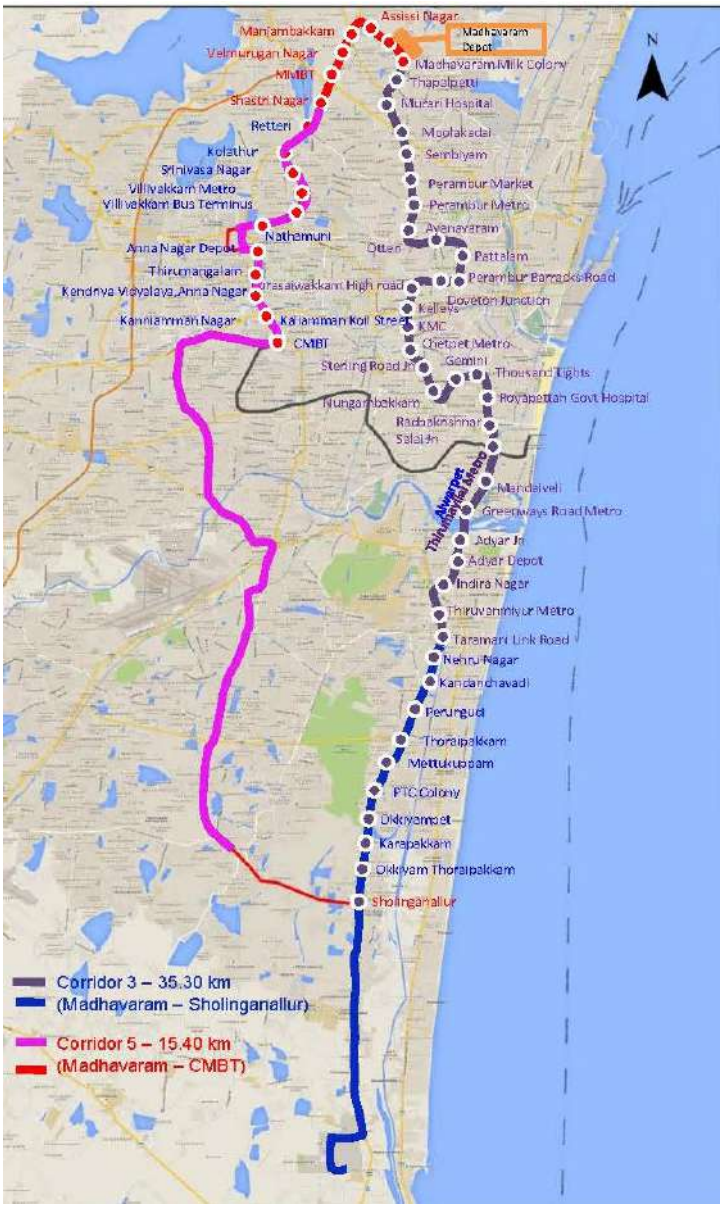
Government of India

CHENNAI METRO RAIL LIMITED

ENVIRONMENTAL IMPACT ASSESSMENT (EIA) FOR CHENNAI METRO RAIL PHASE-II PRIORITY CORRIDORS



EIA REPORT

NOVEMBER 2017

RITES
THE INFRASTRUCTURE PEOPLE
(A Government of India Enterprise)

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ABBREVIATIONS AND ACRONYMS

CMRL	:	Chennai Metro Rail Ltd
BIS	:	Bureau of Indian Standards
BOD	:	Biochemical Oxygen Demand
CO	:	Carbon Mono Oxides
COD	:	Chemical Oxygen Demand
CPCB	:	Central Pollution Control Board
CTE	:	Consent to Establish
cum	:	Cubic Meter
dB	:	Decibel
^{o}C	:	Degree Centigrade
DMRC	:	Delhi Metro Rail Corporation
DPR	:	Detail Project Report
EIA	:	Environmental Impact Assessment
EMP	:	Environmental Management Plan
EPA	:	Environmental Protection Agency
ETP	:	Effluent Treatment Plant
GIS	:	Geographical Information System
gm	:	Grams
Ha	:	Hectare
HC	:	Hydro Carbon
Hz	:	Hertz
IMD	:	India Meteorological Department
IS	:	Indian Standards
JICA	:	Japan International Cooperation Agency
Kg	:	Kilogram
KLD	:	Kilo Liter per Day
km	:	Kilo Meter
km/h, Kmph	:	Kilo Meter per Hour
KV	:	Kilo Volt
KWh	:	Kilo Watt Hour
m	:	Meter
mg	:	Milligram
mg/l	:	Milligram per Liter
mm	:	Millimeter
mm/s	:	Millimeter per Second
μm^3	:	Micro Cubic Meter
MoEFCC	:	Ministry of Environment, Forest and Climate Change
MRTS	:	Mass Rapid Transit System
MSL	:	Mean Sea Level
MT	:	Metric Ton
mg/m^3	:	Milligrame per cubic Meter
NO_x	:	Nitrous Oxides
OP	:	Operation Policy
PHPDT	:	Peak Hour Peak Direction Traffic
PIA	:	Project Implementation Agency
PM	:	Particulate Matter
PMC	:	Project Management Consultant
RO	:	Reverse Osmosis
ROW	:	Right of Way
SO_2	:	Sulfur di Oxide
SPCB	:	State Pollution Control Board
SPM	:	Suspended Particulate Matter
TBM	:	Tunnel Boring Machine

