DL:0.02)	BDL(DL:0.02)	BDL(DL:0.02)	BDL(DL:0.02)	BDL(DL:0.02)	BDL(DL:0.05)
21	Lead (as Pb)	mg/L	0.05	0.06	0.08	0.02	0.05	0.06	0.01	0.04	BDL(DL:0.001)
22	Mercury (as Hg)	mg/L	0.29	0.08	0.25	0.16	0.22	0.24	0.38	0.15	BDL(DL:0.01)
23	Nickel (as Ni)	mg/L	0.09	0.08	0.27	0.03	0.06	0.08	0.11	0.07	BDL(DL:0.3)
24	Arsenic (as As)	mg/L	0.06	0.03	0.01	0.02	0.04	0.04	0.03	0.05	-
25	Total Chromium (as Cr)	mg/L	0.34	0.34	13.5	1.66	0.26	0.4	0.58	0.226	-
26	Escherichia coli (MPN)	Present/Absent	Present	Present	Present	Present	Present	Present	Present	Present	Present

4.3.4 Air Quality

101. 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 test conducted in 2021 -2022 are presented in Table 4.16 and 4.17, respectively. 24-hour air quality monitoring results indicates that the air quality was moderate, while the parameters of Sulphur dioxide (SO2) and Nitrogen dioxide (NO2) were within the permissible level of National Ambient Air Quality Standards (NAAQS) and World Health Organization (WHO) guideline. Particulate Matter was within NAAQS but exceeded WHO guideline. Concentration of Carbon Monoxide (CO) exceeded the permissible level of NAAQS in all the monitoring locations but was generally within WHO guidelines. CO exceeded prescribed limits on Corridor 4. The NAAQS laid down by CPCB and WHO guideline are given in Table 4.18.

Table 4.16: Ambient Air Quality (24hr Time weighted Average)

Sl No	Parameter	Unit	Pollution							
			Corridor-4							
			4A	4B	4C	5C	4D	4E	4F	4G
1	Sulphur Dioxide (SO_2)	µg/m^3	5.52	12.16	10.47	9.58	8.48	9.43	8.82	10.50
2	Nitrogen Dioxide (NO_2)	µg/m^3	11.52	18.03	17.53	13.60	23.64	17.53	12.17	17.71
3	Particulate matter (PM_{10})	µg/m^3	68.90	82.87	62.68	84.12	58.85	74.14	56.61	47.62
4	Particulate Matter ($PM_{2.5}$)	µg/m^3	36.67	48.75	38.33	41.67	34.64	24.74	29.28	33.33
5	Carbon Monoxide (CO)	mg/m^3	6.0	7.0	6.0	6.0	5.0	8.5	5.8	8.0

Table 4.17: Ambient Air Quality (24hr Time weighted Average)

Parameters	Sulphur dioxide (SO_2)	Oxides of Nitrogen (NO_2)	Respirable Particulate Matter (PM_{10})	Respirable Particulate Matter ($PM_{2.5}$)	Carbon Monoxide (CO)
Units	µg/m^3	µg/m^3	µg/m^3	µg/m^3	mg/m^3
5A	11.5	23.1	60.7	28.4	BDL(DL:1.14)
5B	9.25	22.4	59.9	26.7	BDL(DL:1.14)
5D	12.4	22.3	62.9	25.5	BDL(DL:1.14)
5E	10.3	18.5	56.8	27.6	BDL(DL:1.14)
5F	13.2	20.1	64.9	32.5	BDL(DL:1.14)
5G	12.1	23.9	57.9	30.4	BDL(DL:1.14)
5H	11.7	21.4	64.7	28.6	BDL(DL:1.14)

5I	14.4	19.6	66.1	26.4	BDL(DL:1.14)
5K	12.9	20.7	62.7	29.5	BDL(DL:1.14)
5L	13.0	21.6	70.0	38.1	BDL(DL:1.14)
5M	13.7	22.5	74.7	41.1	BDL(DL:1.14)
5N	14.3	24.0	67.0	33.2	BDL(DL:1.14)
5O	13.5	23.1	73.8	39.0	BDL(DL:1.14)
5P	8.56	14.7	76.1	38.1	BDL(DL:1.14)
5Q	14.1	26.2	74.0	40.6	BDL(DL:1.14)
5R	12.5	21.8	69.4	46.2	BDL(DL:1.14)
5S	15.5	23.8	67.4	35.9	BDL(DL:1.14)
5T	8	26	78	24	BDL(DL1.14)
5U	8.5	30	72	26	BDL(DL1.14)
5V	7.6	32	75	30	BDL(DL1.14)
5W	6.8	26	79	31	BDL(DL1.14)
5X	7	27	71	29	BDL(DL1.14)
5Y	8.5	27	81	36	BDL(DL1.14)
5Z	7.3	28	69	24	BDL(DL1.14)
6A	7.8	25	83	39	BDL(DL1.14)
6B	8.3	29	70	26	BDL(DL1.14)

Table 4.18: National 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) µg/ m^3	Annual	50	20	-
	24 Hours	80	80	-
Oxides of Nitrogen (NO_2) µg/ m^3	Annual	40	30	40
	24 Hours	80	80	-
Particulate Matter (size less than 10µm) or PM_{10} µg/ m^3	Annual	60	60	20
	24 Hours	100	100	50
Particular Matter (size less than 2.5µm) or $PM_{2.5}$µg/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) µg/m^3	8 Hours	100	100	100
	1 Hour	180	180	-
Lead (Pb) µg/m^3	Annual	0.5	0.5	-
	24 Hours	1.0	1.0	-
Ammonia (NH_3) µg/m^3	Annual	100	100	-
	24 Hours	400	400	-

**Source: CPCB guidelines for AAQM*

4.3.5 Noise

1. The noise data was collected at 8 noise monitoring stations at hourly interval during morning, afternoon and evening such that peak and off-peak hours are covered. Most of the stretch is along the existing road. Later in 2019, more detailed monitoring of noise was conducted at 30 sample locations with sensitive receptors which are located within 200 m on either side of the alignment of Corridor 4, as listed in Table 4.21 and shown in Figure 4.8. The noise monitoring results are given in Table 4.19 and Table 4.19A, the detailed test reports of the 2019 noise monitoring can be found in Annex 1. , Baseline Noise levels are recorded in the year (2021-2022) at 26 locations along the project alignment before the commencement of construction activities and the noise level observed are listed in 4-20.

Figure 4-8: Locations of noise monitoring at sensitive receptors on Corridor 4

Field Survey: Nov/Dec 2019

Table 4.19: Ambient Noise Level Monitoring Results (by land use) – (2016 to 2019)

Location	Land Use	L_{max}	L_{min}	L_{day}	L_{night}
Corridor-4 *Light House to Poonamallee Bypass*					
4A	Commercial	75.98	68.23	72.92	70.85
4B	Residential	67.06	52.36	62.79	57.32
4C	Residential	77.20	57.66	70.80	59.90
5C	Residential	81.60	61.26	77.66	66.61
4D	Residential	78.94	63.03	76.11	68.14
4E	Commercial	75.35	72.62	75.02	74.00
4F	Silence Zone (educational)	76.27	69.84	73.65	71.37
4G	Silence Zone (religious)	82.54	58.91	79.42	66.57

Note: 4E to 4G in July 2016, 4A,4B,4C,4D in May 2017

Table 4.20: Ambient Noise Level Monitoring Results (by land use) - 2021 to 2022

Location	Land use	Leq_{day}	Leq_{night}
Corridor-4 *Light House to Poonamallee Bypass*			
5A	Commercial	60.2	52.2
5B	Commercial	50.1	39.7
5D	Commercial	48.1	38.9
5E	Commercial	46.1	36.5
5F	Commercial	51.1	41.1
5G	Commercial	47.9	36.2
5H	Commercial	59.7	50.2
5I	Commercial	51.9	41.6
5K	Commercial	63.9	42.9
5L	Commercial	64.4	42.3
5M	Commercial	62.4	41.6
5N	Commercial	61.7	43.5
5O	Commercial	61.7	42
5P	Commercial	61.3	42.7
5Q	Commercial	60.5	42.3
5R	Commercial	62.8	41.7
5S	Commercial	61.6	42
5T	Commercial	66.1	57.3
5U	Commercial	66.4	58
5V	Commercial	67	58.4
5W	Commercial	64	54.9

5X	Commercial	67.3	58.8
5Y	Commercial	66.9	57
5Z	Commercial	65.8	58.7
6A	Commercial	65.7	59.3
6B	Commercial	67	57.7

Field Survey: 5A to 6B; Pre-construction Baseline study 2021-2022

Table 4.21: Ambient Noise Level Monitoring Results (at sensitive receptors)

No	Name of the Sensitive Receptor	Locations on Corridor 4	Type of Sensitive Receptor	Distance from the outer most proposed tracks (m)	L_{eq} (Day) 50 dB(A)[16]	L_{eq}(Night) 40 dB(A)
1	Queens Mary College	Light House Station – Kutchery Road	College	94.57	53.5	35.1
2	St. Thomas church	Light House Station – Kutchery Road	Church	110	46.4	31.6
3	St. Bede's Anglo Indian Hr. Sec. School	Light House Station – Kutchery Road	School	71.16	56.8	35.2
4	Santhome church	Light House Station – Kutchery Road	Church	110	47.5	32.7
5	Rosary Church	Light House Station – Kutchery Road	Church	1.0	44.3	30.4
6	St. Raphael's Girls Hr. Sec. School	Light House Station – Kutchery Road	School	6.07	59.6	33.9
7	Majood Jamal	Kutchery Road - Thirumayilai Metro	Mosque	5.5	46.2	33.5
8	Jumma Mosque	Kutchery Road - Thirumayilai Metro	Mosque	11.87	43.7	34.6
9	Luz Church	Thirumayilai Metro - Alwarpet	Church	76.43	45.2	31.3
10	Anjaneyar Temple	Alwarpet - Bharathidasan Road	Temple	9.66	43.6	32.5
11	Trinity Hospital	Alwarpet - Bharathidasan Road	Hospital	7.58	52.8	38.2
12	AVT Hospital	Alwarpet - Bharathidasan Road	Hospital	28.9	55.1	36.8
13	SIET College	Adyar Gate Junction to Nandanam	College	31.17	57.3	35.3
14	Venkateshwara Hospital	Nanadanam to Panagal Park	Hospital	38.23	51.6	37.9

[16] *Presented data in table 4-17 is based on a day time from 6.00 AM to 10.00 PM (CPCB). Hourly data can be found in Annexure 1 if needed to calculate for different day time periods (WBG: 7 AM – 10 PM)*

No	Name of the Sensitive Receptor	Locations on Corridor 4	Type of Sensitive Receptor	Distance from the outer most proposed tracks (m)	L_{eq} (Day) 50 dB(A)[16]	L_{eq}(Night) 40 dB(A)
15	Government Arts College	Adyar Gate Junction to Nandanam	College	18.48	56.9	33.4
16	Little Oxford Matriculation Higher Sec School	Nandanam to Panagal Park	School	73.81	50.4	34.7
17	Thyagarayar Higher Secondary School	Nandanam to Panagal Park	School	22.45	49.8	31.9
18	Thirumala Tirupathi Devasthanam	Nandanam to Panagal Park	Temple	25.6	54.6	49.6
19	Rose of Sharon Ac Church	Kodambakkam Metro to Kodambakkam Flyover	Church	180.34	48.9	37.2
20	Meenakshi College for Women	Kodambakkam Flyover to Power House	College	120.9	52.9	35.7
21	Chennai Higher Secondary School	Power House to Vadapalani	School	19.00	56.2	34.3
22	Saraswathi Vidyalaya Sr. Sec. School	Power House to Vadapalani	School	12.79	54.7	33.3
23	Vijaya Hospital	Vadapalani to Saligramam	Hospital	15.70	51.1	39.1
24	Karthikeyan Matric School	Vadapalani to Saligramam	School	35.96	49.8	34.7
25	Narayanan E-Tecno School	Alwar thiru nagar to Valasarwakkam	School	14.17	47.3	36.5
26	The Holy Cross Matric Hr. Sec. School	Valasaravakkam to Karambakkam	School	87.30	52.6	38.1
27	Parvathy Hospital	Alapakkam Junction-Porur Junction	Hospital	57.56	48.3	36.7
28	Lakshmi Hospital	Ramchandra Hospital to Iyappanthangal Bus Depot	Hospital	38.38	52.7	37.6
29	Mangalam Hospital	Mullai Thottam to Poonamallee Bus Terminus	Hospital	23.85	54.1	35.3
30	Government Hospital	Mullai Thottam to Poonamallee Bus Terminus	Hospital	18.01	59.3	41.5

Field survey: Nov/Dec 2019

2. The Ambient Noise limits laid down by CPCB and WHO have been given in Table 4.22. The noise levels monitored at 8 locations along the alignment were above the national and international permissible limits. Noise levels was also monitored at 30 sensitive locations

belonging to the silence zone, with 60% slightly exceeding the noise limits of 50dB the daytime limit (23.3% per WHO guideline of 55dB), and 1 out of 30 exceeding 40 dB the nighttime limit. The predominant source of ambient noise at the monitored locations are from road traffic (urban arterials and regional highways).

Table 4.22: Ambient Noise Limits

Area Code	Category of Area	CPCB Limits in dB (A) Leq		WHO/IFC/WB Guideline	
		Day time*	Night time	Day time	Night time
A	Industrial area	75	70	70	
B	Commercial area	65	55	70	
C	Residential area	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 9.00 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.*

4.3.6 Vibration

3. 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.

4. 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.

5. Measuring the peak particle velocity (PPV) is mostly used for representation of vibrating situation when the pressure wave passes through the particles. Soil conditions have a strong influence on the level of ground-borne vibration. The PPVs are usually expressed in terms of m/s or mm/s.

6. The dynamic analysis and seismic response have been studied for 13 identified sensitive receptors on Corridor 4 comprising educational institutions and hospitals which are located near by the project corridors as shown in Figure 4.9 & 4.10. Of these locations, 2 are heritage assets namely Rosary Church and Our Lady of Light Shrine; permission to conduct vibration study at the third heritage asset Santhome Church was not available.

Figure 4-9: Locations of vibration measurement at sensitive receptors Part 1

Field Survey: Nov 2019

Figure 4-10: Locations of vibration measurement at sensitive receptors Part 2

7. The induced ground vibration level is summarized in Table 4.24 and monitoring schedule is shown in Table 4.23.

8. All the measurements are characterized on ground level i.e., pickup point is on ground level. Peak VdB vibration level at 11 out of 13 monitored locations is found to exceed acceptable criteria for ground borne vibration prescribed by the Federal Transit Administration (FTA) USA and Railway Design & Standards Organisation (RDSO) (**Annexure 3**). However the observed levels at all 13 locations are well below the construction vibration damage criteria for blasting as per Directorate General of Mines Safety (DGMS) and Central Institute of Mining and Fuel Research (CMFRI or CMRI) which are relevant only if blasting is undertaken during construction (Table 4.24).

Table 4.23: Monitoring Schedule

No	Location	Monitoring schedule	Duration (hrs)	Date of Commencement
Part 1				
1	C4-D-St. Bede's Anglo Indian School	10:35 AM – 6:52 PM	08	22/11/2019
2	C4-E-Aashraya Hospital	08:52 AM -5:00 PM	08	24/11/2019
3	C4-F- Jain Temple	11:47 AM - 7:59 PM	08	19/11/2019
4	C4-G- Luz Church	10:42 AM – 6:47 PM	08	17/11/2019
5	C4-H-Anjaneyar Temple	10:28 AM -6:37 PM	08	23/11/2019
6	C4-I – SIET College	11:16 AM - 7:24 PM	08	20/11/2019
7	C4-J-Thirupathi Thirumala Devastanam Temple	8:43 AM – 5:01 PM	08	21/11/2019
8	C4-K-Koncept Hospital	10:34 AM - 6:38 PM	08	25/11/2019
9	C4-L-The Holy Cross Matric IIr. Sec School	10:19 AM - 6:28 PM	08	26/11/2019
10	C4-M- Government Hospital	09:46 AM – 5:47 PM	08	27/11/2019
Part 2				
C4-A	Near Porur Lake	7:45 PM -7:40 PM	24	20/07/2019 to 21/07/2019
C4-B	Vadapalani Junction	1:03 PM - 12:55 PM	24	19-07-2019 to 2007-2019
C4-C	Santhome Church	9:57 AM - 10:03 AM	24	16-07-2019 to 1707-2019

Table 4.24: Standards for Vibration

Type of structure	Vibration (mm/s) for dominant excitation frequency, Hz		
	< 8Hz	8-25Hz	>25Hz
DGMS			
(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

After CMRI Standard (Dhar et al, 1993)

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: 70mm/s		
Hard rock conditions: 100mm/s		

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

Table 4.25: Baseline Vibration

S N	Name of location	Surface Type	PPV (Maximum) mm/sec			VdB (Maximum)			VdB (Average)			VdB RMS	
			East	North	Up	East	North	Up	East	North	Up	Max.	Time
Part 1													
1	C4-D-St. Bede's Anglo Indian School *	Marble	0.231	0.141	0.497	79.176	74.888	85.830	68.43	65.82	68.56	82.82 (Up)	02:26 PM
2	C4-E- Aashraya Hospital **	Cemented Floor	0.089	0.082	0.187	70.85	70.18	77.34	66.09	66.08	63.86	74.33 (Up)	3:19 PM
3	C4-F- Jain Temple ***	Marble	0.303	0.096	0.103	81.53	71.54	72.16	73.86	65.78	65.48	78.52 (East)	12:34 PM
4	C4-G- Luz Church	Cemented Floor	1.840	0.324	0.474	97.20	82.11	85.42	72.70	69.95	69.98	94.19 (East)	6:30 PM
5	C4-H- Anjaneyar Temple	Marble	1.110	0.504	0.833	92.81	85.95	90.32	75.64	68.62	75.55	89.80 (East)	02:25 PM
6	C4-I – SIET College	Marble	0.261	0.170	0.251	80.24	76.51	79.90	68.27	68.16	67.45	77.22 (East)	07:16 PM
7	C4-J- Thirupathi Thirumala Devastanam Temple	Marble	1.420	0.499	0.792	94.95	85.87	89.88	79.25	69.78	75.51	91.94 (East)	11:54 AM
8	C4-K- Koncept Hospital ****	Marble	0.894	0.200	0.502	90.93	77.92	85.92	74.01	68.73	70.80	87.92 (East)	01:57 PM
9	C4-L-The Holy Cross Matric IIr. Sec School	Tiles	0.439	0.099	0.237	84.75	71.81	79.40	72.32	66.66	69.50	81.74 (East)	11:46 AM
10	C4-M- Government Hospital	Marble	0.311	0.250	0.266	81.76	79.86	80.40	69.31	66.37	69.08	78.75 (East)	10:23 AM
Part 2													
C4-A	Near Porur Lake	Soil	0.207	0.356	0.325	78.22	82.93	82.14	64.34	66.77	72.20	79.92 (North)	04:34 AM
C4-B	Vadapalani Junction	Soil	0.210	0.430	0.788	78.34	84.57	89.83	67.58	75.22	79.29	86.82 (Up)	06:36 AM
C4-C	Santhome Church	Soil	0.456	0.356	0.094	85.08	82.93	71.39	65.49	62.95	62.59	82.07 (East)	12:05 PM

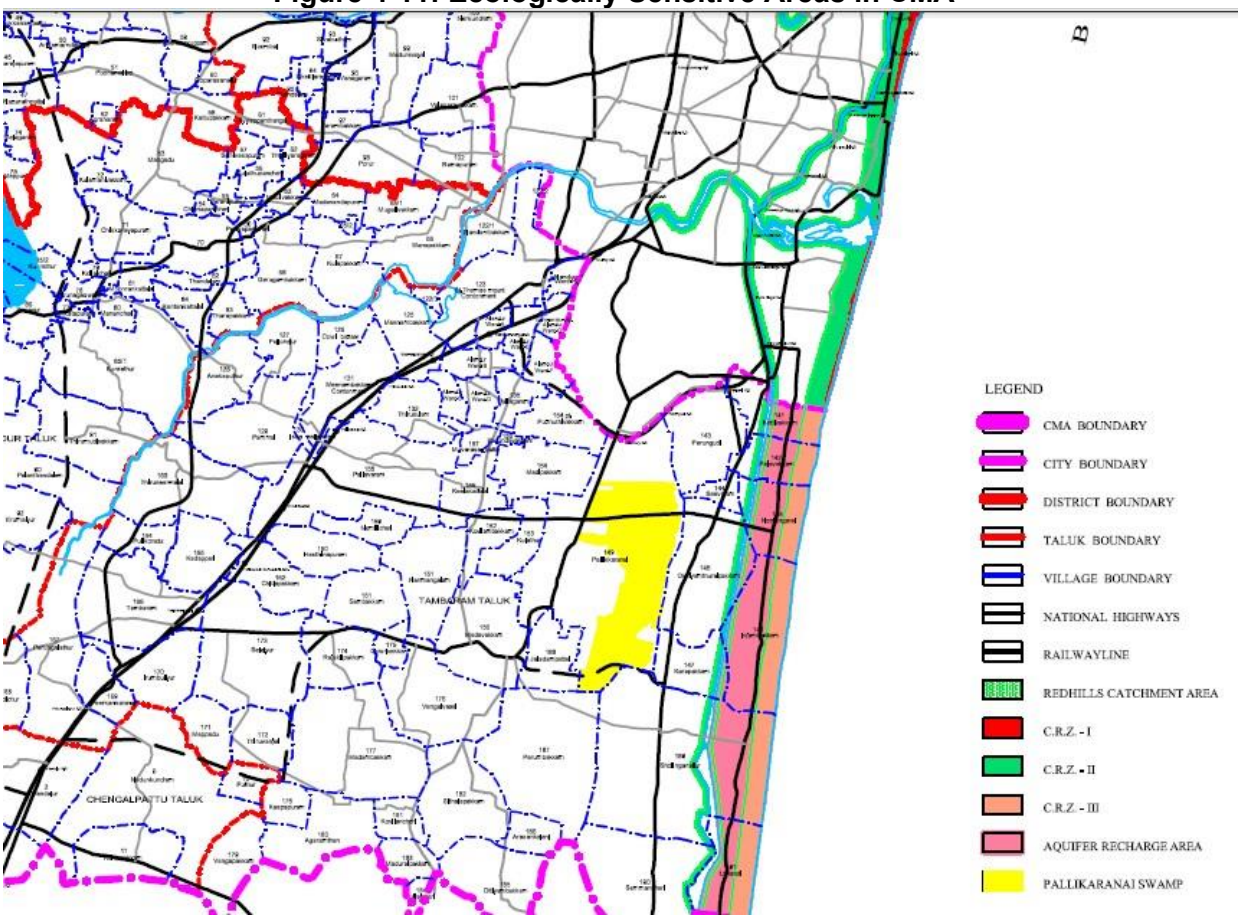
Note: Representing locations of* C4-D- Queens Mary's College ** C4-E- Rosary Church *** C4-F- Jumma Mosque **** C4-K- Meenakshi College for Women

4.4 Ecological Environment

9. Corridor 4 passes through the urbanized area of Chennai which is considered as a modified habitat. No natural habitat exists on or near the alignment. The coastal zone near Foreshore road is used for commercial activities such as fisheries and vendors and is void of any natural vegetation. The area for the planned depot at Poonamalle bypass is currently in use as agricultural land.

4.4.1 Ecologically Sensitive Areas in CMA

Figure 4-11: Ecologically Sensitive Areas in CMA



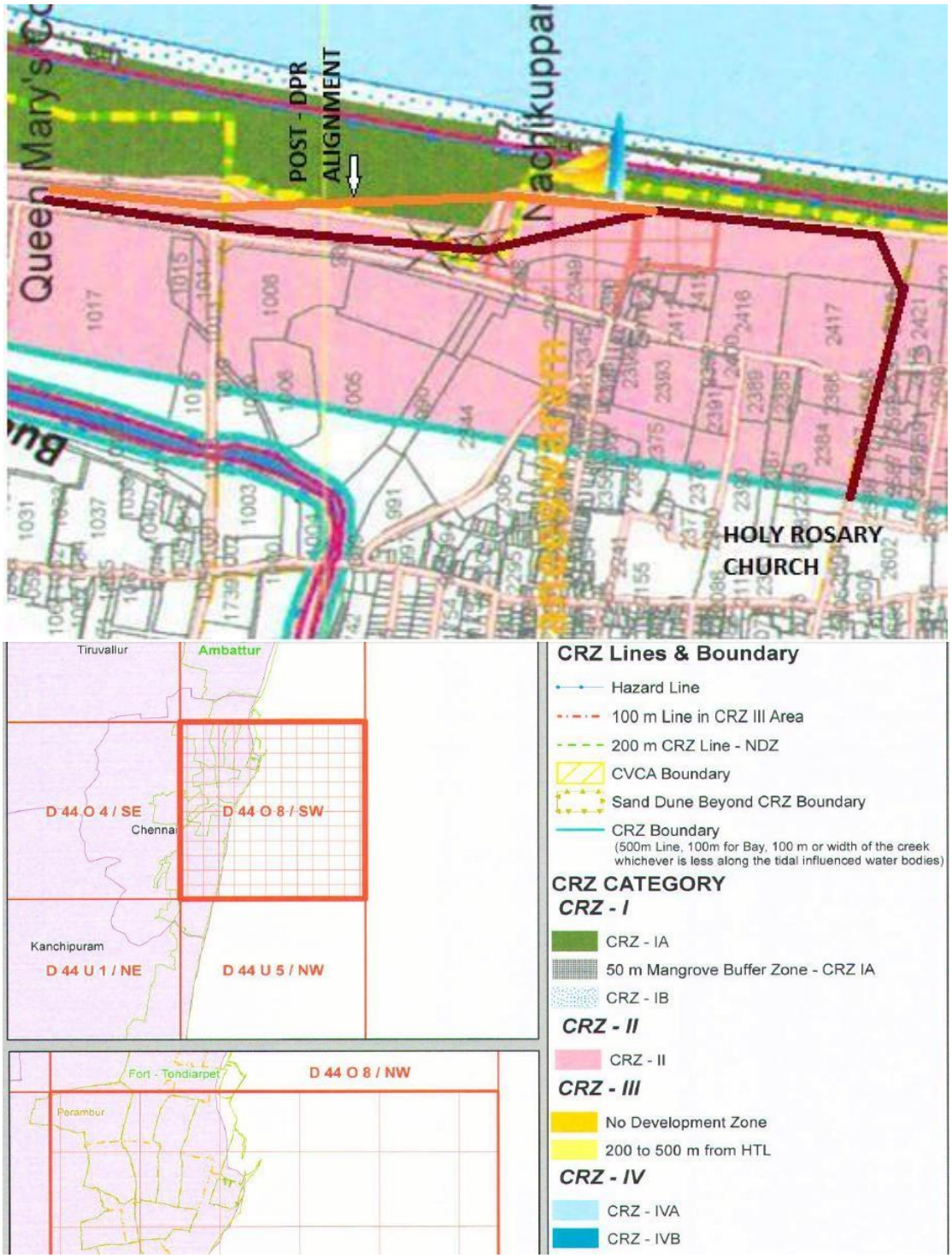
Source: Second Master Plan for Chennai Metropolitan Area, 2026

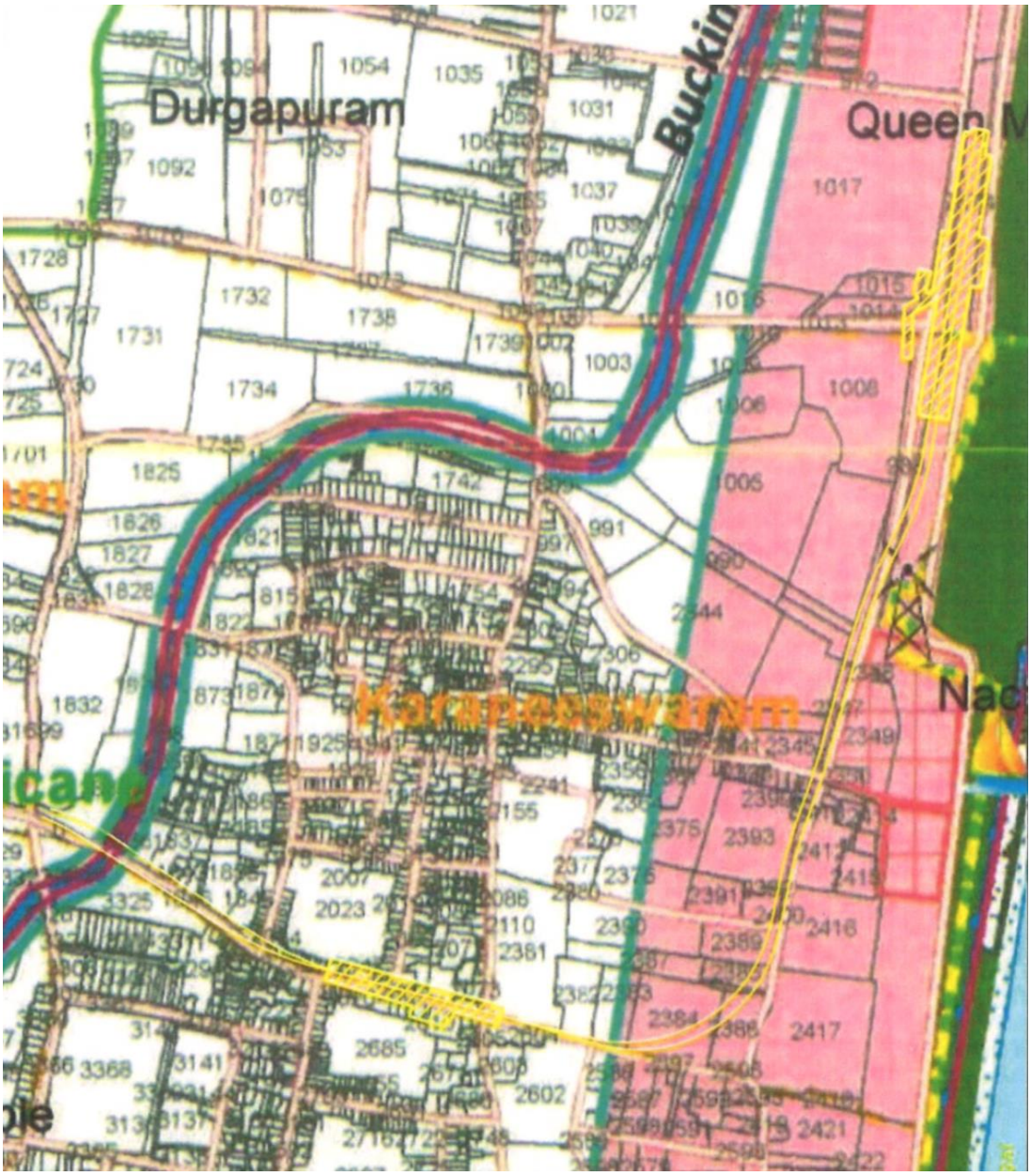
10. The ecologically sensitive areas in Chennai Metropolitan Area (CMA) are depicted in Figure 4.11.

11. The section of alignment from Lighthouse to Thirumayilai with a length of 1.56 km along Corridor 4 falls in CRZ. The DPR alignment (shown in violet colour in Figure 4.11) from Lighthouse station to Kutchery Road is located in CRZ II category. And the other section between Kutchery Road and Thirumayilai Metro is identified as CRZ II and CRZ IV-B due to the alignment passes through the tidal influenced water bodies (shown in blue colour in Figure 4.12).

12. In the alignment (shown in brown in Figure 4.12) which is revised post-DPR, length of about 2249m length of alignment traverses through CRZ area (18,344.91 sq.m of area in CRZ II and 220.9 sq. m of area in CRZ IV-B),

Figure 4-12: Alignment in CRZ II and IV-B Area





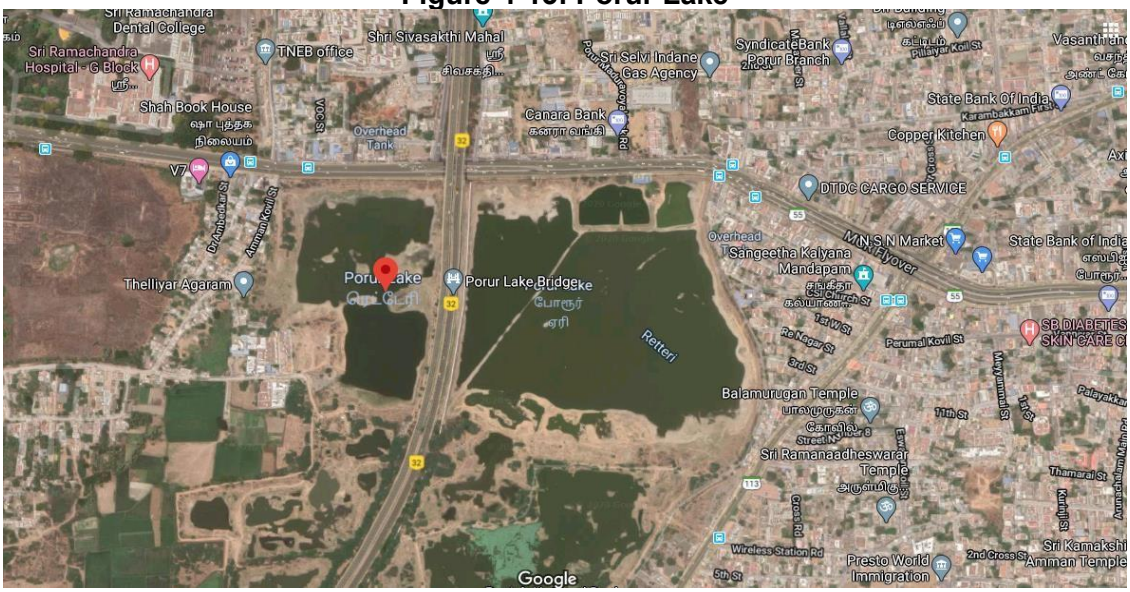
Source: Coastal Zone Management Plan Tamil Nadu Sheet No. D 44 O 8 /SW, NCSCM 2017-18

13. The elevated alignment of Corridor 4 is proposed to pass across Porur lake, which is located on the fringes of the suburb of Porur in south-west Chennai. Porur Lake functions as a source of water for the people residing in Chennai. It also acts as a drainage area that is connected with the Chembarambakkam Lake. As shown in Figure 4.14, Porur Lake is located at 13.034223 degrees north and 80.15065 degrees east. It occupies a water spread area of 250 acres with a capacity of 46 million cubic feet.

14. Since 1995, the government has prohibited activities like swimming, bathing and washing clothes in Porur Lake. In the year 2012, another initiative was taken by the Water Resources

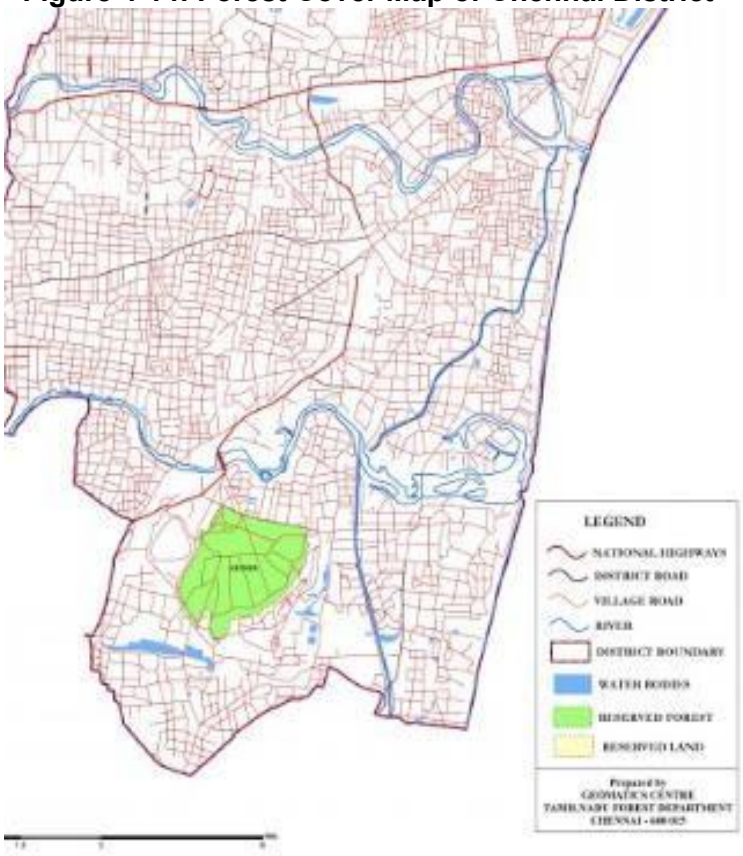
Department, not only to restore the lake, but also to meet the city's growing demands for drinking water. This project was aimed at increasing the capacity of the tank to 70 mcft. Since 2019 CMWSSB started tapping Porur Lake for drinking water and started desilting the lake during the dry season, when hardly any water was left in the lake. Many uncontrolled and illegal activities also termed as encroachment are responsible for disturbing the ecology of any setting or area. Porur Lake also acquired the ill fate of many other lakes in India in terms of degradation of water quality. This is evident from the observations of the residents of Porur. According to these residents, Porur Lake has turned into a dumping ground for garbage and the release of sewage. They have even emphasized on the fact that when this lake's bund would be breached, flooding of several localities around the lake would be its consequence. This troublesome event would take place every year during the monsoon season. Bearing in mind the desilting operations, the lack of water in the dry season and the continuous polluting Porur lake is assumed to have little ecological value.

Figure 4-13: Porur Lake



15. No mangroves are located near the project alignment. The nearest mangroves are those planted after flood of 2015 in Adyar river islands 2.2 km away and natural mangrove forest at Pichavaram 185 km away from Chennai. No forest area falls along Corridor 4. Forest cover map of Chennai district is shown in Figure 4.15.

Figure 4-14: Forest Cover Map of Chennai District



16. The following Table 4.26 lists the bird-watching areas in Chennai. (*Source: Madras Naturalists' Society*)

Table 4.26: Bird Watching Areas in Chennai

S.no	Location
1	Indian Institute of Technology, Adyar – tropical dry evergreen forest with exotic plantation
2	Pallikaranai Marsh – Open water interspersed with reeds and bulrushes
3	Adyar Estuary/creek/Adyar Poonga – Estuary with Mudflats
4	Nanmangalam Forest Reserve – Scrub covered slopes and water covered pools
5	Guindy National Park – Tropical Dry Evergreen Forest
6	Vandalur Hills and Zoo – Undulating terrain with original scrub and planted trees
7	Crocodile Bank – Coastal setting with artificial ponds and tall planted trees being used as a heronry
8	Pallavaram Hills – Original scrub and some trees
9	Manali and Madhavaram Jheel – Lakes
10	Edayanchatram – Open scrub
11	Thiruneermalai, Pammal – Hillock with some scrub
12	Red Hills and Cholavaram – Lakes
13	Ennore Creek – Coastal vegetation
14	Chemmencheri tank – Waterbody
15	Chembarampakkam lake

17. Guindy National Park with an area of 2.70 sq. km, which is under Reserve Forest category is classified as a Protected Area (ENVIS Centre of Wildlife and Protected Areas) and is located at distance of 2.6 km from the project alignment. In terms of density of vegetation cover, the area falls under sparse category.

18. The Guindy National Park is classified under tropical dry evergreen forests of the Coromandal coast and is being used for recreational purposes. The vegetation is mainly of the tropical dry evergreen type, and over 350 species of plants have been found including trees, shrubs, climbers, herbs and grasses. Chital and Blackbuck graze are found in the open grassland on the northern end of the park. Nocturnal animals include the toddy cat, civets, jungle cat, pangolin, and hedgehog. The dense forest, grasslands and water-bodies provide an ideal habitat for a large species of birds. Apart from snakes, certain species of tortoise and turtles, lizards, geckos, chameleons and the common Indian monitor lizard are also found here.

19. 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. Corridor 4 falls in default ESZ of Guindy National Park. Vide MoEF&CC 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 sq.m is not proposed, prior EC need not be sought and hence prior approval of NBWL need not be sought. In accordance with 2011 Guidelines for declaration of ESZ around national parks and wildlife sanctuaries, activities relevant to the project are categorized in Table 4.27.

Table 4.27: 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

Some of the ecologically sensitive areas of Chennai district are shown in Figure 4.15 and

Figure 4-16.

Figure 4-15: Ecologically Sensitive Areas of Chennai District

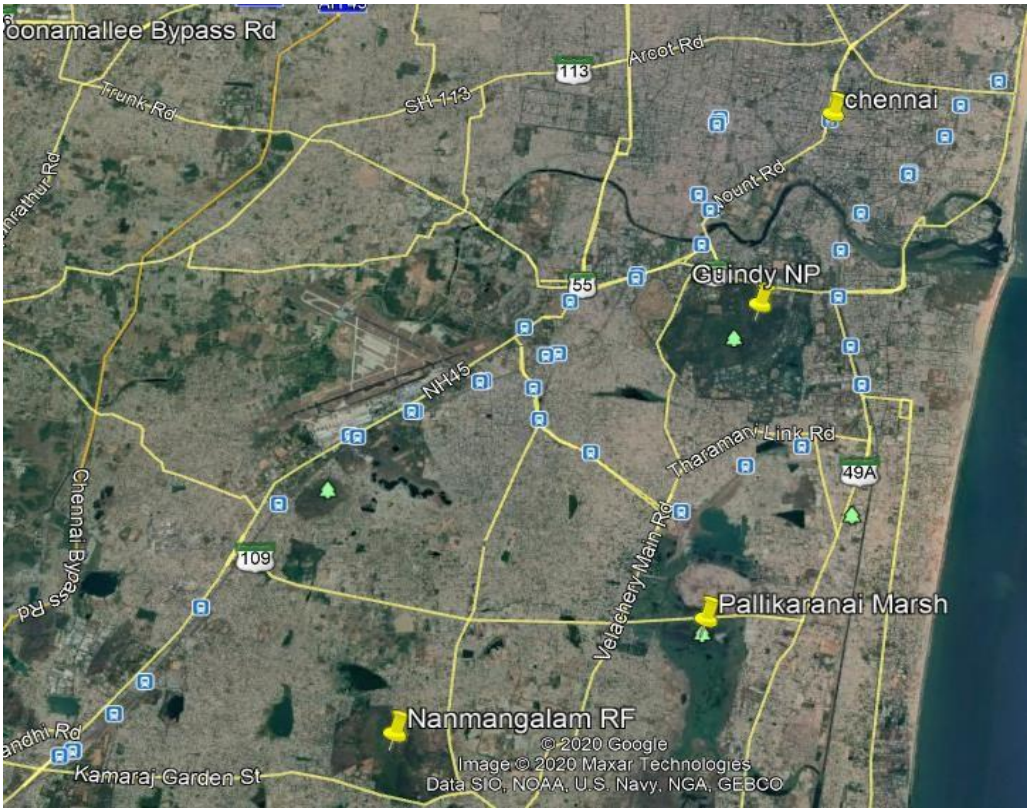
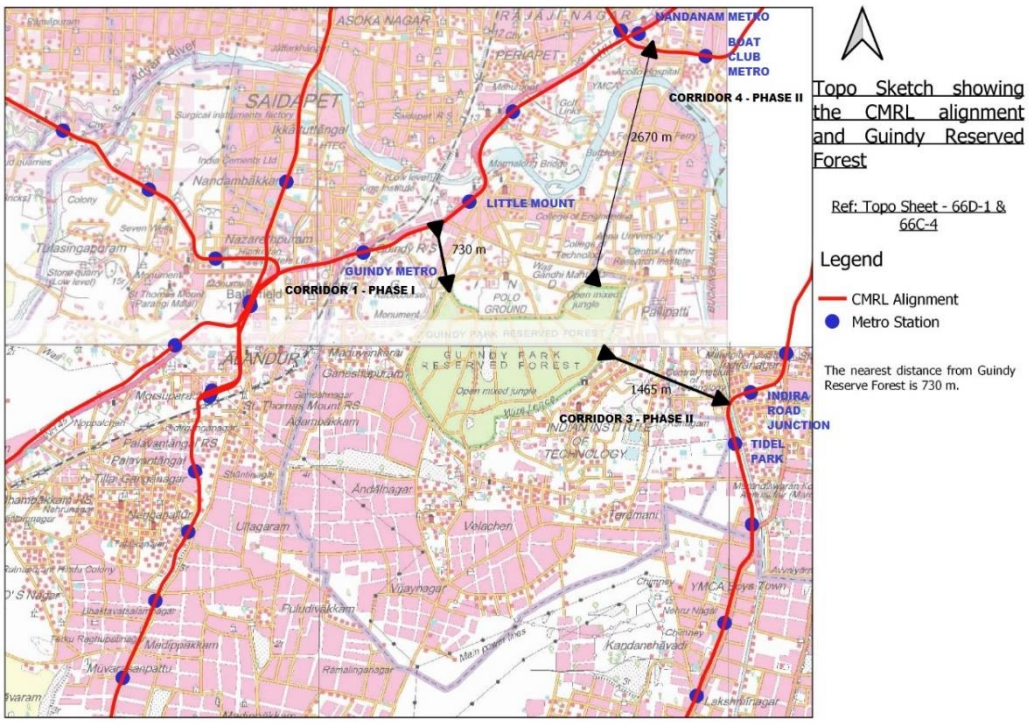


Figure 4-16: Topo sheet showing CMRL alignment , ESZ areas and Guindy National Park



20. The Nanmangalam Reserve Forest is home to 100-125 species of birds in addition to 40 different species of butterflies and close to 20 species of damselflies and dragonflies. 442 different species of flowering plants are found inside the forest alone. The Reserve Forest's most famous inhabitant and star attraction is the great horned owl.

21. Pallikaranai Marsh is a freshwater swamp. It 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). Biodiversity of Pallikarnai is seen in (*Source: nammapallikarnai.org*) 125 species of birds, 10 mammals, 21 reptiles, 9 amphibians,49 fishes,9 molluscans and 7 butterflies and 120 plant species. It is home to some of the most endangered birds such as the Black bellied tern, Great-knot and black -tailed godwit. Pallikarnai known for diverse variety of visitors and resident bird species. It is also home to some of the mostly rare reptiles such as the fan throated lizard, Russel viper and cobra. Other estuarine fauna present at the marsh includes the windowpane oyster, mud crab, mullet, halfbeak and green chromide. Plankton study shows that the water body is Eutrophic in nature.

4.4.2 Flora and Fauna

22. Corridor 4 passes underneath Panagal Park which is a recreation park; the metro station will be located underground at the south-east corner of the park. Tree count was carried out along the proposed alignment and in depot sites in 2018. Most of the trees exist along the sides of road and on median. The predominant tree species along the project corridors are listed below in Table 4.28.

Table 4.28: Predominant Tree Species along the Corridor (Local name- Botanical name)

Species	IUCN status
1. Vembu- *Azadirachta indica* (Neem)	LC
2. Vadam- *Terminalia catappa* (Indian Almond)	LC
3. Nirkadambai - *Neonauclea purpurea*	NE
4. Thoongumoonji – *Samanea saman (Rain tree)*	-
5. Panei - *Borassus flabellifer* (Palmyra)	NE
6. Pungam – *Millettia pinnata*	LC
7. Mayir Konnai - *Delonix regia* (Gulmohar)	LC
8. Nettilingam- *Polyalthia longifolia* (False Ashoka)	NE
9.Vagai – *Albizia lebbeck*	NE
10.Thennai - *Cocos nucifera* (Coconut)	NE
11. Shevaga – *Morinda tinctoria*	-
12. Nuna - *Bombax malabarica*	NE
13. Arasu - *Ficus religiosa* (Peepal)	NE
14.Al - *Ficus benghalensis* (Banyan)	NE
15. Ma – *Mangifera indica* (Mango)	DD

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

23. The number of trees likely to be cut is presented in Table 4.29. 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.

24. 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.

Table 4.29: Tree Cutting

S. No	Description	Number of Trees for felling*
Corridor-4 (Light House to Poonamallee Bypass)		
1	Alignment	707
2	Poonamallee Bypass Depot	187
	Sub-Total	**894**

***This figure will be confirmed upon completion of socio-economic survey, preparation of land plan and impact micro plan*

25. A biodiversity survey was conducted from 16th November to 15th December 2020. The primary data on floral diversity and faunal diversity was collected from Nanmangalam RF and Pallikarnai Marshland area, in order to know any endangered species of flora and fauna found in the areas. The result indicated that the Nanmangalam RF harbours a notable diversity of flora and fauna, with the potential of functioning as an in situ conservation area for plants. The merit of the RF is further enhanced by the presence of a sizeable number of endemics and endangered organisms. The primary ecological data for Porur lake was not collected because there are no migratory birds observed in that area, except local birds based on secondary literature. On the other hand, Porur Lake is an artificial water resource and polluted. Most of the plantations in Poonamallee depot area are manmade and mostly exotic trees are present. Native flora and fauna is not affected in corridor 4 depot. Hence, the biodiversity assessment was not carried out initially. In addition, due to COVID-19 restrictions , CMRL could not initiate the ecological survey at the Porur lake. CMRL will conduct an ecological survey of the Porur lake once the site survey restrictions are minimized.

4.5 Socioeconomic Environment

4.5.1 Utilities

26. Corridor 4 is planned to run through the urban area above the ground i.e. elevated in less densely populated and underground in populated and sensitive areas. The alignment will cross drains, a large number of 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 etc.

27. 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 suburban services and direct impact on the public besides set back in construction and project implementation schedule & costs. Therefore, meticulous detailed survey and planning will be required to protect/divert the utility services. The utility maps and network information are attached in **Annexure 4**.

28. The underground part of the alignment from Lighthouse station to Kodambakkam Flyover passes a total of 8 colleges, 13 schools and 18 hospitals, all located within 200 meter from the center of the alignment. The elevated section of the alignment from Kodambakkam Flyover to Poonamalle bypass passes 11 colleges, 30 schools and 15 hospitals. Exact details of these sensitive receptors including their coordinates and distance to the alignment can be found in **Annexure 2.**

29. Based on the Resettlement Plan (RP) for the project a total of 1 school and 4 religious structures will be directly impacted by the cut-and-cover construction of the underground stations. The elevated section of corridor 4 will directly impact 2 schools and 4 religious structures. All affected structures will be duly compensated as per the RP.

30. Corridor 4 will impact 734 households engaged in commercial activity (214 owners, 386 tenants, 48 squatters 85 encroachers and 1 kiosk) leading to loss of business premises, business income and rental income. Furthermore, corridor 4 will impact 297 residential households (236 owners, 43 tenants, 12 squatters and 6 encroachers) Affected households will be duly compensated following the Entitlement Matrix which is part of the RP.

31. The underground section will pass the 1.6 hectare urban Natesan Park on the south-west side (underneath Venkatanarayana Road) and will traverse underneath the 3.2 hectare urban Panagal Park, with a station planned on the south-east side of Panagal Park (underneath Venkatanarayana Road) and metro entrances both north and south of the park.

4.5.2 Physical Cultural Resources

32. No archaeological monuments/sites are located on or along the proposed corridors. Three draft lists of heritage assets in CMA are available (http://www.cmdachennai.gov.in/HeritageBuildings.html). Phase I list which was sent in year 2013 comprised 20 assets in Grade I, 43 in Grade II and 3 in Grade III; Phase II list which was sent in year 2014 comprised 38 assets in Grade I, 3 in Grade II and none in Grade III; Phase III list which was sent in year 2016 comprised 29 assets in Grade I, 28 in Grade II and none in Grade III. In Grade I assets no interventions are permitted except to strengthen their life. In Grade II assets, internal changes and adaptive reuse will be generally allowed, but external changes will be subject to scrutiny; ensure the conservation of all special aspects. In Grade III assets, external and internal changes, and adaptive reuse would generally be allowed. Of these the following three are located close to the proposed alignment. These 3 heritage assets in Table 4.30 are as shown in photographs placed below.


Santhome Church


Rosary Church


Our Lady of Light Shrine

Table 4.30: Heritage Assets near the Underground section of the Alignment

S.no	Name of Heritage asset	Approx. distance from road Centre line followed by the C4 alignment (m)	Grade
1	National Shrine of Santhome Church, Santhome High Road, Santhome	110	I
2	Rosary Church, Rosary Church Road	1*	I
3	Our Lady of Light Shrine, Luz Church Road	73	I

Note: * Distance up to boundary is 1m, distance up to building is 17m.

33. Besides these three heritage assets the underground alignment passes another 5 mosques, 8 churches and 31 temples, all located within 200-meter distance from the alignment. The elevated section of the alignment passes another 10 mosques, 37 churches and 81 temples. Details of these physical cultural resources can be found in Annexure 2.

4.5.3 Demographic Features

34. 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. The other socioeconomic baseline is described in the standalone Social Impact Assessment.

35. Based on the RP a total of 1031 households will be fully or partially affected by the construction of corridor 4. Table 4-31 provides a breakdown of this number between residential and commercial and partially or fully affected.

Table 4.31: Impact on Families

Tenure	Residential		Commercial		Grand Total
	Affected not-displaced	Displaced	Affected not displaced	Displaced	
Owners	115	121	199	15	450
Encroacher	6	0	85	0	91
Squatters	0	12	0	48	60
Kiosk	0	0	0	1	1
Tenants	20	23	330	56	429
Total	141	156	614	120	1031

36. The affected families will be given compensation and assistance to mitigate loss of land, properties, loss of rental incomes, loss of livelihood and business income.

5. ANTICIPATED IMPACTS AND MITIGATION MEASURES

5.1 Methodology

37. 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

38. 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.

39. 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.

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

- For physical impacts an average of 15-meter corridor on either side along the existing road;
- For vibration impacts any sensitive receptors in an area of 100 meter on either side of the metro alignment;
- For noise impacts any sensitive receptors in an area of 200 meter on either side of the metro alignment.

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

42. 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.

43. 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.

44. 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}, $PM_{2.5}$,SO_2 , NO_2 and CO 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 Zinc and organic matter. Porur 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 mineral content and high levels of coliforms.
1.6 Ground water quantity	High	Chennai is facing major water shortages.
1.7 Land degradation and pollution	Medium	The project alignment is following major roads which pass mainly through residential and commercial areas. Underground section will generate huge amounts of spoil.
2. Biological environment		
2.1 Trees, terrestrial and aquatic vegetation	Medium	Guindy National Park is located at 2.6 km from the alignment, corridor 4 partly falls within its eco sensitive zone. Furthermore,

VEC	Sensitivity level	Remarks
2.2 Terrestrial fauna (mammals, birds, insects)	Low	the alignment passes Porur lake. Pallikaranai Marsh and Nanmangalam Forest reserve are located further away at 10 and 12 km respectively. Approx. 707 trees at project alignment and 187 trees at poonamalle depot , total of 894 trees have to be removed from the project alignment.
2.3 Ecologically important areas	Medium	
3. Social environment		
3.1 Private land and buildings	Medium	Approximately 1031 families will be affected, approx. 14,022 m^2 of private land needs to be acquired.
3.2 Public property/ infrastructure/ utility structures	High	Major pipelines and high voltage lines run along the proposed alignment
3.3 Noise	High	The existing ambient noise levels in general already exceed the CPCB and WBG-EHS limits.
3.4 Vibration	High	There are several structures located near the proposed alignment, including 3 heritage sites. Regular traffic adds to vibration levels
3.5 Occupational health and safety	Medium	The project area already experiences some road safety issues due to the traffic. A moderate risk of flooding exists for the underground section.
3.6 Public health and safety	Medium	
3.7 Physical cultural resources (PCR)	Medium	The alignment passes 3 heritage sites and multiple religious places, some of them at close distance.

45. 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.

46. 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.

47. Intensity of impact. The intensity or seriousness of an impact entails understanding the repercussion or risks posed by the impact. This is a subjective criterion 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.

48. 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

49. 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.

50. 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.

51. The negative environmental impacts will mainly occur during construction work and during operation phase. The significant impacts screened are:

I. Design phase:
- Loss of about 894 trees for construction of metro rail alignment as well as depot area.
- Dislocation or involuntary resettlement of people as there will be a need for land acquisition for elevated as well as underground sections and also for depots.

II. Construction phase:
- Subsidence, noise and vibration due to tunnelling boring machine (TBM), excavation machines, and materials hauling.
- Safety risks, inconvenience of traffic nuisance and poor accessibility due to road closures and diversions, noisy conditions etc. will also be created due to plying of large number of heavy trucks transporting construction material, equipment and machinery in and around the project area.
- Increased noise and air pollution resulting from traffic volume during construction.
- Increased local air pollution due to rock crushing, cutting and filling works, and chemicals from asphalt processing.
- Increase in Emission from the machinery and vehicles, emission from the site operation in construction yard, dumping of excavate and waste at disposal sites.
- Degradation of water quality in surface as well as ground water due to run off and wastewater from the construction sites, construction yards, waste disposal sites, labour camps, hazardous waste etc.,
- Risk and damage of aquatic ecosystems due to accidental release of waste.
- Risks for damage to structures from vibration during construction .

III. Risks and vulnerabilities related to occupational health and safety due to physical, chemical and biological hazards during project construction.Operation phase:

- Risks for damage to structures and annoyance to people from vibration during operation.
- Increased noise from train operation
- Risks and vulnerabilities related to occupational health and safety due to physical, biological, and electromagnetic hazards during project operation.