Executive Summary

CHAPTER 0
EXECUTIVE SUMMARY

0.1 INTRODUCTION

0.1.1 Objective and Scope

The objective of the study is to assess environmental impact of implementing two priority metro rail corridors in Chennai.

The scope of Environmental Impact Assessment (EIA) included establishing environmental baseline, assess impacts resulting from pre-construction, construction and operation phases and propose safeguard measures for protection of environment. An environmental management plan was developed to mitigate the adverse impacts during construction and operation phases of the project. A post project environmental monitoring program was recommended and estimated the environmental cost. Rehabilitation and Resettlement is presented as part of a separate Social Impact Assessment (SIA) Report.

The Ministry of Environment Forests and Climate Change (MoEFCC), Government of India, Notification of 14th September 2006 and its amendment dated 1st December 2009 list projects that require environmental clearance. As per this Notification a metro rail project does not require environmental clearance from MoEFCC.

0.2 PROJECT DISCRIPTION

The study area for the EIA study is the area along the Metro corridors and depot locations. Two priority metro corridors have been proposed for Chennai metro Phase-II which are listed below;

- Corridor 3: Madhavaram Milk Colony to Sholinganallur and
- Corridor 5: Madhavaram Milk Colony – CMBT

Corridor-3 (Madhavaram Milk Colony to Sholinganallur): 40 stations have been proposed in priority Corridor-3 consisting of 10 stations as elevated and 30 stations as underground.

Corridor-5 (Madhavaram Milk Colony-CMBT): Total of 18 stations have been proposed in priority Corridor-5 consisting of 1 at grade, 5 stations as elevated and 12 stations as underground.

Depots: The proposed land requirement for major depot at Madhavaram is 57.2 Ha. Out of 57.2 Ha. Land, depot facilities requires 27.8 Ha.

0.3 ENVIRONMENTAL BASELINE DATA

The Environmental baseline data collected for EIA study includes Physiography, geology and soils, ground water hydrology, flora and fauna, meteorology, air pollution and noise.

0.3.1 Land Environment

Physiography: 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. It is bounded by the Bay of Bengal on the east. 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 like a pancake. It rises slightly as the distance from the sea-shore increases but the average elevation of the city is not more than 22 ft above mean seal-level, while most of the localities are just at sea-level and drainage in such areas remains a serious problem.

Soil: The major soil in this region belongs to Alfisols and Entisols which are generally poor in soil nutrients. They have medium to high permeability. They have low water holding capacity except in patches of clayey soils. Soil samples were collected at 8 locations along the two proposed priority metro corridors, It is found that the soils are slightly alkaline in nature and organic matter content in soils varies from 1.02% to 1.29%.

Geology and Minerals: 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.

Land Use/Land Cover: The north and west of the Fort and older city are congested areas, while the density of population is comparatively much low on the semi circular belt around these crowded areas. During last two to three decades, the settlement has increased in outskirts of city. The land use land cover map (**Figure 2**) depicts that the built-up area is 58.05%, forest area 4.48%, water body 8.51%, agricultural land 2.75% and waste land is 20.27%.

Seismicity: The Bureau of Indian Standard upgraded the seismic status of Chennai from Low Seismic Hazard (Zone II) to Moderate Seismic Hazard (Zone III)–(BIS: 1893 (2001)).

0.3.2 Water Environment

Water Resources: Chennai is entirely dependent on ground water resources to meet its water needs. Ground water resources in Chennai are replenished by rain water and the city's average rainfall is 1,276 mm. The local city supply is 830 million litre of water per day. The city will get additional 880 mld from sources such as Minjur desalination plant (100 mld), Krishna water (500 mld), Nemeli desalination plant (100 mld), and Cauvery water from Veeranam Tank (180 mld).

Drainage: Adyar River is a 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 Kattipara cause way. Cooumriver flowing through the central part of the district and carries only drainage water, which is highly polluted. The flow of Cooum River at Korattur is 40.2 MCM/year for an average duration of 31 days in a year. Otteri Nulla 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.

Water Quality: Testing of water samples collected from 8 locations indicated that all parameters are in acceptable limit except dissolved solids, calcium and chlorides on Corridor 3. Bacteriological contamination found at all locations.

0.3.3 Meteorology and Air Environment

Meteorological data on rainfall, wind, humidity, and temperature were collected from Indian Meteorological Department (IMD) for latest five years. The ambient air quality and noise level had been monitored during the month of July 2016.

Meteorology: Chennai has a tropical wet and dry climate. The hottest part of the year is May with maximum temperature varies 41.7°C to 42.8°C. The coolest part of the year is January, with minimum temperature varies 19°C to 25°C. Mean Relative Humidity varies from 56% to 88% at 08:30 hrs and 57% to 81% at 17:30 hrs. Cyclones in the Bay of Bengal sometimes hit the city. The highest annual rainfall recorded is 1049.3 mm in November 2015.

Air Quality: Eight monitoring stations selected at strategic locations along three proposed corridors. The monitoring stations were selected to generate the representative samples for air quality covering residential, institutional and industrial area along the corridors. 24 hour air quality monitoring results indicates that SO2, NO2, PM10 and PM2.5 were within the limits for residential, Industrial and rural areas. However CO exceeds prescribed limits.

0.3.4 Noise Environment

Ambient noise levels were monitored for 24 hours at 8 locations in the month of July 2016 along existing roads at hourly interval during morning, afternoon and evening such that peak and off peak hours are covered. Noise levels at all locations are exceeding the noise level standards prescribed by CPCB either day or night or both for Residential Zone, Commercial Zone and Silence Zone as well. It is within permissible limit at Sholinganallur Junction at night.

0.3.5 Ecological Environment

Most of the trees exist along the road on sides and median. Site construction activities will results in loss of trees about 934. No rare or endangered species of trees were noticed during field studies.

0.3.6 Archaeological Sites or Monuments

No archaeological monuments/sites are located on or along the proposed corridors.

0.4 NEGATIVE ENVIRONMENTAL IMPACTS

Negative impacts likely to result from the proposed development are as follows: Impacts due to Project Location; Impacts due to Project Design; Impacts due to Construction; and Impacts due to Project Operation.

0.4.1 Impacts due to Project Location

Project Affected People (PAPs): Details will be presented in the separate Social Impact Assessment (SIA) report.

Change of Land Use: Land will be required permanently for stations, Depot, Ramp and running sections. Both government and private land will be acquired for the project the detail of which is given in the section on civil engineering in the DPR.

Loss of Forests/Trees: There are approximately 934 trees which are likely to be cut during construction along the two proposed priority corridors and one depot site. With removal of these trees, CO_2 absorption is likely to decrease by 2,802 kg/year and Oxygen production is likely to decrease by 10,274 kg/year.

Utility/Drainage Problems: 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 etc. These utilities/ services may be impacted due to construction of 2 priority corridors.

Impact on Archaeological Monuments/sites: No Archaeological Monuments / sites are directly affected due to proposed project.

0.4.2 Impacts due to Project Design

Impacts due to project design are seen in following ways: Right of Way, Alignment and Architectural Design, Inter-model integration will lead to increase use of metro, Congestion at inside and outside the stations, Uses of Energy and water at stations and risk due to earthquake.

0.4.3 Impact due to Project Construction

The most likely negative impacts related to the construction works are mostly of temporary in nature. The likely impacts due to construction are;

Soil Erosion: Run off from unprotected excavated areas, can result in excessive soil erosion, especially when the erodability of soil is high. In general, construction works are stopped during monsoon season.

Air Pollution due to Construction: Particulate pollution occurs due to excavation, loading and unloading of construction materials, vehicular and construction equipment emission and emission from the DG sets etc. Resulting pollution is short term.

Noise Pollution: Without mitigation measures noise level is predicted to meet the Ambient Noise Quality Standards (ANQS) 55 dB (A) at a distance of about 900 m. With respect to occupational exposure, all sensitive receptors including labour camps should be located beyond 125 meters from the noise generating source location.

Vibration: Pile driving for piers and tunnel driving generate vibrations. Vibration is pronounced in section of hard rock. TBM operation generates vibrations which are transmitted in all directions. 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.

Impact due to Land Subsidence: Land subsidence is anticipated at stations which will be constructed by cut and cover method.

Risk at labour camps: 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.

Impact due to Labour Camp: The water requirement at camps will be 333 KLD, waste water generation 276 KLD & municipal solid waste generation 742 kg per day. This will vary depending on the construction schedule during construction. Labour camp activities are of short duration.