52. Adverse impacts that are likely to result from Corridor 4 development have been listed in Table 5-3 under the following headings:

- Impacts and Mitigation Measures during Project Location and Design;
- Impacts and Mitigation Measures during Construction;
- Impacts and Mitigation Measures during Project Operation (including depot)

Table 5.3: Impacts Screening

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	Land degradation use of ground water and construction materials			*	*				*				*	Moderate	Minimal –ve
2	Land degradation, location of construction yards		*		*				*				*	Minor	Minimal –ve
3	Land degradation, location of muck disposal sites			*		*		*					*	Moderate	Minimal –ve
4	Flora and fauna, impact on trees and ecosystems			*		*			*				*	Moderate	Minimal –ve
5	Private land and buildings			*		*				*			*	Moderate	Minimal –ve
6	Aesthetic impact, alignment, architecture and station planning			*	*					*			*	Moderate	Minimal –ve
7	Public property/ infrastructure/ utility structures			*		*			*				*	Major	None
8	Physical cultural resources		*		*			*					*	Minor	Minimal –ve
9	Public health and safety, risk of flooding due to sea level rise resulting from climate change			*	*					*		*		Moderate	Minimal –ve
10	Public Health and safety, risk of flooding due to anomalous heavy rainfall		*			*				*	*			Minor	Minimal –ve
11	Public Health and Safety, earthquake Risk			*	*				*			*		Moderate	Minimal –ve
B.	**Impacts due to Project Construction**														
1	Air quality, ambient air pollution		*			*			*				*	Moderate	None
2	Water quantity, increased water demand		*			*			*				*	Minor	None
3	Groundwater quality, impact on water and soil quality		*			*		*				*		Moderate	Minimal –ve
4	Groundwater quantity, dewatering		*		*			*					*	Minor	None
5	Land degradation, muck disposal			*			*		*				*	Major	Minimal –ve
6	Land degradation, waste disposal			*			*		*				*	Moderate	None
7	Land degradation, impacts due to labour camp		*			*		*				*		Moderate	None
8	Land degradation, soil erosion		*		*			*				*		Minor	Minimal –ve
9	Public and private property, damage due to ground subsidence			*		*				*		*		Moderate	None
10	Traffic and utility diversion		*			*				*			*	Major	None
11	Noise and Vibration		*			*			*				*	Major	None
12	Occupational Health and Safety		*		*				*			*		Moderate	None
13	Energy, increased energy demand		*			*		*					*	Minor	None

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		
14.	Damages to aquatic ecosystem due to accident release of waste		*			*			*				*	Moderate	Minimal –ve
C.	**Impacts due to Project Operation**														
1	Water supply and Sanitation at Stations			*		*		*					*	Moderate	Minimal –ve
2	Noise			*		*			*				*	Major	Minimal –ve
3	Vibration			*		*			*				*	Major	Minimal –ve
4	Health and Safety			*	*				*			*		Moderate	Moderate –ve
5	Energy Consumption at stations			*		*			*				*	Moderate	Minimal –ve
6	Depot • Water supply • Sewage and Effluent • Oil Pollution • Noise • Surface Drainage • Solid waste • Loss of trees			*	*			*					*	Moderate	Minimal –ve
	POSITIVE IMPACTS														
1	Employment Opportunities			*			*			*			*		Moderate +ve
2	Benefits to Economy			*			*			*			*		Moderate +ve
3	Direct benefits to passengers			*			*			*			*		Moderate +ve
4	Reduced fuel consumption			*			*			*			*		High +ve
5	Reduced air pollution			*			*			*			*		High +ve
6	Utilization of Grade Separator (1. The Grade separator is designed as an integrated structure with the proposed elevated metro lines thereby reducing the additional land acquisition, felling of trees, etc. 2. Better flow of vehicular movement through Grade separator, reduces traffic stagnation.)			*		*				*			*		High +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
Likelihood: U: unlikely; L: likely; D: definite

53. For each of the VECs, potential impacts are evaluated and mitigating measures have been proposed.

5.4 Air Quality

54. **Impact.** The major sources of ambient air pollution are demolition of structures to be removed; operation of construction equipment; installation of earth retaining structures, pile driving where cast-in-situ is not feasible, blasting in rock; movement of vehicles transporting construction materials, muck and waste. The pollution is in terms of fugitive dust and emissions from trucks.

55. 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 muck/waste disposal site. Vehicular emission is estimated as in Table 5-4.

Table 5.4: Emissions due to truck movement

Pollutant	Emission (ton)
Carbon Monoxide (CO)	63.00
$PM_{2.5}$	2.0
Hydro-Carbons (HC)	2.0
Nitrogen Oxide (NO_x)	131.0
VOC	20.0
Carbon dioxide (CO_2)	8145

56. Emissions from DG sets, pollution at sites of waste disposal and muck disposal during unloading and stacking, emissions from fuel and other hazardous chemicals are among other sources of air pollution.

57. Air pollution from road based vehicles especially particulate is found to cause diseases of brain, heart, lungs and kidneys.

58. **Mitigation**. Mitigation measures which will be adopted to reduce the air pollution are listed below:

- Contractor's transport vehicles and other equipment shall conform to emission standards. The Contractor shall carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.
- 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. DG sets compliant with emission standards will be used The following dust protection methods will be used:
    - Dust screens during excavation and demolition near sensitive receptors o 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
- 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 habitat areas.
- The Contractor will ensure that the authorized vendor covers loads of construction and demolition (C&D) waste and hazardous waste being transported from construction sites. All trucks carrying loose material should be covered and loaded with sufficient free - board to avoid spills through the tailboard or sideboards. Containers carrying hazardous waste are loaded onto trucks with due care to avoid escape of fumes or spillage enroute. Transportation of muck and waste will be scheduled by time and route to minimize air pollution in habitat areas. The contractor will implement similar safeguards while transporting muck.
- The temporary muck storage areas will be maintained by the Contractor at all times until the excavate is re-utilized for backfilling or as directed by GC. 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.
- 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.
- Construction yards with aggregate crushing and screening, pre-casting, material and fuel storage and GC plants will be located away from habituated or ecologically sensitive areas.
- Labour residing in camps will be provided with LPG fuel for cooking.

59. **Residual impact**. Through modal shift from fossil-fuel driven transport to electric public transport the metro will have a long-lasting high positive residual impact on the air quality. The magnitude of the beneficial impact of metro will increase with increasing ridership.

60. Based on number of daily vehicle kilometer reduction, daily reduction in fuel (diesel and petrol) consumption has been estimated. The reduction has been estimated based on retiral - without addition - of pre-BS VI vehicles from year 2020 onwards; in accordance with the report commissioned by Niti Aayog, 100% of 3 wheelers and buses and 40% of private 2 wheelers and cars have been assumed to be electric from year 2030 onwards. The benefit is an interplay between shift from road modes to Metro and shift from more polluting pre-BS VI road vehicles to less polluting BS VI road vehicles. The estimated daily vehicle-kilometre that will be reduced due to operation of Corridor 4 is given in Table 5.15. Reduction in fuel consumption is reported in Table 5.16. The reduction of air pollution is presented in Table 5.17. 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.

Table 5.5: Reduction in Daily Vehicle kilometers

Mode	Daily vehicle km Reduced due to Corridor 4		
	2025	2035	2045
Bus	1,065,268	1,429,592	1,614,089
2 wheeler	225,656	528,539	804,727
Car	135,548	379,296	476,847
3 Wheeler	60,562	137,509	201,331

Source: Detailed Project Report for Corridor 4 Chennai Metro Phase 2, Oct. 2018

Table 5.6: Reduction in Fuel Consumption (million litre per year)

Mode/Year	2025	2035	2045
Diesel	96.30	0.20	0.30
Petrol	2.90	3.50	4.70

Table 5.7: Pollution Reduction (ton/year)

Pollutant	2025	2035	2045
CO	2,581	195	276
PM	57	1	1
$HC+NO_x$	2,475	32	45
CO_2 (net)	180,839	71,809	53,834
Treatment cost (Rs million per year)	602	59	59

5.5 Water quality and quantity

61. **Impact**. Public facilities such as water supply, sanitation and washrooms are very much needed at the stations. The water requirement for stations would be for drinking, toilets, cleaning and also for other purpose like Air Conditioning. Water Demand for alignment is calculated and presented in Table 5.8. The water requirement for the stations will be met through the public water supply system.

Table 5.8: Water Demand

S. No.	Particular	Water Demand at Each Station (KLD)	Total Water Demand (KLD)
1	In Underground stations with softening plant	85.0	765
2	In Elevated stations	16.6	298.80
		Total	1,063.80

62. Thus there would be total water requirement of 1,063.8 KLD in 30 stations. Arrangement of water will have to be made at each station separately with proper drainage system for wastewater. CMWSSB water supply will be supplemented by rainwater harvesting along viaduct and rooftop of elevated stations. Sewage of 904.2 KLD will be generated. Wastewater will be led into municipal sewage system.

63. The water demand will increase during construction phase for meeting drinking and domestic water requirement of workers. Water consumption during construction is of the order of 433 KLD for Corridor 4.

64. Construction materials, oils and greases 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.

65. Chemicals used in tunneling could result in pollution of seepage water and further contaminate the groundwater or surface water into which this water is discharged: polyurethane resin used to seal water leaks through tunnel segments is toxic to aquatic life with long lasting effects (ECHA). Bentonite used to seal infiltration of water through soil is not classified as harmful. Polymers are used to facilitate tunneling in clayey soils.

66. Table 5.9 shows groundwater levels 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. It indicates that significant dewatering of excavations might be required.

Table 5.9: 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		
August 2019	5	*18*	42	31% wells seen more than 2m rise	8.2 % wells seen more than 2m fall
January 2020	21	*33*	30		
August 2021	11	*39*	38	<2m rise in 24%; >2m rise 38%	<2m fall in 35%; >2m fall 3.4%
January 2022	44	*39*	13		

(*CGWB Yearbooks 2013-14,2014-15,2015-16,2016-17,2017-18,2018-19, 2019-20, 2021-22 for Tamil Nadu and Puduchery)*

67. **Mitigation.** Sufficient water for construction purpose would be made available from CMWSSB supply, or treated effluent from ETPs located nearby or seawater or surface run off in view of the quality requirements of construction based contractor-defined estimated volumes.

68. Sewage and wastewater from labour camps, construction sites and construction yards will be treated to meet CPCB standards by means including precipitation chambers before disposal into sewage system. Dewatered water will used for dust suppression purpose, and the remaining will be suitably treated to meet CPCB standards before recharging groundwater or discharging into storm water drain.

69. The dewatering of tunnel muck will be conducted prior to transportation to the muck disposal site. The muck disposal plan will contain detailed requirements of such activity. Seepage water during tunneling will be collected, treated and added to groundwater to recharge.

70. Wastewater generated will be collected and discharged into municipal drains after proper treatment to meet the CPCB standards. Efforts should be made conserve the water by recycling water in the system. Also, as an environmental conservation measure, to conserve and augment the storage of groundwater, it is proposed to construct rainwater harvesting structure of suitable capacity at the elevated stations and in the elevated alignment. Each pillar can 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 2.80 lakh cum per year on Corridor 4.

71. Water required for operation of depot shall be sourced from municipal supply. This shall be supplemented by rainwater harvesting. Treated sewage will be used for horticulture and non-drinking purposes in operational facilities and staff quarters if any. Train washing requires 22 KLD by year 2055, generating 19 KLD sewage. Water demand will be 70 KLD for domestic purpose including staff quarters at Poonamalle depot resulting sewage will be 63 KLD.

72. To conserve and augment the storage of groundwater, it has been proposed to construct rainwater harvesting structures in the proposed depots to receive runoff from sloping roof of the depot as well as recharge of ground water in uncovered land area. On Depot potential for rainwater harvesting is 0.77 lakh cum per year from roof of structures in the depots. In addition, estimated quantity of 1.57 lakh cum per year will be available for ground water recharge.

73. Sewage will be generated from depot which could be treated up to the level so that it could be used for horticulture and non-drinking purposes in the Depot. For Poonamalle Bypass depot Sewage Treatment Plant (STP) and Effluent Treatment Plant (ETP) are proposed. The wastewater from depot will have oil, heavy metals grease and detergent as main pollutants. This has to be treated as per requirement of Tamil Nadu State Pollution Control Board, the standards for discharge of effluent on land for irrigation purposes are included in Annexure 11 Oil spilled in depot should be trapped in oil and grease trap and disposed to authorized collectors so as to avoid any underground/ surface water contamination. Oil that is mixed in water shall be removed in the ETP.

74. **Residual impact**. 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.

75. Water demand at stations will impact the availability of this commodity which cannot be completely mitigated through rainwater harvesting. A minimal negative residual impact will therefore remain.

5.6 Land degradation

76. **Impact**. Change in land use and excavation of soil will lead to soil erosion. Measures must be taken to avoid damage to the topsoil (more specific) from median, and depot site topsoil. It has to be preserved and utilized. Soil excavation will be required for piling activities for metro piers. Muck from tunneling containing bentonite would also be generated in the project.
1.
77. Corridor 4 construction is a material intensive activity. Huge quantity of different construction materials will be required for construction of elevated section and stations. These shall be sourced from the nearest source. 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 shall be sourced only from legalized and approved quarries.

78. Construction material waste, demolition waste and hazardous waste from construction equipment and construction vehicles can pollute air, water and soil. The procedure of demolition will be conducted as per the demolition plan prepared by the Contractor in consultation with CMRL. The existing structures should be demolished one after another cautiously.

79. 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, its bulk which is carried over long distances for just dumping, its 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 reuse 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. Normal construction waste can go to existing facilities conform to national systems, however when large scale spoil disposal will take place in specific designated locations this will need to be carefully managed.

80. 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 competent 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.

81. During construction phase there would be establishment and operation of Batching Plant and Casting Yard which would be located in an area designated and allotted by CMRL away from habitation. If possible, these facilities 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 batching plant and casting yard 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 to be approved by MDBs prior to putting the site into use.

82. There would be significant movement of men, material and machinery in batching plant and casting yard. It is expected that both batching plant and casting yard would be located at same complex. Huge quantity of cement, aggregates and other construction materials would be

used in batching plant and casting yard. There would be generation of dust, noise, flue gases and other contaminants from the working of heavy machinery for handling and transporting the construction materials. The mitigation measures for different aspects, such as the soil and groundwater quality baseline shall be collected by contractor prior to mobilization and shall be monitored during construction, have been elaborated in EMP.

83. 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.

84. The disposal of the hazardous waste should be as per the requirements given in the Hazardous Waste Management Rules 2016. 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 shall maintain a record of sale, transfer, storage of such waste and make these records available for inspection. The contractor shall get Authorized Recyclers to transport and dispose Hazardous Waste, under intimation to the Project Authority.

85. During construction activities the contractor is responsible for providing and maintaining necessary (temporary) housing and allied facilities for the workforce in accordance with living standards approved by CMRL. Improper disposal of municipal solid waste generated by labour camps can pollute surface water bodies and groundwater. Burning of waste can cause air pollution. Construction workers are more prone to infectious diseases due to unsafe sexual activity and lack of sanitation facilities (water supply and human waste disposal) and insect vectors. Problems could arise due to cultural differences between workers from outside and local residents. Criteria for the camp management and the workers code of conduct are further specified under section 5.14, Occupational Health and Safety.

86. **Mitigation**. The construction activities will cause soil erosion during excavation. This can be mitigated by utilizing around 35 % of excavated soil for land filling purposes. The excavated top fertile soil is suggested to be preserved and used later for gardening and lawn establishment.

87. Subject to specifications issued by CMRL in the works contracts, the earth excavated during cut and cover and tunneling and displaced during piling will be used as backfill on the project. Such backfill will result in estimated surplus quantity of 0.94 million cum from Corridor 4. If this muck is not contaminated by hazardous substances such as heavy metals or POPs17, the contractor will be permitted to sell it as fill for activities outside the project; in case of hazardous contamination it will be disposed at permitted sites by licensed vendors

88. Sites for muck disposal will be decided by CMRL before start of construction in consultation with and after approval of TNPCB, Municipal Corporation/Municipalities and CMDA. The sites will be located away from residential areas, water bodies and ecologically sensitive locations as to avoid disrupting natural drainage. Spoil and waste disposal sites will be selected

[17] 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.

following the site selection criteria as included in annexure 10 and will be subject to approval of MDBs prior to use. Responsibility of disposal of this soil will lie with contractor and will be regulated by TNPCB rules. Bentonite slurries used in diaphragm wall construction should be reconditioned and reused wherever practicable. Disposal of residual muck containing bentonite, a natural clay, should be at a designated site away from water bodies due to its capacity to increase pH values and should follow the international good practice. The C&D waste would be handled and disposed off to waste processing facility or for back filling of low lying areas only if the area is covered afterwards with a good quality layer of topsoil of sufficient thickness, leaving no significant impact on environment.

89. Soil erosion by runoff will be controlled by installing proper drainage systems using contour information. Material will be stabilized by watering or other accepted dust suppression techniques. 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, which will be approved by CMRL.

90. 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 labours, free of charge. Labour camps will be in full compliance of BOCW Act.

91. It is estimated that about 5,784 people will work during peak construction activity on 50% sections of the corridors on site, in casting yards and depots. Estimated total population in the labour camps will be 5,784. The water requirement at camps will be 780 KLD, wastewater generation 492 KLD & municipal solid waste generation 1.3 ton per day. This is tentative and will vary depending on the construction schedule during construction.

- **Water supply:** Uncontaminated water for drinking, cooking, washing and health care must be provided to all workers in the labour camp.
- **Sanitation Facilities:** Construction sites and camps shall be provided sanitary latrines and urinals. Sewerage drains should be provided for the flow of used water outside the camp. Drains and ditches should be treated with bleaching powder on a regular basis. The sewage system for the camp must be properly designed by providing septic tanks, built and operated so that no health hazard occurs and no pollution to the air, ground or adjacent watercourses takes place. Garbage bins must be provided in the camp and regularly emptied and the garbage disposed in a hygienic manner. Labour camps should also be provided with proper ventilations and air cooling system.

92. Solid waste generated will have to be disposed in compliance with Municipal Solid Waste (Management & Handling) Rules, 2000, as amended to date. Municipal solid waste will be collected and taken away and disposed by municipality. Solid waste management facilities will be arranged by the construction contractors. Prior to commencement of the works contractor has to prepare a solid waste management plan, describing the expected amounts of waste, the handling and temporary storage of the waste and the final destination of the waste. In the waste management plan distinction has to be made between hazardous and non-hazardous waste including the procedures to establish the waste category.

93. Solid waste generation from passengers at stations is likely to be 342 ton per day. Non-hazardous solid waste generated in stations will be collected and transported to the disposal sites by Chennai municipal corporation.

94. The solid waste generated from the Depot will be taken by the cleaning contractor weekly and disposed to the municipal waste disposal sites. It is estimated that municipal solid waste of about 0.18 ton per day will be generated from Poonamalle Bypass depot. During operational phase the depot will need to have in place a Pollution Prevention and Waste Management plan and needs to have permanent facilities installed to handle and temporarily store both hazardous and non-hazardous waste. Storage of lubricants, oil, fuel and other noxious fluids must take place within roofed, rain-exclusive containment structures with concrete or non-permeable flooring material and should have a capacity of at least 115% of the volume of the largest container stored, constructed only in locations with zero probability of flooding during heavy rains. Training in spill prevention and spill response should be provided to all workers involved in refueling or equipment servicing.

95. **Residual impact**. Since it will take some time for soil to settle after the construction works a minimal negative residual impact for soil erosion and ground subsidence might exist, especially at muck disposal sites. Although contractor has to take every effort to prevent contamination of construction yards and waste disposal sites, a certain degree of pollution cannot be ruled out. Therefore, a minimal negative residual impact exists, especially if the contractor's liability for any pollution that has arisen is insufficiently covered.

96. The project will use large amounts of construction material and thus will deplete construction material sources to a certain extent. Materials shall be sourced from the nearest source and from legalized and approved quarries. Requirement of electricity will be optimized by proper use of natural day/night light. Full height platform screen doors will be implemented so as to conserve energy for ventilation and air conditioning in underground stations. Green Building features will be implemented in station design. Residual impact is considered minimal negative.

97. Locations will be sought that are away from residential areas, water bodies and environmentally or ecologically sensitive areas. It cannot be ruled out that construction yards and muck disposal sites could cause a change in drainage patterns around the sites. When sites are carefully selected the residual impact will be minimal negative.

5.7 Flora and Fauna

98. **Impact**. The construction of Corridor 4 were felled of about 894 public trees in total, 187 of these are located at the Poonamallee Bypass depot. site. None of the trees to be cut are rare or endangered species. With removal of these trees, the process for CO2 conversion will get affected and the losses are reported below:

- Total number of Trees : 894
- Decrease in CO_2 absorption due to loss of trees: 2,682 kg/year
- Decrease in Oxygen production due to tree loss: 9,834 kg/year

99. 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), CO2 sequestered per year per tree has been estimated for this report as 3 kg for typical tree of 30 cm girth.

100. CMRL has obtained the CRZ clearance from TNCZMA prior to contractor's mobilization. CMRL has ensured the compliance of the general conditions and specific conditions set forth in the CRZ clearance.

101. Corridor 4 passes underneath Panagal Park which is a community park; underground station is proposed at the south-east corner of the park with access on roads at its periphery. The station will be constructed by cut and cover, loss of trees and birds and animals dependent on trees might be dislocated.

102. Artificial Light at Night (ALAN) has been linked to important maladies such as cancer incidence and reduced skeletal muscle function. Effects of ALAN on wildlife have been recorded: influences on nest site selection by sea turtles, changes in the diversity and behavior of nocturnal moths, and alterations to ecological interactions of insects. Trees in close proximity to sources of artificial lights budburst earlier than trees away from lights. In birds, a positive phototaxis effect (attraction to lights) resulting in high mortality due to collision with illuminated buildings and windows. More subtle effects of light pollution on birds are also known, such as disorientation, alterations in reproductive physiology, disruption of circadian rhythms, and changes of flight behavior (Light pollution is greatest within migration passage areas for nocturnally-migrating birds around the world, Sergio A. Cabrera-Cruzetal, Scientific Reports volume 8, Nature). Independently the elevated structure could impede flight of birds.

103. The elevated section of corridor 4 will pass Porur Lake. As discussed in section 4.4.1 Porur lake is assumed to have little ecological value, therefore no additional ecological mitigation measures are foreseen for this lake other than prevention of surface water pollution as described in section 5.5.

104. **Mitigation**. 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. Tamil Nadu Forest Department, Government of Tamil Nadu is responsible for the conservation and management of the trees. It is proposed to plant twelve saplings for each tree to be cut. Hence 12,146 trees shall be planted. The native plant species and miscellaneous indigenous tree species are recommended for plantation.

105. At Panagal Park, an ecological restoration plan is required with a process of assisting the recovery of the ecosystem that will have been degraded, damaged or destroyed due to the construction of Corridor 4. Passive restoration actions may include fencing and installing informatory signs in sensitive areas during construction, which will minimize construction impacts. Active restoration actions include soil decompaction, revegetation, removal formal or informal trails out of sensitive area. These actions will accelerate ecosystem recovery and promote the health and longevity of the Panagal Park.

106. In addition to the compensatory plantation, green belt area will be developed for the total length of elevated corridor using native shrubs, herbs and grasses. A central ribbon area will be planted with small tree species which grows up to height of 4-5 m. The peripheral ribbons will be planted with grasses and perennial herbs interspersed with medicinal plants like Tulasi, Vinca, Evolvulus, Hemidiscus etc. Appropriate shade loving and light loving trees could be preferred depending on the location. In a case study of green belt in cement industry in India, ambient concentrations of SO2 was found to reduce by 39%, NOx by 40%, SPM by 37%, THC by 86%,

CO by 93%, VOCs by 87.1% across the green belt and the overall air pollutant removal efficiency was calculated as 63% (Assessment of Carbon Sequestration Ability of Trees for Adopting in Green Belt of Cement Industries in Karnataka, March 2016, Central Pollution Control Board Zonal Office South). Thus the green belt will provide aesthetic view of elevated track and also helps to serve as dust and noise absorbent barrier.

107. Efforts will be made to minimize the cutting of trees by transplantation of the young trees. Transplantation will be done in coordination with the forest department.

108. Lighting at Panagal Park station will be kept to the minimum and of frequencies and brightness which do not affect bird behavior. Construction and operation of the metro viaduct on these sections could disturb nesting and breeding due to noise

109. **Residual impact**. An estimated and total 894 trees were felled for the project. Compensatory plantation will be done in a ratio of 12 saplings against each tree felled. However because of the time it will take for the saplings to mature the short term residual impact will be minimal negative. Once the saplings have matured the residual impact will be positive.

5.8 Private land and buildings

110. **Impact**.. The proposed project will require transfer of 31,797 m^2 government land out of which 29,100 m^2 is for Poonamallee depot and acquisition of 14,022 m^2 private land out of which 7,100 m^2 is for depot. 1,031 families comprising title holders, tenants and non-title holders who are residents physically displaced and business owners economically displaced due to acquisition of land and buildings will be affected by the project. These families comprise a total of 4,755 project affected persons. 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.

111. **Mitigation**. The impacts due to land acquisition, resettlement and socio-economic impacts are assessed in the separate Resettlement Plan for the project.

112. **Residual impact** The project affected people will be duly compensated as laid down in the Resettlement Plan for the project. Residual impact is expected to be minimal negative.

5.9 Aesthetics

113. **Impact.** The introduction of metro system implies a change in streets through which it will operate. An architecturally well designed elevated section can be pleasing to the eyes of beholders. Recent metro rail projects have attempted to incorporate this objective in their designs. Since a low profile would cause the least intrusion, the basic elevated section has been optimized at this stage itself.

114. **Mitigation.** During design stage, the stakeholder engagement will be conducted to disclose the station designs and to incorporate the feedbacks.

115. **Residual impact.** An architecturally well designed elevated section can be pleasing to the eyes of beholders. Residual impact is expected to be minimal negative.

5.10 Public property/ infrastructure/ utility structures

116. **Impact**. Corridor 4 is planned to run through the urban area above the ground i.e. elevated in less densely populated and underground in populated and sensitive areas. The alignment will cross drains, large number of 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 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.

117. The Organizations / Departments responsible for concerned utility services are reported in Table 5-10.

Table 5.10: Organizations Responsible for Utilities and Services

S.no	Organization/ Department	Utility/Services
1.	PWD / Chennai Municipal Corporation	Road
2.	Chennai Municipal Corporation/ Chennai Metro Water Supply and Sewerage Board (CMWSSB)	Sewerage and drainage lines. Water mains and their service lines, including hydrants and fountains etc., water treatment plants, pumping stations, Roads, surface water drains, nallahs, sewer lines, streetlights, high mast lights etc.
3.	NHAI	National Highways
4.	TNHD	State Highways
5.	BSNL (OFC and Telephone Cables)	Tele cables, junction boxes, telephone posts, O.H lines
6.	Airtel, Vodafone, Idea, Jio	Telecommunications cables, junction boxes, telephone posts, etc.
7.	Power Grid Corporation of India Ltd.	HT towers, cables
8.	Irrigation Dept.	Canal
9.	BPCL	Gas pipelines
10.	Gas Authority of India (GAIL)	Gas pipelines
11.	Chennai Corporation and Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO)	HT/other overhead Power lines

118. 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. Utility lengths to be diverted are as follows: sewer and water supply lines (depth 2.5m below ground) 3,420m and 15,000m between Lighthouse and Kodambakkam Flyover, and Power House and Poonamalle Bypass respectively; telecom cables (depth 1m to 4m below ground) 40,919m and 185,990m respectively; above ground HT/LT electric cables 22,888m Power House and Poonamalle Bypass.

119. During construction phase there will be great amount of issues encountered for the utility system/infrastructure facilities already existing within the alignment. The most important and hazardous aspect will be pipelines network running along the alignment. A decision has to be taken regarding encasing these pipelines as shifting/relocating will be of great inconvenience to the residential areas.

120. During construction period, complete/partial traffic diversions on road will be required, as most of the construction activities are along the road. 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.

121. Corridor 4 does not pose any substantial direct physical risk to existing buildings since there is distance of more than 15 meters between buildings and proposed alignment except at a few shops the alignment is passing over the temporary shops. Here special care has to be taken for safety of the structures during construction when they will be shifted for short duration.
122.

123. **Mitigation**. Shifting of pipelines is a hazardous operation of relocation and therefore a proper HAZOP study (& risk analysis) has to be conducted by contractor and CMRL during pre-construction period for any kind of handling of this issue in concurrence with gas supply agency. The similar study has to be conducted for water supply and high tension lines with the concurrence with concern agencies.

124. Delayed approvals and diversion of utilities can affect construction schedule while damage to utilities can cause disruption to essential services to the citizens. Ahead of start of construction on the respective sections, diversion plans will have to be prepared based on updated location drawings and concurrence of respective agencies. Preferably they will have to be diverted by the agencies themselves.

125. Span and pile arrangement of the viaduct may be suitably adjusted to ensure that pier foundations do not foul with major underground utilities. They will be diverted either temporarily or permanently before or during construction in those sections where the alignment cannot be fine-tuned to avoid conflict with utilities.

126. Preparation of Traffic management Plan and maintenance of diverted roads in good working condition to avoid slow down and congestion shall be a prerequisite during construction period.

127. Various construction technologies are in place to ensure that traffic impedance is done at the minimum. They are:

- The requirement would be mainly along the central verge/ side of the road
- As regards to the alignment cutting across a major traffic corridor, 'Box Girder Construction Technology' would be applied to prevent traffic hold-ups or diversions of any kind
- Cut and cover at underground stations will be employed to ensure that traffic impedance is minimized

128. The basic objective of the following guidelines is to lay down 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 shall develop detailed and robust traffic management plans consistent with the Indian Roads Congress (IRC) on Traffic Management in work zones (IRC:SP:55-2014), prior to mobilization for respective sections with site- or station-specific plans and measures to minimize the overall impact on traffic throughout the construction and operation periods.

- All construction workers should be provided with high visibility jackets with reflective tapes as most of viaduct and station works are on the right-of-way. The conspicuity of workmen at all times shall be increased so as to protect from speeding vehicular traffic.
- Warn the road user clearly and sufficiently in advance.
- Provide safe and clearly marked lanes for guiding road users.
- Provide safe and clearly marked buffer and work zones
- Provide adequate measures that control driver behaviour through construction zones.
- The primary traffic control devices used in work zones shall include signs, delineators, barricades, cones, pylons, pavement markings and flashing lights.
- Advance traffic updates/ information on communication systems for users of affected roads.
- Efforts will be given to divert traffic to roads wide enough to accommodate extra traffic.
- Incorporation of community safety considerations into plan design, especially at locations such as Kutchery Road where buildings are close to the construction site.

Residual impact. A great amount of issues with the utility system/infrastructure facilities already existing within the alignment is expected to be encountered. However by adjusting span and pile arrangement of the viaduct and temporarily or permanently diversion of utilities in those sections where the alignment cannot be fine-tuned, the residual impact can be reduced to nil.

5.11 Detailed Noise and Vibration Modelling

129. **Impact**. Noise is a contributing factor to degradation of human health. The noise pollution will be generated by construction activities, mainly due to demolition of structures to be removed; installation of earth retaining structures; pile driving where cast-in-situ is not feasible; blasting in rock etc., and also due to the construction equipment if they are not in maintained condition. Also during such activities if existing vehicular traffic is not properly diverted then congestion and then continuous honking habits will also lead to incremental noise levels which are of indirect nature. This will also pave way for vehicular air pollution which is also to be minimized effectively. Corridor 4 construction is equipment intensive.

130. Annexure 2 lists a total of 270 identified receptors such as schools, hospitals and places of worship. From this list 10 representative sensitive receptors were chosen for initial noise modeling. In addition to these receptors a total of 8 high-rise residential buildings were identified as potential sensitive receptors during the noise modeling carried out. 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.

131. The major sources of noise during construction phase are due to operation of various 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 (Construction Noise Handbook August 2006, FHWA, USA) ranged from 76 dB(A) to 84 dB(A); vibratory pile driver at 101 dB(A). The noise levels generated by various construction equipment are given in Table 5-11.

Table 5.11: 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

Equipment	Actual Lmax Noise Level (dBA) at 50 ft from source
Auger drill rig *	84
Compressor *	78
Dump truck *	76
Excavator *	81
Flatbed truck *	74
Front end loader *	79
Vibratory Pile driver *	101
Press Pile	70
Batching Plant	90
Booster pump	80

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

132. During construction phase, there will be significant increase in vehicular movement for transportation of construction material. In addition to the noise mentioned above, there will also be background noise of the usual traffic resulting due to traffic congestion. During construction

phase, the increase in vehicular movement is expected to increase up to a maximum of 5 to 6 trucks/hour.

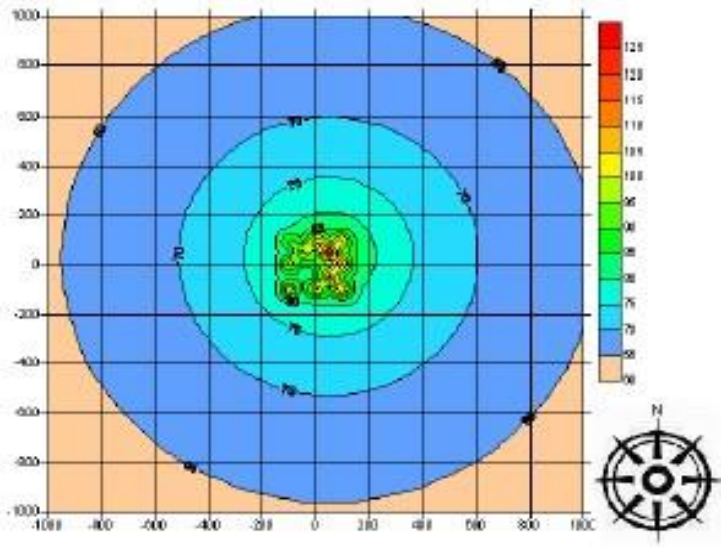
133. The effect of high noise levels on the operating personnel has to be considered as this may be particularly harmful. It is known that continuous exposures to high noise levels above 90 dB(A) affects the hearing acuity of the workers/operators and hence, should be avoided. To prevent these effects, it has been recommended by Occupational Safety and Health Administration (OSHA) that the exposure period of affected persons is limited (Table 5-12).

Table 5.12: 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	0.5
115	0.25
120	No exposure permitted at or above this level

134. Noise modelling during construction phase was carried out using CPCB/ MoEF&CC approved noise model “DHWANI” assuming that all the equipment emit noise simultaneously considering as worst-case scenario. The spatial variation of the predicted noise levels at an interval of 5 dB(A) without control around the project site on the area of 1 km x 1 km are shown in Figure 5.3. Modelling result shows that noise level meets the Ambient Noise Quality Standards (ANQS) 55 dB(A) (average between 6 am to 10 pm) at a distance of about 900m. Uncontrolled noise levels generated from construction equipment, in the range of 94-124 dB(A) have been considered for prediction purpose. However, the CPCB standards specify to limit the construction equipment to ensure that noise emission specifications for such equipment should not exceed 75 dB(A). The noise levels predicted here is without mitigation measures. It is assumed that with the adoption of the mitigation measures noise levels will be further restricted within very short distances from the source. With respect to occupational exposure, the permissible threshold is 90 dB(A) (continuous exposure over 8 hours). Thus, based on the modelling results it can be concluded that all sensitive receptors (i.e. labour colonies) should be located beyond 125 meters from the noise generating source location during construction activities.

Figure 5-1: Spatial Variation of Construction Equipment Noise Levels dB(A)



135. Operation phase is extremely important from environmental issue viz. noise levels. The noise will be generated due to friction of the rolling stocks on the tracks which will generate incremental noise levels. The major noise level generating activities includes 1. Approach and breaking of rolling stocks 2. Rolling stock leaving from station, 3. During its travel between two stations and 4. Announcements on the Metro station.

136. Noise generations for metro operation activities have been recorded from past experience from existing metro railways in India as well as project authorities. The following data includes various noise levels in above activities. During the operation phase the main source of noise will be from running of metro trains. Noise radiated from train operations and track structures generally constitute the major noise sources. Airborne noise is radiated from elevated structures. The noise level at 2m 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. Refer Tables 5-13 and 5-14.

Table 5.13: 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 5.14: 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**

2. Source: Studies carried out by Central Road Research Institute (CRRI) for metro projects in India 232.

The main source of noise from depot is the operation of workshop. The roughness of the contact surfaces of rail and wheels and train speed are the factors which influence the magnitude of rail - wheel noise. The vibration of concrete structures also radiates noise. Due to less activity and the absence of sensitive receptors near the depot site, no impact on the around the depot due to noise is anticipated.

137. As part of the detailed design a noise modeling and assessment along the alignment should be conducted prior to start of construction by CMRL and contractor. At sensitive receptor locations within 200 m along the alignment (where operational stage noise level is expected to be higher than permissible limits). Appropriate mitigation measures including design, height and length of noise barriers at sensitive receptor locations shall be determined by CMRL and contractor and agreed by MDBs.

138. **Mitigation**. In order to establish feasibility of noise mitigation for this project initial noise modeling has been carried out for this EIA for 6 schools, 2 churches, 2 hospitals and 8 high-rise residential buildings. The predicted noise levels during construction phase are summarized in table 5-15.

Table 5.15: Summary of predicted Noise Levels during construction phase

Sl.No	Name of the Sensitive Receptors	Distance (m)	Construction											
			Without Barrier							With Barrier				
			Baseline Noise levels db(A)		Predicted Noise levels db(A)	Final Noise[18]		Status - No Barrier		Mitigation - Model	Final Mitigated Noise		Status with barrier	
			$L_{eq,d}$	$L_{eq,n}$	$L_{eq,d}$	$L_{eq,d}$	$L_{eq,n}$	$L_{eq,d}$	$L_{eq,n}$[19]	$L_{eq,d}$ & $L_{eq,n}$	$L_{eq,d}$	$L_{eq,n}$	$L_{eq,d}$	$L_{eq,n}$
1	St. Bede's Anglo Indian Hr. Sec. School	125	71.4	69.2	61.10	71.79	69.83	No-Impact	No-Impact	48.10	71.42	69.23	No-Impact	No-Impact
2	Rosary Church	85	65.6	63.6	64.40	68.05	67.03	No-Impact	Impact	51.40	65.76	63.85	No-Impact	No-Impact
3	Luz Church	36	73.5	73.6	53.30	73.54	73.64	No-Impact	No-Impact	55.10	73.56	73.66	No-Impact	No-Impact
4	SIET College	240	71.6	65.8	55.40	71.70	66.18	No-Impact	No-Impact	42.40	71.61	65.82	No-Impact	No-Impact
5	Meenakshi college for women	16	74.3	55.4	78.90	80.19	78.92	Impact	Impact	65.90	74.89	66.27	No-Impact	Impact
6	Vijaya Hospital	200	69.4	64.0	69.90	72.67	70.89	Impact	Impact	64.10	70.52	67.06	No-Impact	Impact
7	Narayanan E-Tecno School	82	57.6	51.5	74.00	74.10	74.02	Impact	Impact	59.50	61.66	60.14	Impact	Impact
8	The Holy Cross Matric Hr. Sec. School	17	63.3	56.9	64.00	66.67	64.78	Impact	Impact	59.20	64.73	61.22	No-Impact	Impact
9	Government Hospital	18	62.9	56.2	73.80	74.14	73.87	Impact	Impact	72.20	72.68	72.31	Impact	Impact
10	Sri Ramachandra Dental College	132	72.2	66.2	58.40	72.38	66.87	No-Impact	No-Impact	50.80	72.23	66.32	No-Impact	No-Impact
11	Prestige Bellavista	89	63.4	59.7		85		Impact			82		Impact	

[18] The final noise presented in this table for residential receptors is based on daytime piling operations since modeling has shown this activity is considered to cause the highest noise levels. Piling operations will not be carried out during nighttime.

[19] As per SHE Manual no construction work shall be carried out during nighttime near sensitive receptors

Sl.No	Name of the Sensitive Receptors	Distance (m)	Construction										
			Without Barrier							With Barrier			
			Baseline Noise levels db(A)		Predicted Noise levels db(A)	Final Noise[18]		Status - No Barrier		Mitigation - Model	Final Mitigated Noise		Status with barrier	
			$L_{eq,d}$	$L_{eq,n}$	$L_{eq,d}$	$L_{eq,d}$	$L_{eq,n}$	$L_{eq,d}$	$L_{eq,n}$[19]	$L_{eq,d}$ & $L_{eq,n}$	$L_{eq,d}$	$L_{eq,n}$	$L_{eq,d}$	$L_{eq,n}$
12	Prince High Land	20	64.9	58.3		87		Impact			85		Impact	
13	Pruva Jade	20	67.1	63.5		95		Impact			89		Impact	
14	Lancor Kiruba Cirrus	9	67.2	63.2		89		Impact			87		Impact	
15	Ceebros	43	68.3	61.5		88		Impact			85		Impact	
16	Cerus-Appaswamy	33	61.6	58.0		86		Impact			79		Impact	
17	Kodambakkam Railway station	20	62.7	54.3		96		Impact			89		Impact	
18	Luz Golden enclave	46	64.2	55.6		85		Impact			82		Impact	

139. Table 5-15 shows that even with the use of noise barriers construction noise cannot be fully mitigated (less than 3dB(A) increase from baseline noise) at all locations, especially during nighttime. High levels of construction noise can be related to piling operations in those instances where in-situ casting is not possible. Piling operations will be restricted to 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.

140. 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;
- DG sets have to comply with the maximum noise levels and acoustic enclosure specifications as set forth in the CMRL Health & Safety Manual;
- 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.

141. During the operational phase the project rail noise was predominantly less than the GOI noise Standards and was identified to be less than the existing ambient noise, even without noise barriers. The results of the noise modeling for the operational phase are presented in Table 5.16.

Table 5.16: Summary of predicted Noise Levels during operational phase

Sl. No	Name of the Sensitive Receptors	Distance (m)	Operation										
			Baseline		Without Barrier					With Barrier			
			Noise levels db(A)		Predicted Noise levels db(A)		Final Noise[20]		Remarks	$L_{eq,d}$	$L_{eq,n}$	Final Noise Level	Status
			$L_{eq,d}$	$L_{eq,n}$	$L_{eq,d}$	$L_{eq,n}$	Leq,d	Leq,n					
1	St. Bede's Anglo Indian Hr. Sec. School	125	71	69	Note 1	Note 1	71	69	No-Impact	Note 1	Note 1	71	No-Impact
2	Rosary Church	85	66	64	Note 1	Note 1	66	64	No-Impact	Note 1	Note 1	66	No-Impact
3	Luz Church	36	74	74	Note 1	Note 1	74	74	No-Impact	Note 1	Note 1	74	No-Impact
4	SIET College	240	72	66	Note 1	Note 1	72	66	No-Impact	Note 1	Note 1	72	No-Impact
5	Meenakshi college for women	16	74	55	Note 1	Note 1	74	55	No-Impact	Note 1	Note 1	74	No-Impact
6	Vijaya Hospital	200	69	64	60	59	70	65	No-Impact	56	55	70	No-Impact
7	Narayanan E-Tecno School	82	58	52	51	50	58	54	No-Impact	36	35	58	No-Impact
8	The Holy Cross Matric Hr. Sec. School	17	63	57	49	46	63	57	No-Impact	35	34	63	No-Impact
9	Government Hospital	18	63	56	67	66	59	58	No-Impact	51	51	63	No-Impact
10	Sri Ramachandra Dental College	132	72	66	56	54	72	66	No-Impact	52	51	72	No-Impact

[20] The noise levels for the high rise buildings are predicted per floor. The noise levels presented in this table are for the floor with the highest predicted noise levels

Sl. No	Name of the Sensitive Receptors	Distance (m)	Operation										
			Baseline		Without Barrier					With Barrier			
			Noise levels db(A)		Predicted Noise levels db(A)		Final Noise[20]		Remarks	$L_{eq,d}$	$L_{eq,n}$	Final Noise Level	Status
			$L_{eq,d}$	$L_{eq,n}$	$L_{eq,d}$	$L_{eq,n}$	Leq,d	Leq,n					
11	Prestige Bellavista	89	63.4	59.7	56.6	47			No-Impact	44.1	34.5		No-Impact
12	Prince High Land	20	64.9	58.3	58.4	48.8			No-Impact	45.6	36.1		No-Impact
13	Pruva Jade	20	67.1	63.5	60.8	51.2			No-Impact	47.4	37.9		No-Impact
14	Lancor Kiruba Cirrus	9	67.2	63.2	61.5	51.9			No-Impact	47.9	38.4		No-Impact
15	Ceebros	43	68.3	61.5	59.4	49.9			No-Impact	46.3	36.8		No-Impact
16	Cerus-Appaswamy	33	61.6	58.0	57.4	47.8			No-Impact	44.3	34.8		No-Impact
17	Kodambakkam Railway station	20	62.7	54.3	Note 1	Note 1			No-Impact	Note 1	Note 1		No-Impact
18	Luz Golden enclave	46	64.2	55.6	Note 1	Note 1			No-Impact	Note 1	Note 1		No-Impact

Note 1: Located at the underground section of corridor 4, therefore no operational impact is expected

142. Although the modeling has shown noise barriers might not be necessary, to be on the conservative site the noise modeling report suggests noise barriers to be put in place near curves in the alignment and at station locations.

143. **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[21] 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.

144. **Additional Measures**- 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. The roughness of running surfaces will be reduced through regular maintenance of wheels and tracks and will be considered for replacing traditional jointed track with continuously welded rail. Also, noise controls at the source will be installed for improved sound-proofing and other noise reducing features will be installed such as engine enclosures and shielding of wheels with vehicle-mounted shrouds.

145. Noise barriers are recommended with noise reduction possibilities in Table 5.16.

Table 5.17: Noise Barrier for Noise Reduction

Place of Noise Barrier	Height of noise barrier	Noise reduction
On the viaduct in front of yard	4m (3.5m Absorptive+0.5m transparent) green color	15 dB(A)
On washing yard (s curve)	5m (Aluminium foam noise barrier) yellow color	17 dB(A)
On the back side boundary wall	3m (100% absorptive) blue color)	13 dB(A)
On the both sides of metro yard shade	3m (100% absorptive) blue color)	13 dB(A)

146. Table 5-15 shows that noise reduction is possible from 13-17 dB(A) after installation of noise barrier. Therefore, study suggested that noise barrier is the best option to reduce the instantaneous noise generated by metro; tree plantation is not a scientific option for reduction of noise levels.

147. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures. Temporary route direction markings will be placed in appropriate locations.

148. To reduce the harmful effects, personnel working at high noise levels would be provided with noise protective gears such as ear mufflers, sound barriers etc. Vehicles used for transportation of construction materials would be equipped with silencers. Careful planning has been made to operate the construction equipment to have minimal disturbances. The construction equipment's will be in use during the daytime and their noise levels would be monitored as per

[21] Noise barriers consisting of 15mm thick UV coated clear transparent polycarbonate sheets meeting the criteria for acoustic performance as per EN 1793 and mechanical and structural performance as per EN 1794 including necessary structural galvanized steelwork and rubber gasket all around, have been included in the tender document. The sound transmission class rating corresponding to sound attenuation of 30dB or above is required.

CPCB standards. Besides other measures such as use of low-noise equipment and ensuring good maintenance, trying to avoid using high-noise equipment simultaneously at the same section etc. will also be implemented to minimize construction noise.

149. 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
- Sound-proof control rooms
- Automation of equipment and machineries, wherever possible.

150. **Residual impact**. During construction, especially during pile driving operations, a residual noise impact on sensitive receptors will exist. However the impact will be temporary, not continuous and only during daytime Operation of the metro will generate a certain amount of noise. The detailed design will incorporate features to reduce the noise and vibration levels. Detailed analysis (computer modeling) of noise will be conducted for each of the identified sensitive receptors based on the detailed engineering design and will be finalized prior to contractor's mobilization. It is expected the detailed mitigation measures will be able to reduce the noise to an extent that the increase is less than 3dB(A) and will be able to reduce vibration to levels under the human annoyance threshold. However, a minimal negative residual impact will remain.

5.12 Vibration

151. As part of the detailed design a noise and vibration modeling and assessment along the alignment should be conducted prior to start of construction by CMRL and contractor at sensitive receptor locations within 62 m along the alignment (where operational stage vibration level is expected to be higher than permissible limits). As part of this EIA an initial vibration assessment has been conducted in which a general vibration assessment for both construction and operational phase has been carried out as well as an assessment of the vibration impacts on 13 selected sensitive receptors has been assessed.

152. **Impact**. Pile driving for viaduct piers and buildings and tunnel driving generate vibrations. Apart from distance from the alignment, 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. Buildings subjected to the vibration of more than 150 VdB might be subjected to structural damage. Historic buildings are more susceptible to vibration effect due to type of building material and design. Corridor 4 is located in moderately to above moderately vulnerable seismic micro zones.

153. In order to evaluate the construction stage vibration levels from the project construction activities, the Construction Vibration Damage Criteria set by FTA for different building category is referred in Table 5-17 and 5-18 below.

Table 5.18: Construction Vibration Damage Criteria as per FTA guidelines

Building Category	PPV (in/s)	PPV (mm/s)	Approximate Lv, RMS velocity in decibels (VdB) re 1 µin/s.
I. Reinforced-concrete, steel or timber (no plaster)	0.5	12	102
II. Engineered concrete and masonry (no plaster)	0.3	7.6	98
III. Nonengineered timber and masonry buildings	0.2	5	94
IV. Buildings extremely susceptible to vibration damage	0.12	3	90

Table 5.19: Vibration Annoyance Criteria as per FTA guidelines

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.

154. During construction of the underground section, TBM will be used. With a tunnel depth of approximately 25 m (vertical distance between tunnel top and floor of building above ground), the

expected vibration level during operation of the TBM is approximately 99VdB in conditions of sandy and clay soil which is dominant in the project area. Attenuation of vibration is expected to be about 16 VdB resulting in a net vibration at the ground floor of the building above ground to be about 83 VdB.

155. The sensitive receptors that were considered for the initial vibration assessment are shown in figure 5-4.

S. No	Location No	Location	Elevated / Underground	Distance from alignment [m]	Location coordinates
9	C4-A	Near Porur Lake	Elevated	8	Lat: 13° 2'11.12"N Long: 80° 9'5.28"E
10	C4-B	Vadapalani Junction	Elevated	12	Lat: 13° 2'58.66"N Long: 80°12'39.45"E
11	C4-C	Santhome Church	UG	10	Lat: 13° 2'0.85"N Long: 80°16'40.16"E
12	C4-D	St. Bede's Anglo Indian School	UG	80	Lat: 13°02'04.6"N Long: 80°16'41.6"E
13	C4-E	Aashraya Hospital	UG	2	Lat: 13° 2'1.09"N Long: 80°16'33.16"E
14	C4-F	Jain Temple	UG	10	Lat: 13° 2'4.72"N Long: 80°16'17.58"E
15	C4-G	Luz Church	UG	68	Lat: 13° 2'17.32"N Long: 80°15'44.74"E
16	C4-H	Anjaneyar Temple	UG	9	Lat: 13°02'18.7"N Long: 80°15'31.5"E
17	C4-I	S.I.E.T College	UG	>100	Lat: 13° 2'9.79"N Long: 80°14'51.81"E
18	C4-J	Thirupathi Thirumala Devastanam Temple	UG	18	Lat: 13° 2'8.91"N Long: 80°14'11.09"E
19	C4-K	Koncept Hospital	Elevated	33	Lat: 13° 3'7.64"N Long: 80°13'7.18"E
20	C4-L	The Holy Cross Matric Hr. Sec. School	Elevated	85	Lat: 13° 2'23.40"N Long: 80°10'19.90"E
21	C4-M	Government Hospital, Poonamallee	Elevated	18	Lat: 13° 3'1.61"N Long: 80° 5'57.75"E

Source: AV Ingenieros / Aimil Ltd. Vibration Forecasting report

156. The heritage sites as presented in section 4.5.2 are C4-C (Santhome Church), C4-E (this hospital is near Rosary Church) and C4-G (Luz Church), all at the underground section of the alignment.

157. Based on the general vibration assessment it is concluded that in general during construction pile driving can affect buildings up to 40 meters distance from the piling location. Annoyance from piling could be felt at a distance of up to 100 meters, as shown in **Table 5.20** and **Table 5.21** and presented in the vibration assessment report in **Annexure 11**.

Table 5.20: 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 5.21: Predicted affected area for annoyance during construction per structure type

Building structure	Affected area distance from track centre (m) – Considering the land use		
	Category 1 (65 VdB)	Category 2 (72VdB)	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

158. Affected areas for vibration during operation of the metro system are presented in **Table 5.22** and **Table 5.23** and presented in the vibration assessment report in **Annexure 11**.

Table 5.22: Predicted affected area for annoyance during operation in the underground section for design and scheduled speed

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	--	--

Table 5.23: Predicted affected area for annoyance during operation in the elevated section for design and scheduled speed

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

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	14 m	4 m	--
1-2 Story Masonry	10 m	2 m	--
3-4 Story Masonry/ Large Masonry on Piles	5 m	--	--
Large Masonry on Spread Footings	3 m	--	--

159. During operation of the metro system in the underground section, a maximum distance of 58 m will be affected by induced vibration if 80 kmph design speed and masonry building structure 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 structure are considered. This distance will be reduced to 10 m if 32 kmph scheduled speed is considered. 2 out of 13 sensitive receptors could be impacted if scheduled speed is considered, these are Near porur Lake and Aashraya Hospital.

160. With regard to the specific sensitive receptors 2 out of 13 could be exposed to induced vibration levels higher than the damage criteria during construction. The construction equipment could cause annoyance to 8 out of 13 sensitive receptors (Annexure 11).

161. During the operational phase 2 out of 13 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, these are Near porur Lake along the elevated section of corridor 4 and Aashraya Hospital, located along the underground section of corridor 4.

162. **Mitigation**. In the case of vibrations from road traffic and pile driving, very deep barriers (in excess of 10 m) were found to 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

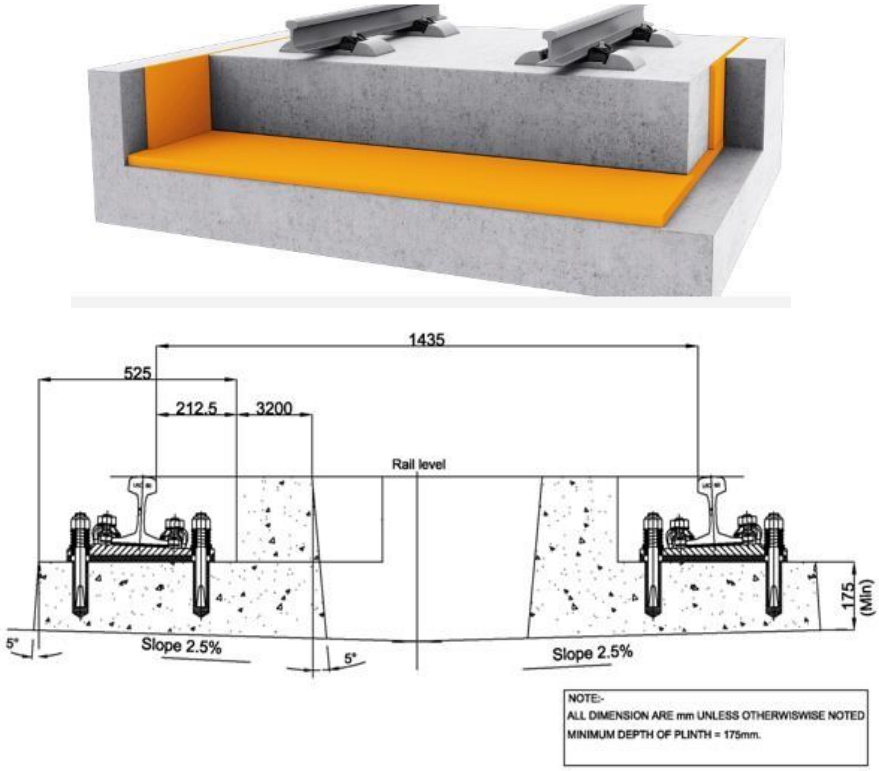
163. Cast in-situ piling will be deployed at locations with sensitive receptors so as to reduce vibration and to meet the vibration thresholds. At locations where the alignment is close to sensitive receptors, the contractor shall implement:

- The detailed noise and vibration analysis (mathematical modelling) at sensitive receptors 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
- Pre-construction structural integrity inspections, including visual inspections of buildings of cultural or historical significance
- The sensitive receptors 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
- Information dissemination about the construction method, probable effects, quality control measures and precautions
- Monitoring during construction

164. Further vibration modelling will be conducted for the sensitive receptors within the vicinity based on the detailed engineering design to determine if the negative impacts can be fully mitigated through the following mitigation measures:

- 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 transmitted from the track and superstructure. Indicative pictures are shown in Figure 5.4.
- Using floating slab and high resilience fasteners to reduce the vibration at the point of emission.

Figure 5-2: Vibration Damping Devices in Track



Source: Getzner Werkstoffe

165. **Residual impact**. Operation of the metro will generate a certain amount of vibration. The detailed design will incorporate features to reduce the vibration levels. Detailed analysis (computer modeling) of vibration will be conducted based on the detailed engineering design and will be finalized prior to contractor's mobilization. It is expected the detailed mitigation measures will be able to reduce vibration to levels under the human annoyance threshold. However a minimal negative residual impact will remain.

5.13 Ground subsidence

166. **Impact**. Tunnel roof caving could cause ground subsidence above the tunnel resulting in settlement damage to structures on ground.

167. Proposed track depth is 18m to 20m; water table is between 1m to 10m; rock is available deeper than 20m between Kutchery Road and Thirumayilai stations, Adyar gate to Alwarpet, Kodambakkam suburban and Vadapalani and less than 20m depth at other locations on Corridor 4; soil is pervious (source: geotechnical investigations along Corridor 4 in year 2016 and scheduled groundwater monitoring by Central Groundwater Board in years 2014 to 2016).

168. During tunneling, material under pressure might come out of open borewells in the vicinity of the tunnel site resulting in ground subsidence beneath nearby structures (in case of Phase 1 Metro those within 16.5 m on either side of centerline of tunnel). Groundwater extraction adjacent the metro project could lead to subsidence under non-metro structures as well as settlement of metro tunnel and stations between Kutchery Road and Thirumayilai stations, Adyar gate to Alwarpet, Kodambakkam suburban (rock deeper than track level). Ground subsidence around

tunnel sections could occur during tunneling due to ground water seeping into tunnel resulting in groundwater drawdown around the tunnel zone.

169. **Mitigation** Caving of tunnel will be prevented by placing pre-cast concrete segments in soft soils and rock bolts or arch ribs in rock. Subsidence above tunnel due to removal of material and water beneath will be prevented by such tunnel support.

170. Artesian wells and borewells in path of tunnel will be sealed. They will be permitted at least 3m on either side of the tunnel width, as in case of Phase 1 Chennai Metro. It is recommended that locations of boreholes need to be rationalized to avoid groundwater extraction near tunnel.

171. Seepage along with existing water in tunnel will be removed ('dewatering'). Similar groundwater loss could occur during construction of underground stations by cut and cover. Groundwater drawdown will also temporarily reduce availability of groundwater for domestic consumption.

172. Groundwater drawdown can be minimized by sealing joints in tunnel lining. In addition, where required adjacent structures will be given additional supports. Sides of deep excavations at stations will be supported by walls which minimize water seepage. In open areas where side support walls in excavations are feasible, such walls will help prevent caving and thereby settlement of adjacent structures; in built up areas where side walls are not feasible, adjacent structures will be provided additional supports.

173. Subsidence under nearby structures could occur due to strata disturbance and loss of bearing capacity of soil under foundations of nearby buildings: this shall be monitored and where required the structures will be provided additional support.

5.14 Occupational Health and Safety

174. **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.

175. Estimated total population in the labour camps will be 5,784. The water requirement at camps will be 780KLD, wastewater generation 492 KLD & municipal solid waste generation 1.3 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.

176. 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.

177. Underground metro systems are known to have the potential to negatively impact the health of personnel due to exposure to high levels of particulate matter in the air (especially originating from train brakes) and high noise levels.

178. 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.

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

- EMI in railway infrastructure like signalling caused by rolling stock. Considering the criticality of signalling, 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 up to at least 10m from the track (Railway EMI impact on train operation and environment, A Morant et al, IEEE, Dec 2012)
- EMI in rolling stock caused by environment.

180. **Mitigation**. CMRL has a 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 organization 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 Redressal. The Health and Safety Manual covers: Contractor organization; 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.

181. 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.

182. 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.

183. Guidance on occupational health, safety and environmental practices involved in construction on elevated, at-grade and underground works, with special focus as below,

- **Health care awareness and clinics**: Construction workers are more prone to Infectious diseases such as HIV/AIDS. It should be prevented by following actions: Counselling, community events, clinic, and coordination with local health authorities.
- **First aid facilities:** At every workplace, a readily available first-aid unit including an adequate supply of sterilized dressing materials and appliances shall be provided. Suitable transport shall be provided to facilitate taking injured and ill persons to the nearest hospital.
- **Day Crèche Facilities:** At every construction site, provision of a day crèche shall be worked out so as to enable women to leave behind their children. At construction sites where 25 or more women are ordinarily employed, accommodation shall be provided for use of children under the age of 6 years belonging to such women. Huts shall be provided with suitable and sufficient openings for light and ventilation. Size of crèches shall vary according to the number of women workers employed.
- **Shelter at Workplace:** At every workplace, shelter shall be provided free of cost, separately for use of men and women labourers. Sheds shall be maintained in proper hygienic conditions.
- **Canteen Facilities:** A cooked food canteen on a moderate scale shall be provided for the benefit of workers wherever it is considered necessary. The contractor shall conform generally to sanitary requirements of local medical, health and municipal authorities and at all times adopt such precautions as may be necessary to prevent soil pollution of the site. Mobile anaerobic toilets (bio-digester based) will be provided.

184. 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.

185. 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.

186. 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.

187. 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. The mandatory requirements are as follows:

188. Legal requirements; Contractor`s organisation and interfaces with CMRL; safety hierarchy and requirements for H&S management, procedures to identify hazards and estimate risk, hazard mitigation measures; incident reporting and monitoring, emergency response plan; arrangements for training, inspection, communication, compliance, reporting, documentation and audit; complaint address.

189. 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.

190. 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.

191. Stations in the underground system will be equipped with full height platform screen doors. These doors provide a physical safety barrier between passengers and personnel in the station and arriving and departing metro trains. Furthermore, these doors are an efficient physical barrier for exposure to noise and air pollutants. When the platform screen doors are open after arrival of a train, air pollutants within the tunnel will have difficulties to enter the station environment since the air inside the station platform (through AC supply) is slightly over pressured with respect to the air within the tunnel.

192. 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.

193. 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.

194. 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.

195. 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.

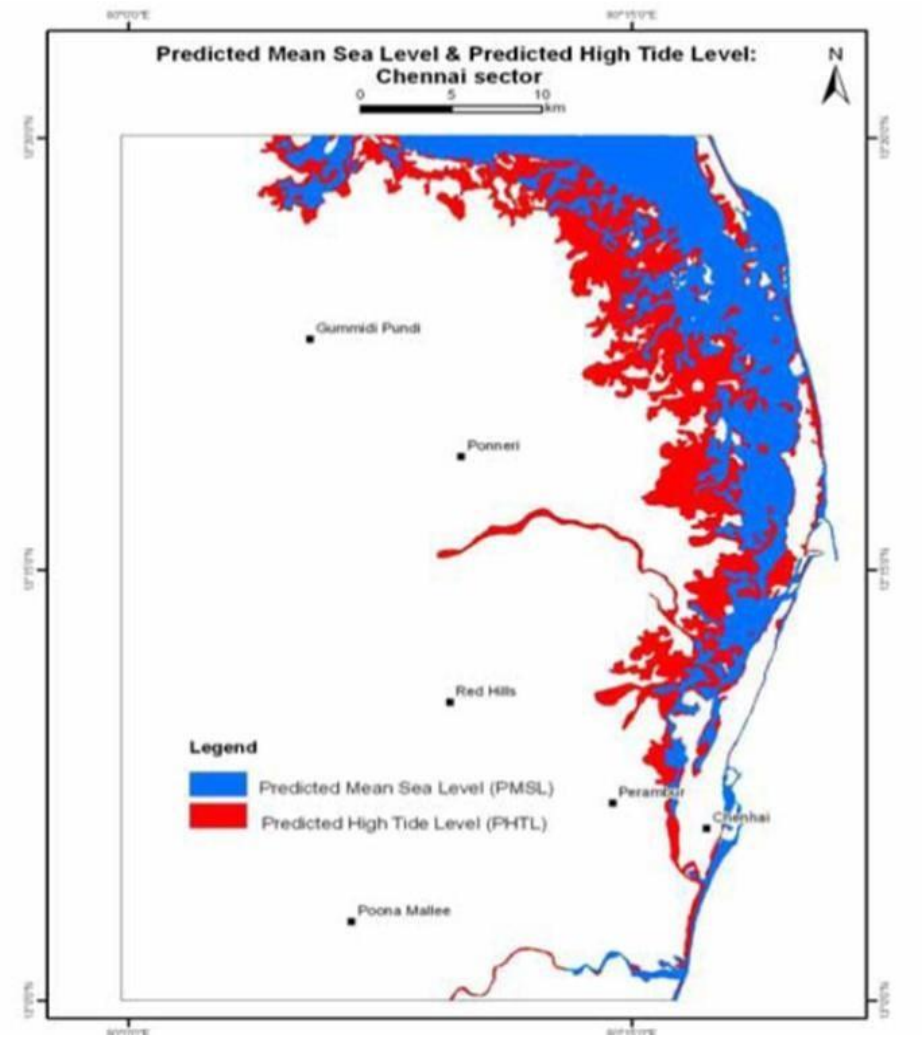
196. The risk of Covid-19 will be reduced as much as possible through CMRL's operational procedures. Government of India protocols governing COVID precautions shall be fine-tuned; staff shall be trained; staff and commuters shall be informed of precautions such as social distancing, sanitizing; arrangements 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.

197. 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.

5.15 Public Health and Safety

198. **Impact.** Vulnerability of project to rise in mean sea level (submergence) and high tide level (degradation) on the project is indicated in Figures 5-3 and 5-4. Belt of width approx. 0.5 km of beach and developed area on alignment between Lighthouse and Kutchery Road is underground and can be subject to flooding disrupting operations.

Figure 5-3: Predicted MSL and HTL in Chennai Sector

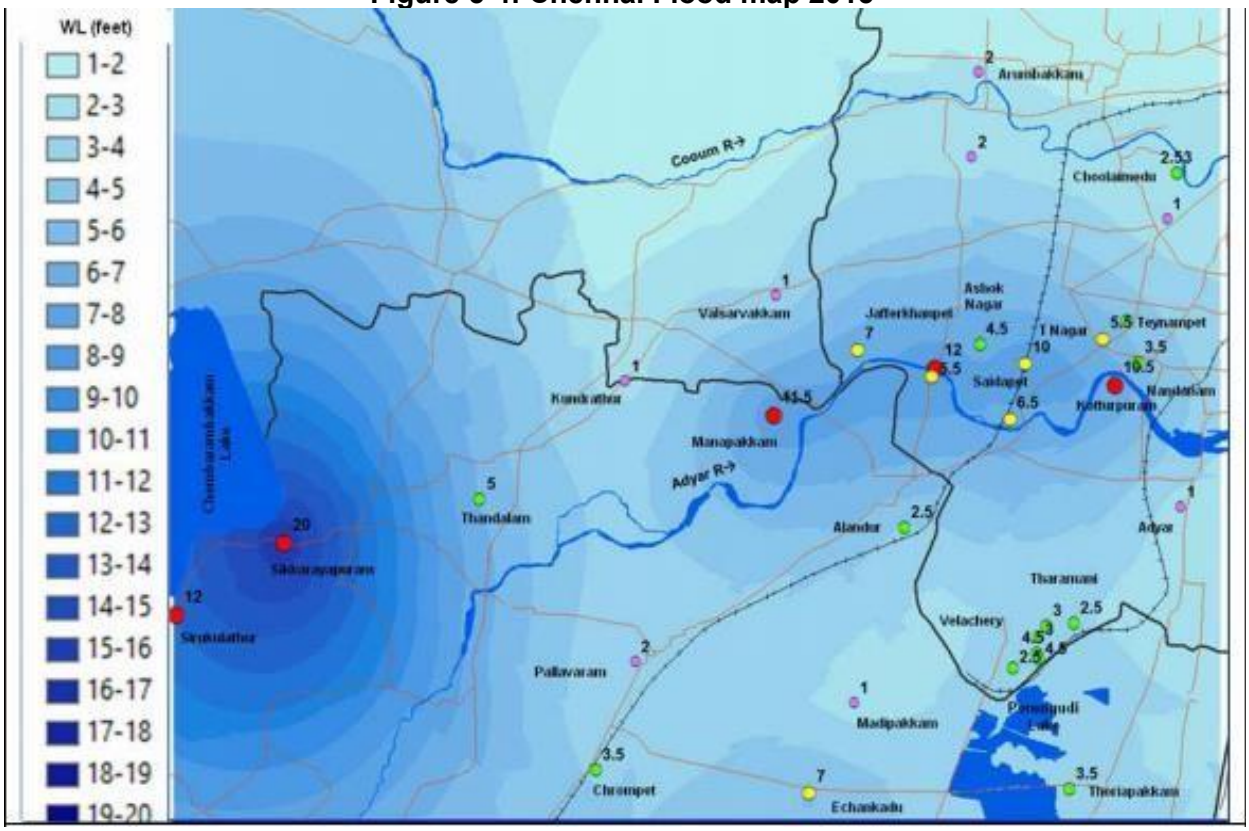


Source: Coastal Zones of India, SAC ISRO- MoEF&CC, 2012

199. In year 2015 Chennai was flooded due to exceptionally heavy rainfall. Flooding was observed in areas adjoining Adyar river though lesser along Cooum river. Most of the alignment of Corridor 4 is not located near these rivers22and therefore flooding is not a likely impact. Figure 5-4 depicts the inundated areas.

[22] Proposed Adyar gate Junction station is about 600 meters away from Adyar River, according to figure 5.2 that area had up to 3.5 feet of water during the 2015 floods.

Figure 5-4: 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

200. Although Chennai is located in Moderate Seismic Zone, different parts of Chennai have variable potential for seismic hazard. Corridor 4 is located in moderately to above moderately vulnerable seismic micro zones.

201. 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.

202. During operation accidents related to train operation like collision, derailment, fire, power outages, or operation stoppage may occur.

203. **Mitigation**. On Corridor 4, flooding gates and other adequate facilities will be made in terms of evacuation of flood water using pumps in Lighthouse stations. Disaster management plan will pay special attention to flooding.

204. Design of line structures – tunnel and viaduct – and station shall be done to facilitate robust safety and quick evacuation. Stipulation of Bureau of Indian Standards engineering codes shall be met while designing the structures while taking into account micro zonation of Chennai in terms of seismic risk.

205. 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.

206. To prevent community H&S issues during construction, contractor on coordination with implemented measures such as provide the construction camps with facilities such as health care clinics, places of worship, and occasional entertainment, preparation of implementation of traffic management plan during construction, access to buildings, awareness and information sharing, and implementation of CMRL SHE Manual.

207. WHO has declared COVID-19 as a pandemic which has affected entire world including India. In view of the prevailing COVID-19 pandemic, the Contractor and workers would need to take additional measures to avoid the spread of the disease and shall follow various guidelines/guidance notes issued by the national/state government, WHO, ILO, World Bank/IFC from time to time. As described in these guidelines, 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. A brief guidance on “To Do” List prepared from these documents is provided in the Annexure 8. Furthermore, the Standard Operating Procedures (SOPs) and Guidelines for Construction Sites for COVID-19 Outbreak developed by National Real Estate Development Council will be mandatory for contractors to follow.

208. 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 underground stations will sustain the following: essential lighting, signaling, and telecommunications, fire-fighting system, lift operation, and tunnel ventilation.

209. 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.

210. CCTV system will provide video surveillance and recording function for the operations to monitor each station. The monitoring shall be possible both locally at each station and remotely from the operation control center.

211. 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 situation.

212. 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. 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. EN50121-31, EN50123, IEC61000 series etc. EMC requirements of international standards for whole railway system to the outside world shall comply with EN50121-2.

213. **Residual impact.** Part of the underground section is within 500m from the sea and can be subject to flooding disrupting operations. Flood gates and other adequate facilities will be made

in terms of evacuation of flood water using pumps in Lighthouse station. Disaster management plan will pay special attention to flooding. With these additional measures the residual impact will be minimal negative.

214. Most of the alignment is not located near rivers and therefore flooding due to rainfall is not considered a big risk. In order to minimize the impact of potential flooding the entry structures of the metro are envisaged to be raised to 0.6 – 1 m above high flood level. With these measures in place the residual risk of flooding due to rainfall will be minimal negative.

215. Corridor 4 is located in moderately to above moderately vulnerable seismic micro zones. Design of tunnel, viaduct and station shall be done to facilitate robust safety and quicker evacuation. Stipulation of Bureau of Indian Standards engineering codes shall be met while designing the structures. Residual risk will be minimal negative.

216. Although both occupational and public health and safety risks can be mitigated to a large extent through proper equipment, ppe's, procedures and education, a chance remains the procedures may not always be followed in full. Therefore a moderate negative residual impact remains.

5.16 Physical Cultural Resources

217. No known archaeological monuments / sites are located on the project corridor. The following three heritage assets are located within 75m from the alignment.

Table 5.24: Heritage assets near the alignment

No	Name of heritage asset	Approx. distance from road followed by the alignment (m)
1	National Shrine of St. Thomas Basilica, Santhome High Road, Santhome	110
2	Rosary Church, Rosary Church Road	1*
3	Our Lady of Light Shrine, Luz Church Road	73

218. Besides these three heritage assets the underground alignment passes another 5 mosques, 8 churches and 31 temples, all located within 200 meter distance from the alignment. The elevated section of the alignment passes another 10 mosques, 37 churches and 81 temples. Details of these physical cultural resources can be found in Annexure 2.

219. **Mitigation**. The alignment will be fine-tuned, if feasible, to steer away from heritage assets on Corridor 4. Before start of civil work the 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 or excavation will be allowed unless cleared by the Archeological Department.

220. Since the project involves cut & cover, and piling for piers there are possibilities that contractor may encounter artifacts during piling operation. Chance find measures are included in the EMP to minimize the impacts on historical / archeological artifacts, in case found during excavation work. CMRL will inform and coordinate with Archaeological Survey of India if any ancient remains are encountered during construction work.

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

222. 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.

223. 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 GC, 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.

224. In locations where alignment is within 75m (as per the reference distance of acceptable vibration impacts) to historical/heritage structures, the contractor shall prepare a monitoring scheme prior to construction at such locations. This scheme for monitoring subsidence and vibration level at such historical / heritage sites shall be submitted to CMRL for approval. The scheme shall include:

- Monitoring requirements for vibrations at regular intervals throughout the construction period.
- Pre-construction structural integrity inspections of historical / heritage / sensitive structures in the project area, especially for any buildings the TBM will pass nearby.
- Information dissemination about the construction method, probable effects, quality control measures, and precautions to be used.

225. The vibration level limits at work sites adjacent to the alignment shall conform to the permitted values of PPV.

226. **Residual impact**. Three assets are located within 75 meter of the alignment. In order to reduce the risk of damage to the assets the contractor shall perform pre-construction structural integrity inspections and prepare a monitoring scheme for monitoring subsidence and vibration level for these locations prior to construction. Residual risk is expected to be minimal negative.

5.17 Energy demand

227. **Impact**. Construction employs energy intensive equipment round the clock. High illumination lighting and minor tools and equipment impose increased demand on energy consumption due to construction.

228. 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 5.14 presents the power demand of alignment during operation.

Table 5.25: Power Demand

Load	2025		2035		2045		2055	
	Normal	Emergency	Normal	Emergency	Normal	Emergency	Normal	Emergency
3 km from Kilpauk GSS-Panagal Park RSS (Chainage -255 to 7436) 7.691km								
Traction	2.45	8.39	3.62	12.41	4.40	15.10	5.36	18.38

Load	2025		2035		2045		2055	
	Normal	Emergency	Normal	Emergency	Normal	Emergency	Normal	Emergency
Auxiliary	11.67	19.95	14.58	24.40	16.32	27.46	17.49	29.62
Total	14.12	28.34	18.20	36.81	20.72	42.56	22.85	48.00
3 .5 km from Koyambedu GSS-Avichi School RSS (Chainage -7436 to 25829) 18.38km								
Traction	5.94	8.39	8.79	12.41	10.70	15.10	13.02	18.38
Auxiliary	8.28	19.95	9.82	24.40	11.14	27.46	12.13	29.62
Total	14.22	28.34	18.61	36.81	21.84	42.56	25.15	48.00

229. **Mitigation**. The contractor shall use and maintain equipment so as to conserve energy and shall be able to demonstrate the abovementioned upon request of CMRL. 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.

230. Requirement of electrical energy for climate control, lighting and other facilities at stations will be optimized by proper use of natural day/night light and design of passenger flow inside stations and on streets outside stations. Installations for solar power will be implemented in stations where feasible. Full height platform screen doors will be implemented so as to conserve energy for ventilation and air conditioning in underground stations, which will also ensure passenger safety just as half height screen doors.

231. In accordance with the IGBC Green Mass Rapid Transit System (MRTS) 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 shall 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 shall be purchased by CMRL on the basis of the unit rate specified by PPA.
- Integrated with other modes of public transport, thereby enhancing connectivity

232. In conformity to other corridors in Chennai, the following design elements are proposed which increase energy efficiency and safety:

- 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.

233. Rooftop solar panels on covered part of depots are proposed. As per the Detailed Project Report of March 2019 the depot at Poonamallee Bypass could generate 4.91 GWh of electricity per year..

234. **Residual impact**.. Requirement of electricity will be optimized by proper use of natural day/night light. Full height platform screen doors will be implemented to conserve energy for ventilation and air conditioning in underground stations. Green Building features will be implemented in station design. Residual impact is considered minimal negative.

235. Energy saving features of the metro such as regenerative braking, lightweight coaches and efficient power equipment 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.

5.17 Impacts due to the change in Design

236. The inclusion of integrated Grade Separator (GS) in the kattupakkam section .Tamil Nadu State Highways Department of GoTN proposed to construct a two-level Grade Separator comprising road at first level and Metro rail at Second level for a length of 2 kms at Kattupakkam. Kattupakkam Integrated Grade separator is located between P381 to P424 (48 piers) , overall length of integrated grade separator has been reduced to 1.527 Kms, which included of two stations such as Kumananchavadi and Karayanchavadi. The proposed grade separator does not additionally require any land acquisition or tree felling for the construction In the 4th Steering committee meeting of Highways and Minor ports department, it was discussed and agreed to construct integrated structure supporting highways and Metro structures. The geographical representation of the grade separator layout is shown in Fig.3.7, Fig 3.8. The GS is located in the commercial land use area that doesn't include any eco-sensitive areas such as wetlands, waterbodies etc.

237. This inclusion increases the requirement of manpower and construction materials such as cement, reinforcement steel, construction water, energy, diesel etc. The additional impact on air and noise quality is expected to be minimal since the components of grade separator are precast structures and going to integrated with the existing metro structures., During construction there may be some temporary impact such as fugitive dust emissions, road traffic. The construction materials (such as sand, earth, aggregates etc..) shall be brought from authorized source / vendor in compliant with environmental regulations of the country. The EMP covers the mitigation measures required for temporary impacts (from air, noise, traffic etc.,,) during construction stage of the project. During operation, the grade separator facilitates the reduction of the travel time, fuel consumption, noise level and vehicular emissions (especially Carbon Monoxide and NO_x) by easing the flow of traffic in the section. The positive Impacts of the grade separator outweighs the negative impacts which are temporary and minimal

5.5 Expected Benefits from Corridor 4

238. Metro rail systems have an advantage over other modes of transport because they provide higher carrying capacity, faster, smoother, and safer travel, occupy less space, and are non-polluting and energy-efficient. To summarize the benefits of a metro rail system:

- Increased Employment Opportunities During the period of construction manpower will be needed for various project activities. In post-construction phase, about 913 people will be employed for operation and maintenance of the system. In addition, more people would be indirectly employed in allied activities.
- Economy: Corridor 4 will have a moderate positive residual impact on the local economy. In operation phase about 913 people will be employed for operation and maintenance of the system. In addition, more people would be indirectly employed in allied activities. Also, the project will facilitate movement of people from different parts of Chennai. Corridor 4 will yield benefits in terms of growth in economic activity due to better accessibility, savings in fuel consumption, corresponding reduction in cost of road construction and maintenance, reduction in vehicle operating costs, savings in travel time, and improvement in quality of life and reduction in loss of productivity due to health disorders resulting from pollution.
- Mobility Safety and Reduced Accidents: The metro network increases the mobility of people at faster rate. The proposed corridor will provide more people connectivity to other parts of the city. Metro journey is safe and result in reduced accidents on roads.

6. ANALYSIS OF ALTERNATIVES

6.1 Introduction

239. This section presents the symmetrically compared feasible alternatives to Corridor 4. 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, Stations and Depot Locations

240. 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.

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

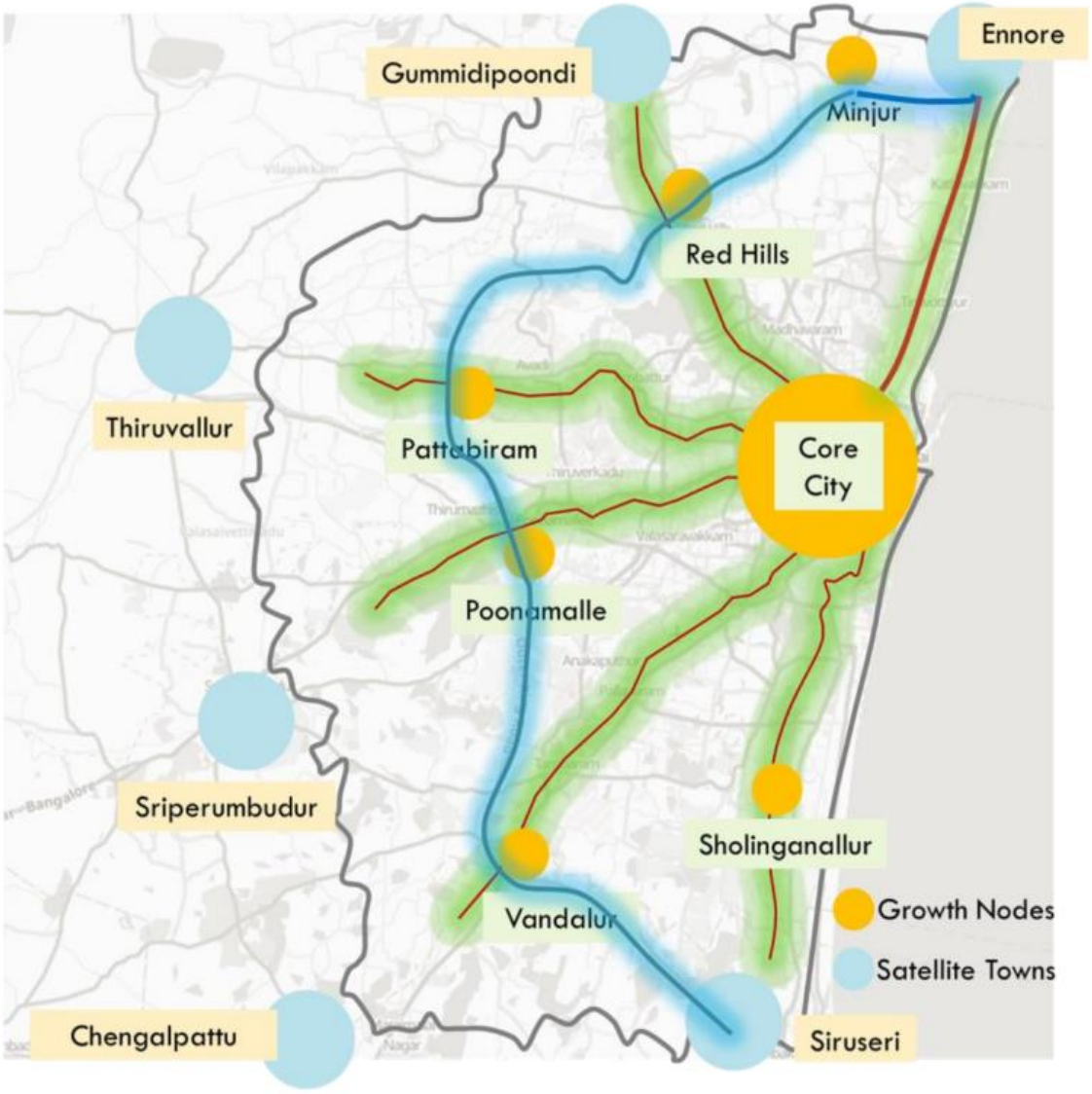
- Sustainability: The transportation system of the City shall be conducive to lower consumption of fossil fuels. It shall be based on managing the travel demand itself, rather than trying to provide for whatever demand exists and allowing demand to grow in an unplanned way.
- Equity: Transportation in 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

242. 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.

243. 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



1.

244. 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

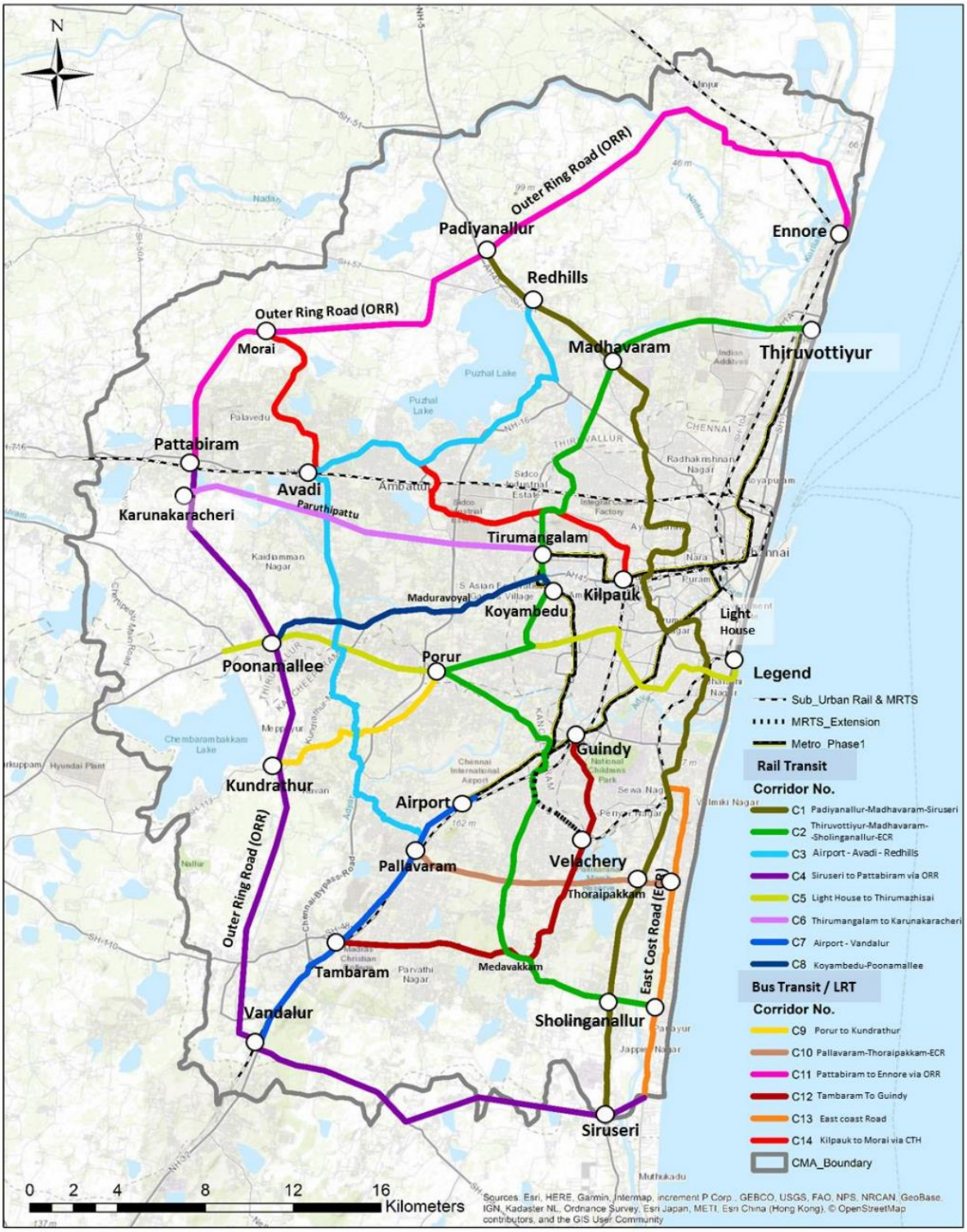
245. The Transport Demand modeling has shown that in the “do noting” scenario, average congestion will increase form a V/C ratio of 0.51 in 2018 to a ratio of 1.20 in 2028 (V/C ratio greater than 0.85 indicates congestion). Tthe average network speed will decrease from 25.4 kmph in 2018 to 10.20 kmph 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 unfavorable. The sustainable urban transport 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.

246. 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.

247. Based on the above the CMP proposes the mass transit corridors as depicted in the 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	

248. 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 – Poonamalle 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.

249. 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.

250. 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

251. 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

252. As can be seen from table 6-2 Metro Rail is the overall most favorable option, considering the specific challenges the proposed alignment poses. For metro the corridor as proposed in the CMP is used, for mono rail, LRT and 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 minimize 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 rationalize the location of proposed stations and underground ramps

253. 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

254. 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 favorable 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. INFORMATION DISCLOSURE, CONSULTATION AND PARTICIPATION

7.1 Consultations

255. 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.

256. 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.

257. 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.

258. 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.

259. Due to COVID-19 challenges, consultations during project implementation will be virtual wherever possible. MDB 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, MDB mission will seek support from relevant Resident Mission staff members to participate in public consultations on behalf of MDB 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.

7.2 Identification of Stakeholders

260. Key stakeholders at central, state, district and local level will be consulted as part of the consultation process. This will be documented in the updated EIA prior to the contractors' mobilization.

- Ministry of Environment, Forests and Climate Change,
- 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 – EIA

261. During the field surveys that were carried out between November 2016 and November 2018 while updating preliminary SIA as part of Detailed Project Report (DPR), interviews of head of individual PAFs to elicit their socio-economic characteristics were conducted in addition to consultation meetings with groups of stakeholders and community. The total number of attendees during the consultations in this period were 117, of which 15 were females and 102 were males. The opinions of the community and stakeholders were obtained during these consultations and summarized in Table 7.1.

262. The CMRL consulted numerous organizations and groups during the preparation of safeguard documents and throughout the course of the environmental and social assessment. The formulation of the GESI action plan has involved the following groups: (i) Awareness for WoMen to Advocate their Rights and Equality (AWARE), (ii) Disability Rights Alliance, (iii) Prajnya Trust, (iv) V-shesh, (v) Association for Non-traditional employment for Women (ANEW), (vi) Penn Thozhilalargal Sangam, and Garment and Fashion Workers Union, (vii) Thozi, (viii) Sahodaran, (ix) Borntowin (B2W), (x) Tamil Nadu Domestic Workers Welfare Trust.

263. All metro stations and trains shall be designed with EWCDT-responsive features to make the commute safer and more comfortable. In the light of the COVID-19 crisis, metro infrastructure will be used as a multimedia platform to disseminate information on communicable diseases and relay messages on preventing sexual harassment. The project's multimodal and land use integration initiatives will support the formulation of a comprehensive policy and plan to ensure universal access, social inclusiveness, EWCDT-responsive amenities and gender equality focused institutional capacity building.

264. The Resettlement framework and the GESI action plan for the project will also provide the mechanism for consultative and participatory approaches, and the safeguard documents provide adequate avenues for grievance redress.

Table 7.1: Public Consultations at Station Locations Onsite 2016 to 2018

Place	Date	No. of participants	Issue	Suggestion/opinion
Alwarpet	03.11.2016	6	Compensation	Adequate compensation for structures should be paid to help re- start life
			Fare	Fare should be comparable with other modes of travel
			Bore wells	Bore wells in station areas will be affected
			Building damage	Should be taken care
			Tenancy	After construction we want tenancy at this place a same rate
			Livelihood	Livelihood will get affected
Luz, Thirumayilai	29.05.2017	7	Solve traffic issues and increase connectivity	Metro will reduce the traffic jam. The long-distance travel will be easy and metro will increase the connectivity.
			Old area; building may collapse due to tunnelling work	Underground track may not be suitable for Mylapore as it is a very old area with heritage buildings- temples, church etc. Many buildings/ residents are century old; therefore, there is a great risk of collapse.
			Business loss due to construction activity	If construction activities go long more than expected, then it incurred loss to commercial/ shops.
			Fare	Fare should be less.
Poonamallee Depot	20.11.2018		Time Saving	Time will be saved in comparison with other means of transport.
			Loss of livelihood	The loss of livelihood for small enterprises is a major issue for employees or working class
			Traffic and pollution during construction of the project	There is a possibility of pollution and traffic problem during construction of the metro project.

Place	Date	No. of partici pants	Issue	Suggestion/opinion
		8	Reduction of road pollution	Metro train will reduce the existing high level of pollution both noise and air.
			Safety and Security	The lady respondents said that the proposed metro project will be helpful for her because metro offers special a special compartment for ladies only.
			Loss of Trees and land	Loss of trees is another major concern according to the respondents. Tree plantation shall be taken care of.
			High ticket cost	The minimum metro ticket price in Chennai metro is Rs.50. The poor and middle class citizens will not be able to afford that money on a regular basis. So, they are using the bus services mostly.
Vadapalani	11.11.2016	10	Road congestion	Operation of metro to reduce congestion on road
			Fare	Metro should be less expensive
			Loss of livelihood	Being a small shop owner, our livelihoods will totally loss. There has to be adequate provision of compensation.
			Reduction in pollution	Metro will reduce the existing traffic load and reduce the level of pollution.
			Metro reduce road side accidents	Metro will reduce the traffic and reduced in road accidents.
Vadapalani	26.05.2017	7	Travel time	Travel time by metro will be lesser
			Congestion and Pollution	Congestion and Pollution due to road traffic will reduce

Place	Date	No. of participants	Issue	Suggestion/opinion
Poonamalee Bus Terminus	03.07.2018	12	Compensation	Due to metro train, other facilities and infrastructure will develop, but affected structures/people should get adequate compensation in order to re-instate their life.
Poonamallee Bus Terminus	03.07.2018	12	Loss of livelihood	Being a small shop owner, our livelihoods will totally loss. There has to be adequate provision of compensation.
			Reduction in Pollution	Metro will reduce the traffic and road accidents.
			Construction resulting Traffic Jam	Construction activity will result traffic jam. As this place is fully commercial, metro construction may disrupt the traffic flow
			Green Cover	The metro train might reduce the green cover and it needs to be taken care of.
			Area development	Due to metro train, other facilities will come such as infrastructure development. Local economy will boost up.
Iyappanthangal Bus depot	03.07.2018	12	Time Save	The metro train facility in Chennai will save time to reach the destinations in comparison with other means.
			Comfortable Travel	It would be easy to reach to the destinations due to the proposed metro project.
			Better connectivity	Metro may improve connectivity with speedy travelling.
			Reduction in pollution and accidents on road and overall	There would be reduced pollution and no accidents while travelling in metro train
			Loss of livelihood	Local vendors located very close to the project site will be affected badly

Place	Date	No. of partici pants	Issue	Suggestion/opinion
			Fare	The metro fare should be as less as possible considering paying power of the people
			Employment	Metro will increase jobs especially for engineers

Source: DPR Corridor 4 SIA January 2019 & Comprehensive DPR March 2019

265. Public Consultations were conducted on site at station locations in 2018 and 2019 after the DPR was finalized. The outcome of these consultations is summarized in Table 7.2. 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.

Prior to the initiation of the grade separator construction, public opinion was informally gathered, revealing a consensus that the grade separator would significantly alleviate the traffic congestion at the location. This consultation addresses environmental concerns, a comprehensive assessment was undertaken to ensure minimal ecological impact, focusing on sustainable practices and necessary mitigation measures will be carried out.

Table 7.2: Public Consultations at Station Locations Onsite 2018 and 2019

Location	Date	Number of Participants	Issue	Suggestion / Opinion of Participants
Bharathidasan Road	8/9/2018	10	Adverse impacts	Loss of Livelihood, income, house/shop
			Benefits	Increase in property values, employment; decrease in travel time, congestion, accidents, GHG
Vadapalani	8/9/2018	12	Adverse impacts	Loss of Livelihood and income, house/shop, income, loss of house/shop, ,
			Benefits	Increase in property values, employment; decrease in travel time, accidents
Valasaravakkam	24/12/2018	8	Adverse impacts	Loss of income; migration
			Benefits	Increase in property values, decrease in travel time and GHG
Alapakkam	24/12/2018	5	Adverse impacts	Loss of customer, income, house/shop

Location	Date	Number of Participants	Issue	Suggestion / Opinion of Participants
			Benefits	Decrease in travel time and GHG
Iyyapanthangal Bus Depot	12/1/2019	7	Adverse impacts	Loss of livelihood, house/shop
			Benefits	Increase in property values, decrease in travel time, GHG
Kattupakkam	12/1/2019	11	Adverse impacts	Loss of income, migration
			Benefits	Increase in economic activity; decrease in travel time, accidents, GHG

7.4 Information Disclosure

266. Information disclosure will follow the procedure and disclosure requirements of MDBs' policies for category A projects. As per ADB's SPS 2009 and AIIB ESF 2019 , the EIA shall be disclosed 120 days prior to ADB's Board Approval and AIIB's Board Approval.

267. All environmental documents are subject to public disclosure, and therefore, it is 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 updated EIA is 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

268. 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.

269. 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.

270. 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 2nd 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.

271. 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
- 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) shall be invited to deliberations of the Committee.

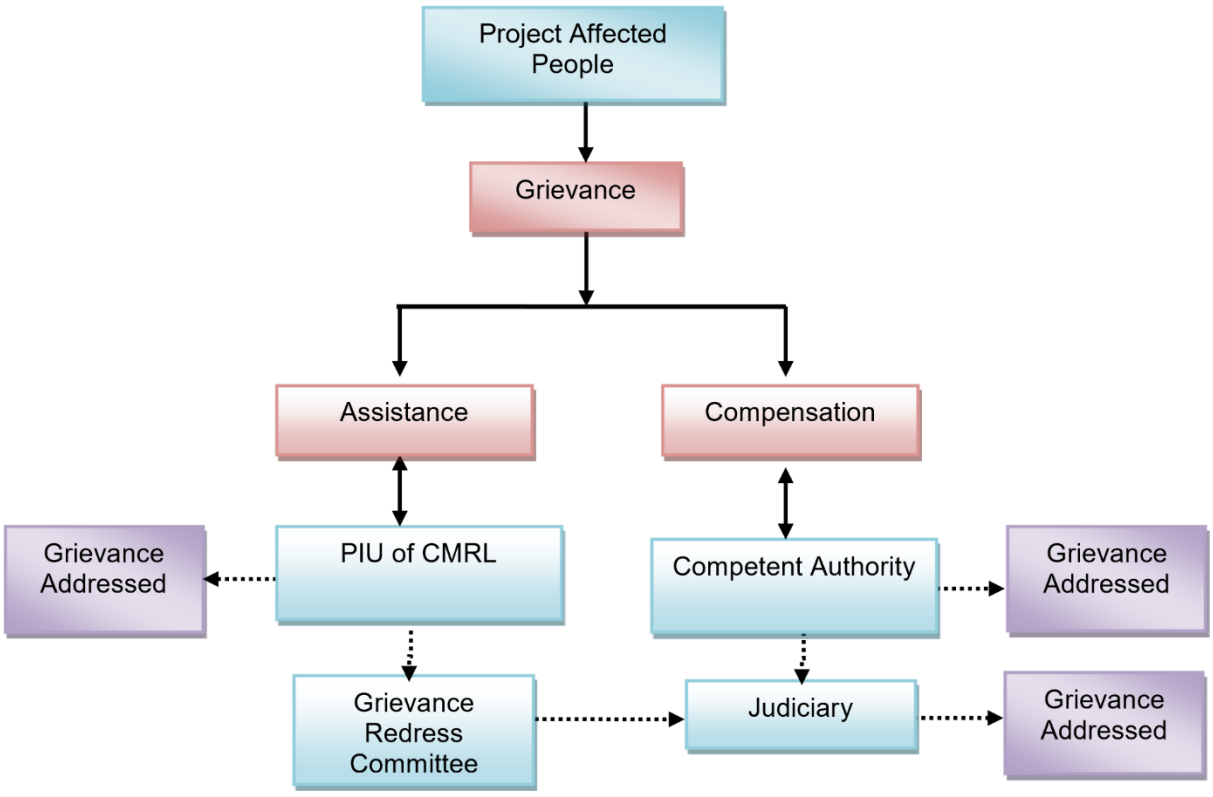
272. Records of the following stages will be maintained in the PIU office, on website of CMRL throughout the life of the project:

- 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.

273. 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.

274. 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



275. 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

276. In addition to the above GRM for addressing complaints from the local community, a separate GRM will be constituted by contractor 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 shall 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 shall 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 shall 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

277. The Environmental Management Plan (EMP) consists of a set of mitigation, monitoring and institutional measures to be taken for Corridor 4 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.

278. 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

279. 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

280. 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.

281. The Department of Planning, Development and Special Initiatives, Government of Tamil Nadu, acting through the Chennai Metro Rail Limited (CMRL) will be the Executing Agency (EA) of the proposed Corridor 4 (Phase-II).

9.3.2 Implementing Agency

282. Chennai Metro Rail Limited (CMRL) is the Implementing Agency (IA) responsible for implementation of the metro rail project. Managing Director, CMRL will be in charge of the overall project activities. CMRL is accountable to the GoTN (i.e. the EA).

283. 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 6**.

9.3.3 Implementation of EMP

284. CMRL: EMP is 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. The Environment clearances related to locations and design of the project is be secured before start of construction. Permissions/certifications required during operation of the project. Environment monitoring during operation.

285. Contractors: 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 environmental 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; and
- professionals in occupational health and labour welfare.

286. The Employer Requirements for Environment, Social, Health and Safety (ESHS) have been prepared for Corridor 4; they will be issued to the Contractor as part of the contract documentation for construction.

287. CMRL and GC: Supervision and review of implementation is 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, waste management plan, muck disposal plan etc.). Implementation of EMP will be continuously monitored by the ESHS team of GC and CMRL. The CMRL-GC team will be common for all sections of the project with a view to facilitate unified approach and knowledge enhancement.

288. The CMRL Core environment team and GC Environmental Specialist will be responsible for monitoring corridor 4. During construction CMRL – Assistant Manager /Environment was assigned and charged for this corridor, assisted by safety, environmental, traffic, labour welfare

professionals deployed by GC and the Contractor. During operation of metro, the core environment team will continue to monitor implementation of EMP by the metro operations contractors and EMoP by external environment monitoring agencies.

289. The CMRL's ESHS team will headed by senior Manager assisted by qualified and trained mid-level safety professionals, environment engineers, traffic engineer, labour welfare officer. The Manager ESHS for the project in CMRL will report directly to Director (Works) and Managing Director, CMRL.

290. GC will contribute,

- Specialists from fields of safety, environment, traffic engineering, occupational and community health, ecology, noise and vibration
- Onsite junior field personnel, at least one site each.
- The visits and review meetings will comprise:
    - Weekly site visits independently by CMRL and jointly with contractor;
    - Weekly review meetings by CMRL and contractor;
    - Quarterly monitoring reports to CMRL;
    - Semi-annual monitoring reports to MDBs.
- Orientation and training of CMRL team in implementation of EMP and environmental monitoring will be undertaken at the beginning of the project.

291. MDBs: Disclosure of all latest safeguard documents on their websites. Implementation of the EMP is l be monitored half yearly by MDBs through their specialists.

292. External Monitor: An external agency is engaged by CMRL in consultation with MDBs to evaluate the environmental performance of abovementioned parties with the listed responsibilities as below. The agency will report to CMRL who in turn report it to MDBs. The terms of reference are attached as Annexure 7.

- To conduct third party monitoring of environmental compliance under the project;
- To ensure that the Project is 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.

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

294. An EMP Matrix is presented in Table 9-3.

9.4 Development and implementation of Subplans

295. 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. 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	MDB[23]
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 (TBM operation for underground section, 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

Plan		Description	Approvals		
			PIU	GC	MDB[23]
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 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.	Yes	Yes	Yes
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	Yes	Yes	Yes

Plan		Description	Approvals		
			PIU	GC	MDB[23]
		together with the Camp Management Plan. Recommendations provided in the EIA must be considered.			
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 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.	Yes	Yes	No
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	Yes	Yes	Yes

Plan	Description	Approvals		
		PIU	GC	MDB[23]
	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.			
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

296. Environmental Monitoring Plan (EMoP) is a companion document of the EMP. EMoP contain 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

297. The monitoring plan is adopted to monitor the performance monitoring of the project in respect to environment. 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 9.3.

298. 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 a) Implementation of EMP and EMoP b) Monitoring of implementation of EMP and EMoP c) Grievance Redressal	Monthly till completion of construction	a) Contractor / GC b) GC / CMRL SH&E team, CMRL SH&E team/MD, CMRL c) CMRL SH&E team/MD, CMRL	CMRL
a) Implementation of EMP, EMoP and Grievance Redressal and their internal (CMRL) monitoring b) Outcome of continuing public consultations	Semi-annually **until completion of** construction	All by CMRL / MDBs	• MDBs • 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 b) Monitoring of EMoP c) Grievance Redressal	Semiannually during first 2 years of operation & maintenance	a) and b) • EMoP Agency / GC • GC / CMRL SH&E team • CMRL SH&E team/MD, CMRL c) CMRL SH&E team/MD, CMRL	CMRL
a) Implementation of EMP, EMoP and Grievance Redressal and Internal (CMRL) monitoring b) Outcome of continuing public consultations	Semiannually during first 2 years of operation & maintenance	CMRL / MDBs	• MDBs • TNPCB
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	Social	As per DPR October 2018, permanent acquisition of 5.7ha private land. 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, governed by the following general principles, which are based on The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013. 2. Land Acquisition is being carried out as per the provisionof GoTN and GoI policies. The affected people will be compensated and assisted as per the provisions of Resettlement Action Plan.	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 4. 2. Proper clearance/permission/consents will be sought from competent authority before construction.	CMRL	CMDA
3.	Contractor Management	EHS	EHS accidents Reputational Risk	1. Integration of EHS contractor management into broader project management, procurement, human resources, legal, and financial management. 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 andtraining). 3. Prime contractor will be responsible for EHS practices of the subcontractor including human resource policy whichcomplies with applicable labour legislations, including	Contractor / GC	CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				decisions on material supplies and equipment given environmentally friendly priorities, and prepare subcontract agreements accordingly. 4. Contractor management incorporates "adaptive management" to monitor and adapt over time; integration with sustainable procurement approach or concepts. 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 management project contractor meetings and reports, reflecting both criticisms or suggestions andpraise; 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. 6. Training and quality control plans.		
4.	Contractor Preparatory Works (Upon issuance of Notice to Proceed)	EHS	Non-compliance withcontract conditions and regulatory requirements.	1. The Contractor shall complete the following activities no later than 30 days upon issuance of Notice to proceed, 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 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	Contractor / GC	CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				vehicles. Arrangements to link with government health programs on hygiene, sanitation, and prevention of communicable diseases will also be included in the action plan; (e) SHEO will submit for GC's approval ofthe 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.		
5.	Labour Management	Labour	Labour right	1. Compliance with GoI labor legislation, ratified International Labour Organization conventions. 2. Prohibition of child labor, including prohibition of personsunder 18 years old from working in hazardous conditions (which includes construction activities) and from working at night; medical examinations required to determine thatpersons above 18 years old are fit to work. 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. 4. Human resource policy or plans that establish (a) the rights and responsibilities of project company employeesand 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 workerrights. 5. Grievance Redress Mechanism for workers should be established as early as possible to function no later than construction commencement. 6. There will be provision for group accidental insurance for the workers. 7. 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.	Contractor	GC / CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		Health and Safety	Accidents and illness	1. Prepare the Health and Safety Plan for each site and assign a safety officer to monitor the compliance. 2. Make mandatory the use of safety gears (helmets, safety belts, masks, gloves, Ear plugs/ muffs and boot) by workers depending on nature of work. 3. Necessary planning and safety approach will be made for rescue during emergency. 4. Use of dust controls (exhaust ventilation) for dust control 5. Workers will be provided with first aid and health facilitiesat the site. 6. There should have facility to deal with medical aspects ofHIV/AIDS treatment with specialized services. 7. GC to conduct Health and Safety Audit.	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 submitto CMRL and GC for approval. 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 LabourOrganisation, International Financial Corporation and World Bank's interim guidance note etc. The key points on COVID-19 Response and Management measures is at Annexure 8. 3. The contractor shall submit a weekly monitoring andprogress report to CMRL and GC.	Contractor	GC / CMRL
6.	Obtaining Clearance, Permission and Consents	Regulatory Compliance	Delay of obtaining CRZ clearance, 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. muck/waste disposal.	1. Consultation and coordination with relevant authorities toprepare the documents to obtain clearance, permission and consents. 2. Conditions set in CRZ clearance, other permission and consents to be incorporated into the site-specific EMPs, with dedicated officers to maintain the regulatory compliance tracker.	CMRL / Contractor	GoTN Forest Dept / TNCRZMA/ TNSPCB

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
7.	Site Clearance and Demolition	Tree felling	About 837 trees will be affected at alignments, stations and depot area. Additionally, in some areas, pruning will be required. Ecological Impacts on Panagal park	1. CMRL and Contractor need to conduct a final tree inventory survey(number, type, height) with the finaldesigns of alignment and station. Trees with conservation value should be transplanted. Plan to avoidcutting patrimonial trees, including adjustments in project design to minimize effect on such trees. 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. 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. 4. Adequate coordination with applicable government regulatory authorities. As alignment passes through built land use, green belt development along elevated sectionis 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. 5. Stakeholder communication to avoid or minimize public concerns or protests. 6. Exploration of restoration options for Panagal park enhancements, to offset negative impacts, accelerate ecosystem recovery and promote the health and longevity of the Panagal Park. Contractor and CMRL will work out an ecological restoration plan with a process of assisting the recovery of the ecosystem that will have been degraded, damaged or destroyed due to the construction of Corridor 4. Passive restoration actions may include fencing and signing sensitive areas during construction, which will minimize construction impacts. Active restoration actions include soil decompaction, revegetation, removal formal or informal trails out of sensitive area. 7. 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
		Noise	Noise will be generated theuse of hand tools such asjackhammers, 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. 2. The existing structures should be demolished one after another cautiously.	Contractor	GC / CMRL
		Physical Cultural Resources	Historic and Cultural ValueLoss	1. Contractor to conduct pre-construction structural integrityinspections 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. 2. Prepare a monitoring scheme prior to construction basedon the above inspections, with a focus at locations whereTunnel Boring Machine will pass close to or under, to prevent the construction delay in case structural damageoccurs during tunneling. 3. Compliance with applicable legislation (permits and procedures) and good international practice. 4. Adaptive management in site-specific EMP during final design, including site locations (stations, emergency exits, ventilation shafts, and construction staging areas). 5. Chance finds procedure to be prepared by Contractor and reviewed by GC/CMRL before submitting to all lenders.	Contractor	GC / CMRL / CMDA
		Biodiversity	Potential Habitat Loss	1.	Contractor / GC/ CMRL	TNCRZMA

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				1. GoI legislation, IFC/WB guidelines and international best practices should be integratedly followed. 2. Assessment of actual and potential disturbance effects of project activities and develop the Biodiversity Management Plan (BMP) to ensure no net loss of any target species including Olive Ridley Turtle. The BMP will outline the actions required by the contractor to conserve or enhance biodiversity during site works particularly during piling and construction work. The BMP will be reviewed by lenders prior to contractor's mobilization.		
8.	Severance of utilities	Social 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 gas lines and traffic signals etc.	1. Assets and utilities will be maintained without affecting and damages by shifting temporary/ permanently where it is necessary. 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 diversions and protection measures to minimize the risk to existing utilities from ground movement and surface settlement. 3. For gas pipeline, Contractor will conduct the hazardous operation study to ensure the smooth and safe shifting. 4. Utility shifting plan will be developed by CMRL and Contractor in coordination with concern authorities and shifting of utilities will be done as per agreed utility	CMRL / Contractor	CMRL / CMWSSB, TANGEDCO, Telecom companies

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				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 removedor re-pavement will be completed as required).		
9.	Noise and Vibration Impacts Related Design	Environmental Nuisance	Noise and vibration from construction and train operation	1. The detailed noise and vibration analysis (mathematical modeling) at sensitive receptors based on final engineering designs should be carried out, based onwhich, a set of mitigations should be prepared and shared with all lenders for review, prior to commencement of construction. 2. Additional assessments of vibration, such as visual inspections of buildings and baseline monitoring in areaswith sensitive buildings of cultural or historicalsignificance. 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.	Contractor	GC / CMRL
10.	Coordinate with the Traffic Department on Traffic Management Plan	Land Occupational safety Community safety	Nuisance from traffic congestion	1. The Contractor shall develop detailed and robust traffic management plans consistent with the Indian Roads Congress (IRC) on Traffic Management in work zones (IRC:SP:55-2014), prior to mobilization for respective sections with site- or station-specific plans and measuresto minimize the overall impact on traffic throughout the construction and operation periods. 2. At congested sections, the temporary traffic coordinators will be engaged by CMRL to facilitate the trafficmanagement. 3. At the minimum, the traffic management plan will have	Contractor	GC/ CMRL/ Traffic Police

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				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. 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. 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). 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 inadvance of disruptions. Efforts will be given to diverttraffic 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. 7. Incorporation of community safety considerations intoplan design, especially at locations such as Kutchery Road where buildings are close to the construction site. 8. CMRL and local authorities continue to play an oversight role in approving these plans during construction, evaluating their cumulative impact with otherinfrastructure projects in the region, and ensuring their dissemination to all relevant stakeholders.		

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				8.		
11.	Construction method, construction material and sites selection	Environment	Pollution and nuisance	1. Contractor is committed to use environmentally friendly construction methods and materials, including cement, asphalt, and base materials etc. 2. Construction material shall be sourced from legalizedand approved quarries. 3. Energy saving technologies will be embedded into the Project design wherever possible. For instance, solar panels, rainwater harvesting. Bureau of Energy Efficiency (BEE) certified/ Energy efficient LED lights, automatic signaling, etc., 4. Update of plan based on final contractor-defined estimated volumes and timing for groundwater pumping with intension of minimizing the groundwaterconsumption. 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, withconsent of CMRL, resort to such extraction. In such instances contractor-defined estimated volumes and timing for groundwater pumping with intention of minimizing the groundwater consumption. 5. Procedures for minimizing waste segregation, reuse, temporary storage, recycling, donation, and disposal. 6. Selection of waste disposal service providers (transport, recycling, and disposal) based on EHS criteria (includingcompliance with all regulatory requirements, nodocumented EHS issues related to materials at operation or site facilities, and agreement to provide	Contractor	GC / CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				access for site visits to discuss EHS management). 7. Final selection of disposal or reuse sites for extracted soils from construction and assessment anddetermination of truck routes from project sites to disposal or reuse site. 8. Focus will be placed on reuse of the extracted soil for enhancement of green space, waste recycle, and storm water runoff. 9. Construction yards with aggregate crushing and screening, pre-casting, material and fuel storage andready-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. 10. The muck disposal sites shall be identified by Contractor and will be decided by CMRL after approval of the Muck disposal Plan and before start of constructionin consultation with TNPCB, 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 dumpingsite in layers and compacted mechanically. Suitable slopes will be maintained on the stockpile. Once thefilling is complete, it will be protected by low walls, provided with a layer of good earth on the top and covered with vegetation.		
12.	Climate Designs	Health and Safety	Natural disasters generated health and safety accidents Maintenance Cost	1. Belt of width approx. 0.5 km of beach and developed area on alignment between Lighthouse and KutcheryRoad is underground and can be subject to floodingdisrupting operations. On Corridor 4, flooding gates will be installed, and adequate facilities will be made in terms of evacuation of flood water using pumps in Lighthouse, Foreshore Road and any other stations with flooding	Contractor	GC / CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				risks. Disaster management plan will pay special attention to flooding and other natural disaster to facilitate robust safety and quicker evacuation, to adapt the disruption of road level access to stations due to rise in mean sea level. 2. Other climate adaptation designs will be embedded inthe final design, such as (a) improving adaptability to seasonal thermal variations in the stations through the use of large open spaces for unrestricted air movement, cross-ventilation and ensuring that enclosed areas are well ventilated; (b) designing for better adaptability torising sea level/high tide/heavy flooding through the use of higher plinth levels and check valves for sewer lines inflood-prone areas and the use of resilient materials that can get wet and then dry out with minimal damage; and (c) rainwater harvesting through gutters and pipes to either harvesting pits or for groundwater recharge. 3. Climate change mitigation measures will be considered, such as solar panels on station buildings and roofs to reduce the extensive use of grid-generated electricitysupplied to the station for operation and maintenance.		
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, soil quality. 2. Additional investigations in areas identified as havingcontaminated 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 thatincludes (a) monitoring during construction consisting of visual inspections, on-site and in-situ monitoring to detect and confirm levels of contamination (and	Contractor	GC / CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				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. 3. Assessment and site-specific measures for controllingnoise, dust, and illumination during construction (for example, when working 24 hours a day). 4. Confirmation of potential uses of groundwater and pumping impacts (for example, settlement or subsidence). Efforts on minimizing the groundwater consumption. 5. Contractor to prepare site-specific EMPs for CMRL to approve before mobilization. 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. 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. 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. 2. The Grievance Redress Mechanism information and focal should be disseminated to public.	CMRL	GoTN
16.	Community Liaison	Social	Complaints	1. To ensure that Grievance Redress Mechanism tofunction effectively for affected people on construction nuisance at ground level with grievance log welldocumented.	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				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 andflammable materials, generators).		
Construction Phase						
17.	Construction Monitoring	ESH	Breach of legislation, EIA, EMP, Contracts Accidents	1. Contractor to collect and monitor the Ambientenvironmental data of air, water (surface and ground), noise& vibration, soil quality and submit monitoring reports to GC / CMRL on monthly basis. 2. GC / CMRL to review the data compared to baseline data and urge Contractor to take immediate actions over any project generated pollution / contamination. 3. GC to submit monitoring reports on quarterly basis to CMRL. 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. 5. CMRL to engage qualified and experienced third party monitor to verify information produced through the Project monitoring process, and facilitate the carrying outof any verification activities by such third party monitor. 6. CMRL to submit the semi-annual monitoring reports (GC's and third party's) using the agreed the template to all lenders. 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	Contractor / GC / CMRL	TNSPCB

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				breach.		
		Biodiversity	Breach of legislation and BMP	1. Apart from the abovementioned measures for EHS monitoring, CMRL to ensure the BMP implementation monitoring and wildlife monitoring. If any wildlife species are found in the construction site, they will be carefully transferred to safe locations within the Coastal Zone or Marsh under the guidance of the biodiversity expert and the local forestry/wildlife agency. 2. Monitor noise level to minimize the impacts, for instance,use of rotary drilling rigs which generates less noise in comparison to impact hammer. The Construction MethodStatement will follow the Good International Industry Practice. 3. Monitoring habitat enhancement to deliver net benefit to any Critical Habitat species.	Contractor / GC / CMRL	Forest Department GoTN / CMRL
18.	Community Liaison	Social	Complaints	1. 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. 2. Grievance Redress Mechanism for affected people should function effectively with grievance log welldocumented.	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				3. Contractor will provide a minimum of two (2) weeks notification to directly affected residents, businesses andother 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. 4. Adaptive management that monitors, adjusts, or adds measures to reflect actual community risks. 5. Important measures to reduce community risk, such as fence and related protection around work sites (includingstrength and visual protection), education and awareness signs and information, and placement of safety risks (explosive and flammable materials, generators).		
19.	Truck and Driver Management	Environment Social	Community disruptionAccidents Reputational risk	1. Contractor's transport vehicles and other equipment shall conform to emission standards. 2. Control, inspection, and documentation of trucks prior to leaving site, including removal of soil on tires. Contractorwill provide a wash pit or a wheel washing and/or vehiclecleaning facility at the exits from construction depots andbatching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt. 3. Definition of allowable routes, speeds, and times (day or week). 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. 5. Driver contracts with clearly specified requirements and remedies for noncompliance. 6. Use of electronic monitoring (GPS), driver training, and	Contractor	GC / CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				stops. 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. 2. Where feasible, infiltration losses could 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 generateless noise than mechanical piling (around 70-75 dB(A)). Also 2m high barricade of GI sheet will be installed on allsides of piling operations. This could effectively cut downnoise levels by 10-15 dB (A). Piling operations will be restricted during day time hours only. 2. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures. 3. Use of low-noise equipment and ensuring good maintenance, and trying to avoid using high-noise equipment simultaneously at the same section. 4. Wherever baseline noise already exceeds the standards,only 3 dB of noise increase is allowed. 5. Information dissemination to local residents and shopowners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				commencement and kept updated as to changes in the management and mitigation plan. 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. 7. Monitoring required during construction, including field observations and measurements.		
		Air	Construction 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). 2. Every vehicle should be washed to remove any dusty materials from its body and wheels before leaving the construction sites. 3. Imposition of speed controls for vehicles on unpaved site roads. Ten kilometers per hour is the recommended limit.	Contractor	GC/ CMRL
		Waste	Soil and surface/ground water pollution	1. Bentonite slurries used in construction should be reconditioned and reused wherever practicable. 2. The disposal of residual used bentonite slurry should follow the international good practice. 3. Segregation and storage of different types of waste in different containers, skips or stockpiles to enhance reuse or recycling of materials and their proper disposal. 4. Nomination of an approved person, such as a site manager, to be responsible for good site practices, arrangements for collection and effective disposal to an appropriate facility, of all wastes generated at the site.	Contractor	GC/ CMRL
		Aquatic Ecosystem	Construction near the lighthouse (Marina Beach) and Porur Lake area may result in accidental release of construction materials (concrete , fuel,chemical etc.,)Construction activities may also cause excessive siltation inside the river. These impacts will in turn affect the aquatic species, as well as water birds.	1. Turbidity curtains will be used during pile driving activities if any to reduce the potential for increases in suspended sediment. 2. The contractor will be prohibited from fishing or other aquatic wildlife 3. Construction in the waterbodies will be avoided during the rainy season to minimize construction duration inside the water. 4. Silt fencing will be installed along the banks of the waterbodies wherever necessary. 5. The construction wastes generated near the eco sensitive locations shall be disposed promptly as per standards. 6. Site specific EMP focusing eco-sensitive areas and sensitive receptors shall be prepared and implemented.		

				7. Water samples shall be collected from the water bodies involved and water quality tests shall be carried out on monthly basis to monitor the quality of surface water.		
		Vibration	Pile driving for viaduct piers and buildings and tunnel driving generate vibrations	1. Cast-in-situ piling will be deployed at locations with sensitive receptors so as to reduce vibration. 2. At locations where the alignment is close to sensitive receptors, the contractor shall implement the pre-construction structural integrity inspections. 3. Contractor to ensure that vibration levels at historically and culturally sensitive Structures, and Structures in poor state condition will not exceed 2.0 mm/s. 4. Information dissemination to local residents and shopowners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior tocommencement and kept updated as to changes in the management and mitigation plan. 5. Monitoring during construction including field observations and measurements.	Contractor	GC/ CMRL
		Physical Cultural Resources	Historic and Cultural Value Loss Conflicts with community	1. Before start of piling and tunneling, 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 or tunneling will be allowed unless cleared by the Archeological Department. 2. Archeological monitoring during construction stage, including specialists in field with authority to stop work. 3. All workers will undergo a briefing with the Archaeology Department to ensure safeguarding of heritage resource and cultural/religious practices. 4. A proof of compliance to this requirement to include the name of participants and date and location of briefing willform part of the monthly report to CMRL. 5. Archeological rescue and protection in case of chance finds, follow specific measures (reporting, monitoring) recommended by UNESCO.	Contractor	GC/ CMRL
		Health & Safety	Noise and vibration generated during piling will affect the health and safety of the workers Accidents	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). 2. To reduce the harmful effects, personnel working at high noise levels would be provided with noise protective	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				gears such as ear mufflers, sound barriers, job rotations per occupational exposure limits etc. 3. Oversight of project safety is needed to ensure proper support and lining of excavated sections to avoid collapse. 4. Where a site boundary adjoins a road, streets or other areas accessible to the public, hoarding should be provided along the entire length except for a site entrance or exit. 5. Procedure to receive, evaluate, and compensate (if applicable) damages due to construction and establishment of financial resources to cover this expense.		
22.	Diaphragm Wall Construction	Air	Construction of diaphragm wall 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). 2. Every vehicle should be washed to remove any dusty materials from its body and wheels before leaving the construction sites. 3. Imposition of speed controls for vehicles on unpaved siteroads. Ten kilometers per hour is the recommended limit.	Contractor	GC/ CMRL
		Waste	Soil and surface/ground water pollution	1. Bentonite slurries used in diaphragm wall construction should be reconditioned and reused wherever practicable. 2. The disposal of residual used bentonite slurry shouldfollow the international good practice. 3. Segregation and storage of different types of waste in different containers, skips or stockpiles to enhance reuseor recycling of materials and their proper disposal. 4. Nomination of an approved person, such as a site manager, to be responsible for good site practices,	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				arrangements for collection and effective disposal to an appropriate facility, of all wastes generated at the site.		
		Health and Safety	Accidents	1. To specify the number and length of shifts for each worker. 2. Oversight of project safety is needed to ensure proper support and lining of excavated sections to avoid collapse. 3. Tunnels have to be properly lit, drained, and ventilated toprovide visibility, dry working conditions, and breathable air free of dust even in confined spaces. 4. Where a site boundary adjoins a road, 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
23.	Excavation (The quantum ofsoil excavated soil will be about 12.31 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). 2. Imposition of speed controls for vehicles on unpaved siteroads. Ten kilometers per hour is the recommended limit. 3. Every vehicle should be washed to remove any dusty materials from its body and wheels before leaving the construction sites. 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. 2. Use of low-noise equipment and ensuring good maintenance, and trying to avoid using high-noise equipment simultaneously at the same section.	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				3. Wherever baseline noise already exceeds the standards,only 3dB of noise increase is allowed. 4. Information dissemination to local residents and shopowners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior tocommencement and kept updated as to changes in the management and mitigation plan. 5. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for theduration of noisy construction activities. 6. Monitoring required during construction, including field observations and measurements. 7. Provide timely notification of residents about tunneling works will limit the nuisance of noise and vibration due to Tunnel Boring Machine (TBM) operation. 8. Contractor to ensure that vibration levels at historically and culturally sensitive Structures, and Structures in poor state condition will not exceed 2.0 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. The wastewater should be discharged aftersedimentation in tanks. 2. To avoid water pollution and soil erosion due to flooding,earthwork will be limited during monsoon season.	Contractor	GC/ CMRL
		Groundwater	Dewatering (if done) will adversely affect the groundwater regime.	1. Dewatering will be done only when required Groundwater will be collected in sedimentation tanks andreused in non-potable uses. Refer to SHE (Addendum tothis EIA report). 2. This water will be treated to meet CPCB standards before discharge. 3. Groundwater monitoring, including groundwater quality	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				and aquifer status.		
		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 lowlying area where it is necessary. 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
		Subsidence	Ground subsidence under existing structures during tunneling due to unanticipated weak pockets of substratum and unanticipated degree of groundwater drawdown, raising safety issues and possible damage to structures	1. Plan showing location of construction site and affected structures. 2. Groundwater extraction adjacent the metro project could lead to subsidence under non-metro structures as wellas settlement of metro tunnel and stations between Kutchery Road and Thirumayilai stations, Adyar gate to Alwarpet, Kodambakkam suburban (rock deeper thantrack level). At abovesaid locations, the bore wells need to be rationalized to avoid groundwater extraction near tunnel. 3. Groundwater drawdown can be minimized by sealingjoints in tunnel lining. In addition, where requiredadjacent structures will be given additional supports. Sides of deep excavations at stations will be supported by walls which minimize water seepage. In open areas where side support walls in excavations are feasible,such walls will help prevent caving and thereby settlement of adjacent structures; in built up areas where side walls are not feasible, adjacent structures will be provided additional supports. 4. Caving of tunnel will be prevented by placing pre-cast concrete segments in soft soils and rock bolts or arch	Contractor	GC / CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				ribs in rock. Subsidence above tunnel due to removal of material and water beneath will be prevented by such tunnel supports. 5. Monitoring records which include but not limited to, groundwater drawdown records from borewells, vibration records, geotagged photographs with date. 6. Real-time monitoring of structures above tunnelingoperations and adjustments of TBM operation if required. 7. 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.		
		Physical Cultural Resources	Historic and cultural value loss Conflicts with community	1. Before start of excavation, Contractor and CMRL willcoordinate with State Archeological 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. 2. Archeological monitoring during construction stage, including specialists in field with authority to stop work. 3. All workers will undergo a briefing with the Archaeology Department to ensure safeguarding of heritage resource and cultural/religious practices. 4. A proof of compliance to this requirement to include the name of participants and date and location of briefing willform part of the monthly report to CMRL. 5. Archeological rescue and protection in case of chance finds, follow specific measures (reporting, monitoring) recommended by UNESCO.	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		Health and Safety	Accidents	1. To specify the number and length of shifts for each worker. 2. Oversight of project safety is needed to ensure proper support and lining of excavated sections to avoid collapse. 3. Tunnels have to be properly lit, drained, and ventilated toprovide visibility, dry working conditions, and breathable air free of dust even in confined spaces. 4. 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
		Aesthetics	Loss of aesthetics value due to excavation and related activities.	1. The excavation sites will be barricaded on all sides usingGI sheets. Hauling will be carried out in non-peak hours. 2. Aesthetic value of the site will be restored aftercompletion of the works.	Contractor	GC/ CMRL
24.	Blasting	Aesthetics	Blasting will raise aesthetics issues among local citizen	1. Rock is found in lower part of tunnel or beneath track level and so blasting is not anticipated. Good housekeeping practice should be adopted. 2. In the unforeseen event that blasting is required, a site- specific EMP will be prepared by Contractor and approved by CMRL before blasting commencement.	Contractor	GC / CMRL
25.	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. 2. The trucks/dumpers carrying the excavated material willbe covered using tarpaulin/similar covering materials. 3. Sprinkling of water should be carried out. 4. Truck tires will be washed to excess remove soil clingingto 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. 5. Water for sprinkling and tire washing will be sourced	Contractor	GC/ CMRL/ TNSPCB/ Traffic Police

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				from treated effluent from ETPs located nearby or seawater or surface runoff. Groundwater will not be usedin view of status in Chennai. 6. Haul roads will be kept in good state of maintenance.		
		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 residential / urban areas.	1. The routing, timing and logistics of the haul truck movement should be planned to have minimal impactson noise level. 2. The route selection will avoid any sensitive receptors. 3. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures. 4. Wherever baseline noise already exceeds the standards,only 3dB of noise increase is allowed. 5. Information dissemination to local residents and shopowners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior tocommencement and kept updated as to changes in the management and mitigation plan. 6. Enclose especially noisy activities if above the noiselimits and employ transportable noise screens between noise sources and identified noise sensitive areas for theduration of noisy construction activities. 7. Monitoring required during construction, including field observations and measurements.	Contractor	GC/ CMRL
		Social	Incessant movement of trucks could create social issues. This will have higher occurrences near depots.	1. The local community has to be taken into confidence before the construction commences. Their advice must be taken and incorporated in decision making. 2. Grievance Redress Mechanism for affected people should function effectively with grievance log welldocumented.	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 onoccupational and community health and safety.	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
26.	Dumping of excavated materials	Air	The dumping operation of excavated material will generate fugitive dust in the nearby areas	1. Site of dumping shall be selected by Contractor inconsultation with CMRL and authorities. 2. The disposal plan will be stringently implemented withsite monitoring and inspections. 3. It will be located outside of urban habitation. 4. Sprinkling of water should be carried out.	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 shall be done in pre-designated low lying areas which are to be identified by Contractor in consultation with CMDA, TNPCB, and CMRL for thisspecific purpose. 2. The disposal plan will be stringently implemented with regular monitoring and inspections. 3. Field inspections, monitoring, and documentation of dumping excavated materials.	Contractor	GC/ CMRL
27.	Traffic diversion	Air	The under constructionareas will be restricted for human and vehicular movements. This will result in detouring of vehicles and/or pedestrians, on the project line which 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.	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. 2. Adaptive management with field inspections and monitoring during plan implementation and adjustments, as needed, to reflect actual traffic congestion or related issues 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.	Contractor	GC/ CMRL / Traffic Police

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		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 busyintersections, to oversee the smooth flow of traffic. 2. Detour route selection to avoid sensitive receptors tonoise. 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 (especially 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 separatearrangements for bus, auto and taxi parking bays will be made. Street furniture for pedestrians will be provided wherever possible. 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. 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 tendto reduce enhanced fuel consumption.	Contractor	GC/ CMRL
28.	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. 2. Grievance Redress Mechanism for affected people should function effectively with grievance log well documented.	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		Health & Safety	Movement thoughconstricted space may cause potential health & safety issues amongst pedestrians	1. Safe passage for pedestrians with proper fall protectionand signage will be planned.	Contractor	GC/ CMRL
29.	Muck generation & disposal (incl. spent Bentonite & drill fluid and slurry)	Surface water	Muck generated incl. spent Bentonite & slurry from 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. 2. The construction sites will be provided with garland drains with intercepting pits to trap silt & muck. 3. Muck will be stored in lined tanks / ponds (if such area is available). Or mechanically dewatered if such area is unavailable. After screening & detention, supernatant liquid from such tanks should be discharged intodrainage lines adhering to CPCB standards. Such tank/ ponds could be covered during monsoon to control runoff. 4. The temporary muck storage areas will be maintained by the Contractor at all times until the excavate is re-utilizedfor backfilling or disposed of as directed by Employer. Dust control activities will continue even during any work stoppage 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. 2. Groundwater quality monitoring.	Contractor	GC/ CMRL
		Aesthetics	Muck generation will create an aesthetic issue	1. The construction site will be covered from all sides toreduce visual impacts.	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
30.	Raft foundation	Soil	Construction of raft foundation will generate concrete spoils. This willhave adverse effects on soil	1. Concrete spoils will be collected manually and will bedisposed in proposed disposal grounds.	Contractor	GC/ CMRL
31.	Steel structure preparation	Soil	Steel structure preparation will create steel scraps	1. Steel scrap will be collected, sorted by diameter and soldto scrap dealers on later date.	Contractor	GC/ CMRL
		Health & safety	Bar bending & other activities (including Working at heights) might pose a H&S threat to workers	1. Workers will be provided appropriate hand gloves andpersonal protective equipment (PPE). 2. Skilled workers working at height or doing hot work willbe required to seek permission from site	Contractor	GC/ CMRL
32.	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 workerswill be implemented. 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 RMyard / construction area will be raised using GI sheets.	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
33.	RCC pouring (using concrete pump)	Noise	RCC pouring using concrete pump will generate low frequency rumbling noise. This will be more perceived and irritating in residential areas.	1. Timing of using RCC pumps will be specified. 2. RCC pumps will be covered from all sides. 3. Bends and excessive head will be avoided. 4. Wherever baseline noise already exceeds the standards,only 3dB of noise increase is allowed.	Contractor	GC/ CMRL
		Soil	Spillage from concrete pouring may contaminate soil	1. The spoils from pouring concrete will be collected andreused as sub-grade material in road constriction.	Contractor	GC/ CMRL
		Aesthetics	Spoils from concretepouring will createunpleasant 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
34.	Setting of concrete (using needle vibrator)	Noise	Needle vibrators generate low frequency noise when dipped in concrete and high frequency noise whenraised. Sound level vary 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. 2. Wherever baseline noise already exceeds the standards,only 3dB of noise increase is allowed per IFC/WB guideline.	Contractor	GC/ CMRL
		Soil	During setting, spillage from cast could take place.	1. The spoils from pouring concrete will be collected andreused as sub-grade material in road construction.	Contractor	GC/ CMRL
35.	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. Rainwater harvesting (as a compensatory measure) will be practiced.	Contractor	GC/ CMRL
		Groundwater	Curing water will drain to the low lying areas and pollute water courses	1. In view of low groundwater levels and proximity of seacoast, use of groundwater will not be resorted to.	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		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
36.	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[20] has found that the average daily noiseexposure was 145ignali. 84 to 99 dB (A) for heavyequipment, 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 reinforced2 m tall GI sheet barrier around the area where heavy construction works is undertaken. 2. Workers working inside or near construction equipment should be provided with proper PPEs like ear plugs / muffs complying with IS 4869. 3. Wherever baseline noise already exceeds the standards,only 3dB of noise increase is allowed. 4. Information dissemination to local residents and shopowners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior tocommencement and kept updated as to changes in the management and mitigation plan. 5. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for theduration 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 shouldbe 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 should take place before commencement of work.	Contractor	GC/ CMRL

[20] Legris, M., and P. Poulin: Noise exposure profile among heavy equipment operators, associated labourers and crane operators. Am. Ind. Hyg. Assoc. J, pp.774-778, 1998.

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
37.	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	1. Labour camps will be constructed in semi urban / urban set-ups. Thus, sewage and other discharges from the labour camps will be discharged in public sewers orseptic tanks should be provided where access to public sewers is not possible.	Contractor	GC/ CMRL
		Groundwater	Surface water on flat terrain could percolate and contaminate groundwater.	1. Contractor to collect the groundwater baseline date priorto construction. 2. Disposal in compliance with applicable regulatoryrequirements. 3. Groundwater quality monitoring. 4. Water abstracted must be measured/ recorded periodically. 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. 2. Municipal solid waste will be collected and taken away and disposed by municipality. 3. Solid waste will have to be disposed in compliance with Municipal Solid Waste (Management & Handling) Rules, 2000, as amended to date. 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. 2. To avoid labor influx risk, sensitizing of local community and the non-local workers separately as well as jointlywill be done regularly.	Contractor	GC/ CMRL
		Health & safety	Living in congestedcondition, 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. 2. Per Building & Other Construction Workers (BOCW	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				Regulation of Employment and Conditions of Service) Act, 1996 the employer (contractor) is liable to arrange for sanitation, health care facilities of labours, free of charge. Labour camps will be in full compliance of BOCW Act.		
		Resources	Labours will consume resources like wood for cooking	1. Liquid petroleum Gas cylinders will be made availablefree of cost to the labourers by the Contractor. 2. Labour camps shall be provided with canteen facility.	Contractor	GC/ CMRL
38.	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. 2. The trucks/dumpers carrying the material will be covered using tarpaulin/similar covering materials. 3. Fugitive dust could be controlled using water sprinkling. Contractors should carry out water sprinkling. 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.	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. 2. Concrete preparation will only take place in casting yards (away from habitation). 3. Wherever baseline noise already exceeds the standards, only 3dB(A) of noise increase is allowed.. 4. Information dissemination to local residents and shopowners 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

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				5. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for theduration of noisy construction activities.		
		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
39.	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. 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
		Noise	Operation of batching plant will generate noise	1. GI sheet barricading around batching area and worker PPE like ear muffs will be used. 2. Batching plant / casting yard shall be barricaded and made as a compulsory PPE zone. This will reduce the impacts of noise generation. 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. 2. Municipal water will be used. In view of fragile groundwater status, extraction will be avoided. 3. The construction sites will be provided with drains with intercepting pits in which the cement and sand will settle. After screening & detention, liquid will be discharged into	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				drainage lines. Disposal in compliance with applicable regulatory requirements. 4. Soil and Groundwater quality monitoring. 5. After Construction, Contractor will conduct soil and groundwater analysis and be obliged to reinstate theused sites no worse than the conditions of pre-construction.		
		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 TNPCBrequirements. 2. The transport, handling and storage of hazardous waste will be done in accordance with the provisions of Hazardous Chemicals (Management & Handling) Rules. 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. 3. The contractor shall maintain a record of sale, transfer, storage of hazardous waste and make these recordsavailable for inspection. 4. The contractor shall get Authorized Recyclers to transport and dispose Hazardous Waste. 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. (A 30 m^3/hr. batching plant will require 150 ignali. 60 KW/hr. (or, 150 ignali. 75 KVA, assuming PF = 0.8) energy. In most cases the Contractor has used DGsets (from 100 – 250 kVA) for batching plant & ancillary facilities. Thus, the diesel req. will range from 30 – 45L/hr, at 100% load)	1. If power from the grid is used, permission from power supply company must be obtained by the Contractor. 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). 3. The required permissions from local Environmental Authorities/Pollution Control Board/ CEIG or any other relevant Authority shall be obtained by the Contractor forusing DG sets for power supply. 4. Diesel storage if done beyond threshold limit (1000 L) permission should be obtained. Diesel should be stored on pukka platforms and spillages should be avoided. 5. Refer to Activity 42 “Use of DG sets” and Activity 44 “Storage of Diesel” for further measures.	Contractor	GC/ CMRL
40.	Casting of segments and I-beams	Groundwater	Casting will require use of water	1. Chennai Metropolitan Water Supply and Sewerage Board /Municipal water will be used. In view of fragile groundwater status, extraction will be avoided. 2. The construction sites will be provided with drains with intercepting pits in which the cement and sand will settle. After screening & detention, liquid will be discharged intodrainage lines. Disposal in compliance with applicable regulatory requirements. 3. 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, most of the power should be drawn from approved lines, not from DG sets.	Contractor	GC/ CMRL
41.	Curing of segments & I-beams	Groundwater	Curing will require asignificant amount of water	1. Wastages from curing could be collected separately and reused if possible. Stagnation of water (and resultant vector propagation) should be avoided. 2. Groundwater quality monitoring. 3. Disposal in compliance with applicable regulatory	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				requirements 4. Groundwater will not be used. Water will be sourcedfrom municipal supply or treated effluent from ETPs or treated surface runoff.		
42.	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. 2. The trucks/dumpers carrying the excavated material willbe covered using tarpaulin/similar covering materials. 3. Sprinkling of water should be carried out. 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. 5. Haul roads will be kept in good state of maintenance.	Contractor	GC/ CMRL
		Noise	Trucks carrying segmentswill 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 impactson noise level. The route selection will avoid any sensitive receptors. 2. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures. 3. Wherever baseline noise already exceeds the standards,only 3dB of noise increase is allowed.. 4. Information dissemination to local residents and shopowners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior tocommencement and kept updated as to changes in the management and mitigation plan. 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	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				duration of noisy construction activities. 6. Monitoring required during construction, including fieldobservations and measurements.		
		Social	Incessant movement of trucks could create social issues	1. The local community has to be taken into confidence. Their advice has to be taken and incorporated in decision making.	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 willcreate an aesthetic problem	1. Proper housekeeping activities have to be undertakennear the casting yard and nearby areas.	Contractor	GC/ CMRL
43.	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. 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. 3. Stack height of DG sets will be as per CPCB requirement [stack ht. = 0.2*(rating in kVA)0.5] 4. Stack monitoring will be conducted monthly of the criteriapollutants. 5. Compliance monitoring will be done to the regularly and check the monitoring instruments. 6. Fuels used for DG will be High Speed Diesel with low- sulfur content.	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		Noise & Vibration	Noise & vibration will be generated from the use ofDG sets	1. DG sets compliant with CPCB norms will be used. 2. Wherever baseline noise already exceeds the standards,only 3dB of noise increase is allowed.. 3. Monitoring required during construction, including field observations and measurements. 4. DG sets will be enclosed type, with noise level approx. 75dB (A) at a distance of 1m in compliance with GSR371(E) dt. 17-05-2002. 5. Noise will be controlled using acoustic enclosure. 6. The DG sets will be mounted on damping skids, which will reduce the vibration generated from DG sets.	Contractor	GC/ CMRL
		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. 2. Refer to Activity 44 “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. 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
44.	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&Dwaste and records of waste loaded by vendors. 2. C&D waste will be reused/recycled as it has the potentialto save natural resources (stone, river sand, soil etc.) and energy. C&D waste generated from metro construction has potential use after processing and grading. 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. 4. Contractor will adhere with the C&D Waste Management	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				Rules.		
		Occupational Health and Safety	Accidents 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. 2. For underground construction, it is very important to conduct a fatigue assessment and to specify the numberand length of shifts for each worker. Oversight of project safety is needed to ensure that tunneling is completed in suitable soil and drainage conditions and with propersupport and lining of excavated sections to avoid collapse. Apart from the stringent inspection, tunnels have to be properly lit, drained, and ventilated to provide visibility, dry working conditions, and breathable air free of dust even in confined spaces. 3. 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 least85 dB(A).	Contractor	GC/ CMRL
45.	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 asbentonite to remove the diesel. The diesel will be quickly collected into steel trays and disposed to authorized recyclers. 2. All bulk diesel tanks shall be properly supported in an elevated position to facilitate gravity discharge. They	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				shall stand within a bund constructed to contain a volume of 110% of the volume of the tank. There shallbe 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. 3. Spillage will be controlled using methods mentioned in the environmental contingency plan. 4. Groundwater quality monitoring.		
		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. 2. If the diesel storage crosses the threshold limits permissions, proper fire protection norms have to beundertaken as per National Building Code, 2005 (if building)/ Oil Industry Safety Directorate Standard 117 (ifinstallation).	Contractor	GC/ CMRL
46.	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 foundationor other permanent works shall be refilled with earth up to surface of surrounding ground.	Contractor	GC/ CMRL
47.	Construction of Grade Separator	Air	Emission of NO_x, SO_x, CO, PM_{10}, $PM_{2.5}$ from Vehicles due traffic stagnation will create air pollution problems. Fugitive dust emission due to construction activities such as handling of excavate/subgrade /gravel for construction of ramps etc.	1. Traffic management plan will be devised in consultation with Chennai Traffic Police. 2. Traffic diversions will be done to reduce the stagnation of vehicles. Prior permissions will be obtained from the concerned traffic department for diversions. 3. Traffic marshals will be deployed at the critical traffic intersections to aid the better flow of traffic. 4. Green cover will be created in the center median and the roadsides. 5. The trucks/dumpers carrying the excavated material will be covered using tarpaulin/similar covering materials. 6. Sprinkling of water should be carried out. 7. 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 a facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt. Used water shall be collected, subject to precipitation and re-used.	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				8. Water for sprinkling and tire washing will be sourced from surface runoff, wastewater from construction sites, construction yards and seawater; use of municipal treated water shall be minimized. Groundwater will not be used in view of status in Chennai. Access roads will be kept in good state of maintenance.		
		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 residential / urban areas.	1. The routing, timing and logistics of the haul truck movement should be planned to have minimal impacts on noise level. 2. The route selection will avoid any sensitive receptors. 3. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures. 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 construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards. 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. 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. Monitoring required during construction, including field observations and measurements.	Contractor	GC/ CMRL
		Resource	Increase in requirement of construction raw materials such as aggregates, gravel, cement, water etc.	1. The construction raw materials will be procured from TNPCB authorized vendors. 2. Reuse of construction materials will be encouraged wherever possible. 3. Sustainable and eco-friendly products will be preferred. 4. Ground water extraction for construction use will be avoided. The municipal treated water will be procured from the CMWSSB for construction use.	Contractor	GC/ CMRL

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
Operational Phase						
47.	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. 2. In addition to the above mitigation measures, the roughness of running surfaces will be reduced through regular maintenance of wheels and tracks and will be considered for replacing traditional jointed track with continuously welded rail. Also, noise controls at the source will be installed for improved sound-proofing and other noise reducing features will be installed such as engine enclosures and shielding of wheels with vehicle-mounted shrouds. 3. Considering that the train generate a rolling noise ofapprox. 85 dB(A) at a ht. of approx. 8-12 m, the additional noise level will be approx. 55 - 60 dB(A) at a ht. of 1.5 m on ground. The noise level will be further reduced due to directivity, and conversion of frictional energy. The noise level at the bottom of the line will be insignificant and could be marginally different from ambient (traffic) noise. Since the rakes will be air conditioned and enclosed from all side, the impacts of noise on the travelers will be nominal. 4. Noise barriers will be installed at locations based on finaldesign noise prediction analysis. 5. 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 meet these standards that is, construction noise level has to be less than level prescribed in these standards. 6. The mitigations suggested based on the detailed noise and vibration analysis carried out prior to commencement of construction, should be strictly followed.	CMRL	GoTN
		Health and Safety	Accidents 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. 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. 3. A standby silent type DG set of adequate capacity at underground	CMRL	GoTN

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				stations will sustain the following: essential lighting, signaling, and telecommunications, fire-fighting system, lift operation, and tunnel ventilation. 4. Automatic Train Protection and Automatic TrainSupervision sub-systems will be installed to provide a high level of safety. 5. CCTV system will be installed for local and centralized monitor of operation. 6. 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. 7. Emergency team, ambulance, contact number andhospital should be available. Emergency response plan should be implemented during operation periods.		

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
			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. 2. Well designed workstations, lighting in Control Centre. 3. Emotional resilience training, counselling for recovery and rehabilitation	CMRL	GoTN
			Severely contagious diseases such as Covid can impact health of staff thereby affecting operations; can cause economic loss to the country and loss of reputation to the project	1. Chennai Metro Covid 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 shall be provided in stations; site record of covid 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	1. A proper housekeeping routine will be followed toenhance the aesthetics of metro rail station & depot.	CMRL	GoTN
48.	Maintenance of trains in Depot	Resources	Train washing will consume water and energy	1. To save water resource, rainwater harvesting structures will be constructed at Depot to receive runoff from sloping roof of the depot as well as recharge of ground water in uncovered land area. 2. Rooftop solar panels on covered part of depots are proposed. As per Ministry of renewable Energy template,5% of rooftop area of depot can generate 3.51 lakh kWh per year in Poonamallee Bypass depot. 3. DG sets will be used as a standby power. If used, referto Activity 50 “Use of DG sets” for further measures.	CMRL	GoTN

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		Surface /ground water Soil contamination	The wastewater discharges from workshops will have high oil & grease, high COD & TSS content	1. No direct discharge to the municipal sewer system, the Sewage Treatment Plant (STP) and Effluent Treatment Plant (ETP) are planned at Depot. 2. The wastewater will be pretreated to meet regulatoryrequirements before being disposed in municipal sewer system. 3. Sewage will be generated from depot which could be treated in compliance with TNPCB regulations up to the level so that it could be used for horticulture and non-drinking purposes in the Depot. 4. Oil spilled in Depot should be trapped in oil and grease trap and disposed to authorized collectors so as to avoid any underground/ surface water contamination. Oil that is mixed in water shall be removed in the ETP. 5. The solid waste generated from the Depot will be taken by the cleaning contractor weekly and disposed to the municipal waste disposal sites.	CMRL	GoTN
49.	Track repair	Environment	Spill accidents	1. CMRL to ensure no illegal disposal of solid waste or wastewater.	CMRL	GoTN
50.	Use of DG sets	Air	Emission from DG sets will create air pollution problems	1. DG sets compliant with CPCB norms will be used.	CMRL	GoTN
		Noise	Noise & vibration will be generated from the use ofDG sets	1. DG sets compliant with CPCB norms will be used. 2. Noise enclosures will be used. 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 construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards.	CMRL	GoTN
		Groundwater	Diesel spillage (from underground or above ground storage facility) will affect groundwater quality adversely	1. Diesel should be stored in designated sites prior to final relocation. 2. Oil that is mixed in water will be removed in the ETP.	CMRL	GoTN
		Health & safety	Storage of Diesel will attract the provisions of Hazardous	1. Diesel should be stored in designated sites prior to finaldisposal.	CMRL	GoTN

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
			Chemicals (Management & Handling) Rules and Petroleum Rules; as amended to date. It could cause serious damage to health & safety of workers / property if ignited	2. Fire fighter is equipped at storage site. 3. Proper onsite emergency plan will be prepared by GCand will be approved through CMRL.		
		Resources	DG sets will consume Diesel (and in effect reduce the levels of a non- renewable resource)	1. DG sets compliant with CPCB norms will be used onlyas backup.	CMRL	GoTN
		Aesthetics	Operation of DG sets will cause an aesthetic issue	1. Enclosures will be used.	CMRL	GoTN
51.	Developmentof feeder routes CMRL	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 routesto 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

Sl. No.	Activity	Aspect / Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		Aesthetics	Better designed coaches will enhance ride pleasure and aesthetics	1. The buses should be properly maintained from time totime in order to enhance the aesthetic value.	CMRL	GoTN
52.	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
53.	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. 2. Implementation of increased densities is decided by State Government and managed by CMDA inaccordance 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
54.	**Operation of Integrated Grade separator in Kattupakkam**	Traffic	Reduced Congestion: Grade separators, such as overpasses or underpasses, help separate conflicting streams of traffic, reducing congestion at intersections. Smooth Traffic Flow: With the elimination of traffic signals and intersections, vehicles can move more smoothly through the area, leading to improved travel times.	1. Robust traffic management plans consistent with the Indian Roads Congress (IRC) on Traffic Management in work zones (IRC:SP:55-2014), prior to mobilization for respective sections with site- or station-specific plans and measures to minimize the overall impact on traffic throughout the construction and operation periods. 2. All necessary provisions as per standards shall be ensured.	TamilnaduHighways dept (TNHD)	TamilnaduHighways dept(TNHD)
		Air	Reduction of Fugitive emissions (Carbon Monoxide) from Vehicles due to traffic decongestion	1. Fugitive dust could be controlled using water sprinkling. Water sprinkling to be carried out at regular interval . 2. Ambient Air Quality monitoring shall be carried out near by work area. 3. Green nets or cover shall be provided	TamilnaduHighways dept (TNHD)	TamilnaduHighways dept(TNHD)
		Noise	Noise from the vehicle	1. All necessary provisions as per standards shall be ensured. 2. Provision of Noise barriers wherever necessary.	TamilnaduHighways dept (TNHD)	TamilnaduHighways dept(TNHD)

		Aesthetics	Better designed grade separators can integrate into the urban landscape, contributing to aesthetically pleasing and well-planned cityscapes.	1. Thoughtful designed grade separator will enhance the aesthetic value.	CMRL	GoTN

Table 9.4: Environmental Monitoring Plan

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 $PM_{2.5}$ and PM_{10}, NO_x and SO_x, CO	GoI and WHO/IFC whichever stringent	Once, 24 hours continuously	Each station, batching plant and casting yard, Muck disposal site	4,667
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 30 excavation sites Surface water at wherever waterbody located within 100m from sites	11,400
Soil	pH, Sulphate (SO_3), Chloride, ORP, water Soluble salts EC, Organic Matter (Oil), 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, Muckdisposal site, construction camps and 30 excavation sites	11,100

Environmental Features	Aspect to be Monitored	Standard to be complied with	Time and Frequency of Monitoring	Location	Estimated cost (USD)
Noise, vibration b) Building condition survey	Noise levels in dB(A) Vibration PPV mm/s Building condition survey	GoI and WHO/IFC whichever stringent FTA Guideline Standards or any other internally recognized standards	a) Once Hourly basis for 24 hours (noise and vibration) b) Vibration: Once, X, Y and Z axis with a high accuracy triaxial sensor. Frequency range from 1to 315Hz. Hourly basis for24 hours b) Building Condition Survey: height	a) At key structure locations b) Key sections of line	a) 6,800 b) 178,091

Environmental Features	Aspect to be Monitored	Standard to be complied with	Time and Frequency of Monitoring	Location	Estimated cost (USD)
			measurements, crack survey, detailed photographic records etc.		
Sub-total					212,058
Construction stage					
Air	Emission of dust and particulate matter as $PM_{2.5}$ and PM_{10}, NO_x and SO_x,CO	GoI and WHO/IFC whichever stringent	24 hours continuously every month	For each station until civil works completed batching plant and casting yard, Muck disposal site throughout construction phase	163,200
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 Surface water at wherever waterbody located within 100m from sites	132,000
Soil	PH, Sulphate (SO_3), Chloride, ORP, water Soluble salts EC, Organic Matter (Oil), Heavy metals, PAH, Moisture Content	GoI and WHO/IFC whichever stringent	Quarterly, 3 samples each location	At batching plant and casting yard, Muckdisposal site, construction camps throughout construction phase 30 excavation sites-once during construction, once post-construction	30,000

Environmental Features	Aspect to be Monitored	Standard to be complied with	Time and Frequency of Monitoring	Location	Estimated cost (USD)
Noise, and Vibration Subsidence	a) Noise levels in dB(A) b) Vibration PPV mm/s c) Deformation monitoring	GoI and WHO/IFC whichever stringent FTA Guideline Standards or any other internally recognized standards	a) Monthly or when complaint is received Hourly basis for 24 hrs (noise) b) Continuous monitoring when the TBM is within 10meters from the structure (vibration) c) Subsidence: building conditions, crack sensors, tilt sensors, continuous height measurement etc.	At key structure locations	a) and b)12,960 c) To be included by Construction contractor in his bid
Occupational and Community Health and Safety	As specified in project ESHS plan prepared by Contractor 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					338,160
Operation Stage					
Air	Emission from DG sets (PM_{10}, $PM_{2.5}NO_x$ and SO_x), Odor	GoI and WHO/IFC whichever stringent	At least 2 times in a year for the first year, annually for another 2 years	Ventilations of UG Stations, DG sets of all stations and Depot	16,533
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 and depot	12,400
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, Depot	3,733
Vibration	PPV mm/s	FTA Guideline Standards or any other internally recognized	At least 2 times in a years for the first year, annually for another 2 years	At key structure locations	16,000

Environmental Features	Aspect to be Monitored	Standard to be complied with	Time and Frequency of Monitoring	Location	Estimated cost (USD)
		standards			
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 and Depot	20,000 *
Sub-total					68,666
Grand total					**618,884**

During construction:
Noise: 2 construction yards on Bypass and Santhome Basilica and 4 locations between Saraswathi school to Government Hospital;
Vibration: 3 receptors from underground section namely St Thomas Basilica, Rosary Church and Our Lady of Light Shrine which are all heritage structures;and Baseline Building Condition Survey from Foreshore Estate station to Thirumayilai station and Bharathidasan Road station to Panagal Park station.
During operation:
Occupational Health and Safety safeguards during operation are not spelt out in the SHE document. Based on experience on other railways, health issues relevant to Chennai metro can be as follows: a) Musculo-skeletal disorders and fatigue, eye strain due to Display Screens impacting drivers, train controllers and ticketing staff: Well-designed workstations, lighting, posture advice and regular health checkups. b) Stress impacting drivers and Train controllers: Risk assessment, changes to job design, task allocation, training, and supervision; emotional resilience training; counselling for recovery and rehabilitation.
**** Lumpsum provision Group Insurance premium excluding surgeries and loss of life or limb: Rs five lakh per year***

9.6 Emergency Preparedness and Response System

299. 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: Damage to one of the utilities water supply, sewage,	Community In case of live gas lines, the	• The potential for disruption of utilities during line construction is low as long as proper pre-dig verification procedures are followed. Disruption could range	➢ For gas utilities • Fire engines to dispense water and foam • Portable	Notification: Contractor to CMRL and utility agency CMRL to utility agency	• Mock drills • Use of extinguishers, fire suits, breathing	• Utility location and diversion plans • Record sheet showing type, size and identification number of

Emergency Situations	Community or individuals impacted	Response procedure	Equipment and resources	Responsibilities	Training need	Accident and emergency records
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 Damage while additional geotechnical investigations are in progress or during pile driving/in-situ casting.	project workforce could also be impacted	from cable or phone outage to customers, to explosion in gas line with potential risk to human health and life. • Contact utility to clear utility related safety hazard (like deactivating the utility). • Seek assistance of the utility to assess damage • Coordinate with un-impacted utilities. • Vital services and infrastructure recovery activities.	extinguishers • Fire protection suits • Breathing apparatus, helmets, goggles and face shield, first aid kits, stretchers, torches, ladders, emergency lighting on standby power ➢ For water and sewage utilities • Quick water sealants	Remedial Action by: utility agency	apparatus, first aid kits, water sealants	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 • Geotagged photographs with date
Ground subsidence due to unanticipated degree of groundwater drawdown	Community	The base document availablewith the ER Team shows the location of structures which are atrisk of subsidence as assessed atstart of construction. In the event of subsidence, move occupants of structures affected as well as those in their proximity to safer locations. Arrange for their temporary relocation till the structures are rehabilitated.	• Helmets, first aid kits, stretchers, torches, ladders, emergency lighting on standby power, tents	Notification: Contractor to CMRL Remedial Action by: Contractor	• Mock drills • Use of first aid kits	• Plan showing location of construction site and affected structures • Groundwater drawdown records from borewells • Vibration records • Record sheet showing type, size and identification number of structure, time of occurrence, type of equipment in use
Ground subsidence under existing structures during tunneling due to unanticipated weak pockets of substratum	Community			Notification: Contractor to CMRL Remedial Action by: Contractor		

Emergency Situations	Community or individuals impacted	Response procedure	Equipment and resources	Responsibilities	Training need	Accident and emergency records
						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 • Geotagged photographs with date
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. 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 atthose locations.* Arrange for their temporary relocation till the structures are rehabilitated. • 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. Arrange for their temporary relocation till the structures are rehabilitated.		Notification: Contractor to CMRL Remedial Action by: Contractor	• Mock drills	
Premature activation of blasting, collapse	Project workforce			Notification: Contractor to CMRL	• Mock drills • Air quality	• 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
of weak rock strata				Remedial Action by: Contractor	monitoring • First Aid • Use of Breathing apparatus, fire suit • Water seal • Evacuation • Search and Rescue	type and configurationof explosive, number of personnel present and evacuated • Geotagged photographs with date
Fire and explosion of flammable gases, flooding during underground works	Project workforce	• The source of fire and explosions could be fuel stored underground or gas pockets. Use fire water and foam to combat fires of oil. Immediately cool the construction equipment and any gas containers to avoid explosion. • Headcount • Search and Rescue • Administer first aid • Gas monitoring • Block tunnel to prevent unauthorized personnel from entering the tunnel to facilitate rescue and reduce exposure to secondary explosions. • Lay ventilation ducts and send fresh air to reduce gas concentration. • Grouting, foam injection for gassy outburst and water inflow.	• Emergency Lighting on standby Power • Emergency Equipment and Rescue Equipment • Breathing apparatus • Gas detector • Fire Proximity suit • First Aid Kit • Stretchers • Torches and • Ladders • Ambulance • Standby non-sparking ventilation fans to evacuate gases and smoke from the underground works. • Standby high power pumps to evacuate flood water from the underground works	Notification: Contractor to CMRL and Fire Department, Police, hospitals and Tamil Nadu Pollution Control Board Remedial Action by: Contractor		• Plan of construction yards and sites showing designated men assembly areas, Emergency Vehicle parking areas androads • Air and gas sample test reports • Record sheet showing location and time of occurrence, number of personnel present and evacuated • Geotagged photographs with date

Emergency Situations	Community or individuals impacted	Response procedure	Equipment and resources	Responsibilities	Training need	Accident and emergency records
			• Quick water sealants • Safety Equipment • Gum Boots • Safety Helmets • Rubber Hand Gloves • Goggles and face shield • Wind Direction Indicator • Ropes and harnesses ➢ Depending on the number of workers underground, one or two rescue teams – one at jobsite and one near the site.			
Fire accidents at electric installations, fuel storage and fueling facilities	Community and project workforce	• Transformer or Substation fire requires equipment be de-energised. • Use fire water and foam to combat fires of oil. • Immediately cool theequipment and any containers to avoid explosion. • Follow designated standoff distance and stand down period. • Administer first aid	• Fire engines to dispense waterand foam • Portable extinguishers • Fire protection suits • Breathing apparatus, helmets, goggles and face shield,	Notification: Contractor to CMRL and Fire Department, Police, hospitals and Tamil Nadu Pollution Control Board Remedial Action by: Contractor	• Mock drills • First Aid • Use of fire extinguishers, fire suits, breathing apparatus • Evacuation • Search and Rescue	• Fuel and vapour sample test reports • Maintenance reports of electric and fuel installations • Record sheet showing location and time of occurrence, number of personnel present and evacuated • Geotagged

Emergency Situations	Community or individuals impacted	Response procedure	Equipment and resources	Responsibilities	Training need	Accident and emergency records
			first aid kits, stretchers, torches, ladders, Emergency lighting on standby power			photographs with date
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. • Control the leak/flow • 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 • CMRL to Traffic Police and Tamil Nadu Pollution Control Board. Remedial Action by: Contractor	• Mock drills • First Aid • Use of fire extinguishers, fire suits, breathing apparatus	• Waste identification report • Record sheet showing location and time of occurrence, number of personnel present and evacuated • Geotagged photographs with date
Air pollution due to leakage and fire of flammable gases from 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. • Use fire water	• Fire engines to dispense waterand foam • Portable extinguishers • Fire protection suits • Breathing apparatus, gas detectors, helmets, goggles and face shield, first aid kits, stretchers, torches, ladders, Emergency lighting on standby power	Notification: Contractor to CMRL and Fire Department CMRL to Tamil Nadu Pollution Control Board Remedial Action by: Contractor	• Mock drills	• Gas sample test reports • Record sheet showing location and time of occurrence, number of personnel present and evacuated • Geotagged photographs with date
Failed launching of pre-cast girders or	Community and project	• Administer first aid • Organise lifting equipment and	• Lifting equipment and gas	Notification: Contractor to CMRL	• Mock drills • First Aid	• Structural drawings of failed elements

Emergency Situations	Community or individuals impacted	Response procedure	Equipment and resources	Responsibilities	Training need	Accident and emergency records
segments	workforce	gas cutters • 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.	cutters • First aid kits, stretchers, torches, ladders, emergency lighting on standby power	CMRL to Police and district labour Commissioner Remedial Action by: Contractor	• Search and Rescue	• Record sheet showing location and time of occurrence, type of lifting equipment used, number of personnel present and evacuated • 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 • First Aid	• Structural drawings of failed temporary works • Record sheet showing location and time of occurrence, number of personnel affected • Geotagged photographs with date
Health and safety impacts due to failure of ventilation in underground station	Metro Passengers and employees	• Notify Operational Control Centre (OCC) and suspend boarding and alighting in affected station; let trains pass through. • Administer first aid • Close entry of passengers into affected stations • Evacuate passengers.	• Standby non-sparking ventilation fans to ventilate • Breathing apparatus for vulnerable passengers • Maintenance equipment, spares and personnel	Notification: CMRL to Emergency Action Committee Remedial Action by: CMRL	• Mock drills • First Aid • Use of breathing apparatus • Evacuation	• Ventilation system readings • Ventilation system maintenance reports • Record sheet showing location and time of occurrence, number of persons affected • Geotagged photographs with date
Service disruption and unplanned congestion due to failure of platform	Metro Passengers	• As soon as duration of failure approaches disruption period allowed in station design, notify OCC and suspend boarding and	Maintenance equipment, spares and personnel	Notification: CMRL to Emergency Action Committee	• Mock drills	• PSD and rolling stock usage log • PSD and rolling stock maintenance

Emergency Situations	Community or individuals impacted	Response procedure	Equipment and resources	Responsibilities	Training need	Accident and emergency records
screen doors or rolling stock doors		alighting at affected station • close entry of passengers into affected stations • Trains arriving in affected duration will pass without stopping • Affected trains will passthrough to maintenance depot for attention		Remedial Action by: CMRL		reports • Record sheet showing location and time of occurrence, number of services affected • 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. • In case of signalling failure, stop affected trains at nearest station. • Suspend operation of trains bound to pass through affected stations or section; stop trains at stations outside affected section • Close entry of passengers into affected stations	Maintenance equipment, spares and personnel	Notification: CMRL to Emergency Action Committee Remedial Action by: CMRL	• Mock drills	• TPS and S&T log • TPS and S&T maintenance reports • Record sheet showing location and time of occurrence, number of services affected • Geotagged photographs with date
Unplanned congestion in stations due to failure of general power through grid supply for lighting, communication etc	Metro Passengers	• As soon as standby supply is activated, notify OCC and suspend boarding and alighting in affected station; let trains pass through. • Close entry of passengers into affected stations • Switch on battery-powered high-power lamps which have been fixed to stations structure • Use portable hailers to address passengers and employees • Use portable lamps to locate	• Handheld 2 way radios and hailing loudspeakers • Portable handheld lamps • Maintenance equipment, spares and personnel	Notification: CMRL to Emergency Action Committee Remedial Action by: CMRL	• Mock drills	• Standby system maintenance reports • Record sheet showing location and time of occurrence • Geotagged photographs with date

Emergency Situations	Community or individuals impacted	Response procedure	Equipment and resources	Responsibilities	Training need	Accident and emergency records
		and evacuate passengers and employees.				
Fire in underground section		• In case of manual or semi-automatic ventilation systems, operator to activate ventilation upon detection of fire In case of fire in station: • Suspend operation of trains bound to pass through affected stations or section: stop trains at stations upstream and downstream of affected station. • Render First Aid • Close entry of passengers into affected station In case of fire in train: • Drive the train on fire to the platform of the next station without stopping at intermediate sections to evacuate the passengers and carry out fire-fighting activities there. • Once notified by the driver of the train on fire, the OCC will direct the train in front of the train on fire to proceed to the next station and the train running behind the train on fire to stop. Trains running on the opposite track will also be directed not to access or stop at the station where the train on fire arrives. • If the train on fire stops at the station or the station is burning,	• Fire protection suits • Breathing apparatus, gas detectors, helmets, goggles and face shield, first aid kits, stretchers, torches, ladders		• Mock drills • First Aid • Use of fire suits, breathing apparatus • Evacuation • Search and Rescue	• Record sheet showing location and time of occurrence, number of services affected • Geotagged photographs with date

Emergency Situations	Community or individuals impacted	Response procedure	Equipment and resources	Responsibilities	Training need	Accident and emergency records
		the train dispatcher shall direct other trains not to approach this station. • In case evacuation becomes necessary while train is in tunnel, passengers will be asked to exit through side doors onto the inspection gallery in the tunnel.				
Flooding of underground stations due to unanticipated sea level rise or failure of pumping equipment	Metro Passengers	• At times of extreme sea level rise based on alerts from meteorological department, deploy trained rescue teams at vulnerable stations • As soon as flooding is imminent, notify Operation Control Centre to suspend operation of trains bound to pass through affected stations or section; stop trains at stations outside affected section • Administer first aid • Notify nearby hospitals for ambulances • Evacuate trains which have been stopped • Close entry of passengers into affected stations • Switch on battery-powered high-power lamps which have been fixed to stations structure • Disconnect grid and standby DG power supply with turnstiles in default open mode. • Use portable hailers to address	• Trained rescue teams at vulnerable stations • Inflatable life jackets • Portable lamps and hailers • 2 way radios • Battery-powered high-power lamps fixed to station structure	Notification: CMRL to Emergency Action Committee, Police, State Government Remedial Action by: CMRL	• Mock drills • First Aid • Use of breathing apparatus, life jackets • Evacuation • Search and Rescue	• Maintenance records of pumps • Record sheet showing location and time of occurrence, number of services affected • Geotagged photographs with date

Emergency Situations	Community or individuals impacted	Response procedure	Equipment and resources	Responsibilities	Training need	Accident and emergency records
		passengers and employees • Use portable lamps to locate and evacuate passengers and employees.				
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 • Administer first aid • Notify nearby hospitals for ambulances and to standby • Evacuate trains which have been stopped • Close entry of passengers into affected stations • Switch on battery-powered high-power lamps which have been fixed to station structure • Disconnect grid and standby DG power supply with turnstiles in default open mode. • Use portable hailers to address passengers and employees • Use portable lamps to locate and evacuate passengers and employees.	• Trained rescue teams • Emergency battery fixed lighting • Hand torches • First Aid Kits • Safety helmets • Ropes and safety harnesses • Stretchers • Ladders • Ambulance • Rail-cum-road Vehicles	Notification: CMRL to Emergency Action Committee, hospitals, Police, State Government, Commissioner Metro Rail Safety (CMRS) * Remedial Action by: CMRL	• Mock drills • First Aid • Evacuation • Search and Rescue	• Magnitude and epicenter of earthquake • Seismic design adopted in design of structures • Record sheet showing location and time of occurrence, number of persons affected • Geotagged photographs with date
Unplanned congestion in stations due to terrorism or sabotage or law and order	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	• First Aid Kits • Stretchers • Ambulance	Notification: CMRL to Emergency Action Committee, hospitals, Police, State Government		• Record sheet showing location and time of occurrence, number of persons affected

Emergency Situations	Community or individuals impacted	Response procedure	Equipment and resources	Responsibilities	Training need	Accident and emergency records
situations on Metro project or outside Metro project		section • Administer first aid • Notify nearby hospitals for ambulances and to standby • Evacuate trains which have been stopped • Close entry of passengers into affected stations .		Remedial Action by: CMRL		• 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* Remedial Action by: CMRL	• Mock drills • First Aid • Evacuation • 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 • Administer first aid • Notify nearby hospitals for ambulance and to standby	• First Aid Kits • Stretchers • Ambulance	CMRL to Emergency Action Committee, hospitals, Police, State Government, CMRS* Remedial Action by: CMRL	• Mock drills • First Aid • Evacuation	

***** *Metro Railway (Operations and Maintenance) Act, 2002 requires reporting of a) collision or derailment of trains or b) accidents attended orusually attended by loss of life or grievous hurt*

9.7 Training and Capacity Building Programs

300. 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.

301. 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, labour 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 agenciès.

9.8 Environmental Management Budget and Resources

302. 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*

Sl. No.	Item/Particular	Cost (INR million)
1	Rainwater Harvesting for operation on elevated section and depot	44.841
2	Noise barriers for operation on elevated sections including sensitive receptors and residential areas	374.592
3	Air, Noise, vibration, Water, Soil monitoring during construction and operation *	46.416
4	Environment Division	9.780
5	Tree Plantation	10.130
6	Sewage Treatment Plant for operation	3.379
7	Effluent Treatment Plant for operation	4.500
8	Training and capacity building	5.594
9	Rooftop Solar Plant on stations and depot	84.397
10	Covid measures	30.000
	Total	**613.629 (USD 8.25 million)**

***** *Does not include cost of monitoring of building condition survey during construction and ecological monitoring. The Noise barriers will be part of civil work cost. Adequate budget for tree transplantation and mitigation measures other than those in Table 9-5 will be allotted by CMRL*

**Noise modelling report recommends the provision of barriers at sensitive receptors, although noise forecast at sample locations for operation is not more than 3 dBA above baseline levels. As these receptors are located all along the elevated section, budgetary provision has been estimated here for the entire elevated length.*

SN.	Misc. Utilities, road works, Topographic Surveys, Geotechnical Investigations, Barrricading, Tree Cutting and replanting, other civil works such as signages, Environmental protection and traffic management	Unit	Rate	Quantity	Cost (INR million) without taxes
1.	Civil works	R.km	4.68	27.085	126.69
2.	Electrical works	R.km	3.69	27.085	100.06
Sub Total					226.75

Source: DPR-Phase II

10. CONCLUSION AND RECOMMENDATION

303. The alignment of the proposed Chennai Metro Corridor 4 and depot area are carefully selected to avoid most of the sites having historical/cultural significance. Three religious structures/ churches shall have vibration impact, however appropriate management measures have been given in the EMP for mitigating the same. Some impacts are anticipated due to cutting of about 707 along the project alignment and 187 trees at Poonamalle depot /361 trees were translocated and 42 nos trees translocated in Poonamalle depot for which compensatory afforestation in the ratio of 1:12 has been proposed. Nearly 1.56 km length of alignment traverses through CRZ area (18,344.91 sq.m of area in CRZ II and 220.9 sq. m of area in CRZ IV-B), for which CRZ clearance shall be obtained and the given conditions in the clearance shall be strictly adhered to. Ecological restoration plan has been suggested for Panagal Park. Other necessary clearance/ NOCs/ permissions for construction shall be obtained by the contractor under the supervision of the GC and CMRL.

304. The alterations in length, design, and alignment of the project do not result in noteworthy adverse effects. Additionally, these modifications contribute to the smooth flow of vehicular traffic while operating the metro, will be achieved through the implementation of an integrated grade separator at Kattupakkam.

305. 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, muck and waste disposal, labour safety, water demand, ground subsidence due to construction; and e) noise, vibration and ground subsidence due to operation. Measures to mitigate adverse impacts have been recommended In the EMP, which shall also forms part of the bid document. Further noise and vibration study will be conducted based on the detailed engineering design, in order to inform the incremental impacts and suggest the mitigations. This will be completed as part of the supplementary study of this EIA by contractors' mobilization.

306. 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 road right of way is not adequate to operate BRT on Corridor 4. Therefore continuity of Metro is required. Requirement of acquisition of property was minimized by fine-tuning of locations and footprint of stations.

307. Public consultations highlighted opinions of participants on benefits of Metro in terms of easing connectivity, pollution, congestion, accidents and travel on roads and safe travel for women; and apprehensions about impact of tunneling on existing buildings and loss of green cover; suggestions for moderate metro fare compensation for impacted shops and other properties. 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.

308. 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.

309. 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.

310. 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.