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

Risk to Existing Buildings: Construction involves cut and cover, tunneling and piling. As part of pre-construction/construction activities building condition survey will have to be conducted, cost of which is not included in EMP.

Muck Disposal: Construction activities will generate about 4.06 Mm^3 of soil. Out of this, about 1.37 Mm^3 is likely to be reutilized in backfilling in underground stations and depots. The balance 2.69 Mm^3 shall be disposed of in environmental friendly manner. Disposal of excess soil should be permitted in low lying areas owned by Chennai Metro Rail Ltd (CMRL) and or CMDA.

Pollution due to Transportation of Construction Material and Soil: During the period of construction emission due to truck movement on account of transportation of civil construction material and disposal/backfill of earth is estimated to be as follows: CO, HC, NOx and PM will be about 78 tons, 2.5 tons, 162 tons and 3 tons respectively. Such transportation is estimated to result in fugitive dust emission of about 19 tons during the period of construction.

Increased Water and Energy Demand: The demand for water and energy will increase during construction phase. Water consumption during construction is of the order of 1657 KLD.

Impact on Ground and Surface Water: Ground water contamination can take place if chemical substances get leached by precipitation of water and percolate to the ground water table. Dumping of construction materials which could result in hazardous leachate percolating into ground water; dumping of used water from the RMC plant; oils and greases from construction sites and labour camp are sources of water pollution.

Impact due to Supply of Construction Material: Poor choice of source and quarrying operations cause dust pollution and wastage of natural resources.

Utility/Drainage Problems: The alignment will cross a number of utilities which will be supported and kept functional.

0.4.4 Impacts due to Project Operation

The project may cause the following negative impacts during operation of the project.

Noise Pollution: Effect of predicted day-time noise level has low impact with respect to the existing ambient noise environment.

Vibration: Passing of trains on elevated section as well as underground section causes vibrations. The dominant component of vibration due to passing on elevated section is horizontal while in tunnel vertical component is dominant. Impact is more in solid rock.

Water Supply and Sanitation at Stations: The water demand at station comprising drinking, toilet, cleaning and air conditioning in Chennai will be of the order of 3024 KLD at underground stations and 224 KLD at elevated stations. The water requirement for the stations will be met through the public water supply system. Solid waste generation from operational staff at stations is likely to be 15 ton per month. Sewage at stations is estimated to be 70 KLD. This will be led into the municipal network.

Pedestrian and Traffic Congestion around Stations: Commencement of metro services results in passenger rush at stations which in turn results in congestion around stations.

0.4.5 Impacts due to Depots

The likely impacts due to proposed construction of depots are;

Water Supply: The water demand at Madhavaram depot would be about 59 KLD for train washing and 42 KLD for domestic purpose including staff quarters.

Sewage and Effluent: About 37 KLD sewage from domestic activities and 53 KLD effluent from train washing will be generated at Madhavaram Depot.

Oil Pollution: Oil spillage during change of lubricants, cleaning and repair processes, in the maintenance Depot cum workshop for maintenance of rolling stock, is very common. If discharged it can contaminate water sources.

Noise Pollution: The main source of noise from depot is the operation of workshop. The roughness of the contact surfaces of rail and wheel and train speed is the factors, which influence the magnitude of rail - wheel noise.

Surface Drainage: Due to the filling of the low-lying area for the construction of depots, the surface drainage pattern may change specially during monsoon.

Solid Waste: It is estimated that municipal solid waste of about 3.6 ton per month will be generated from Madhavaram Depot.

Cutting of Trees: About 541 number of trees are observed at Madhavaram Depot.

Loss of livelihood: Loss of livelihood if any is dealt in SIA Report.

0.5 POSITIVE ENVIRONMENTAL IMPACTS

Various positive impacts have been identified are;

Employment Opportunities: In post-construction phase, about 1715 people will be employed for operation and maintenance of the system. Thus, the project would provide substantial direct employment and consequent indirect employment.

Benefits to Economy: These corridors will yield benefits in terms of growth in economic activity due to better accessibility, savings in fuel consumption, corresponding reduction in cost of road construction and maintenance, reduction in vehicle operating costs, savings in travel time, improvement in quality of life and reduction in loss of productivity due to health disorders resulting from pollution and accidents.

Direct Benefits to Passengers: The project will result in direct benefits to users of Metro and other modes: reduction in vehicle operating costs, savings in travel time, improvement in quality of life, reduction in loss of productivity due to health disorders resulting from pollution and reduction in road accidents.

Reduced Fuel Consumption: It is estimated that about 3 Lakh litres of diesel and 0.44 Lakh litres of petrol will be saved in year 2021. These reductions will increase to 10 Lakh litres of diesel and 1.10 Lakh litres of petrol in year 2045. The estimated daily savings will be of about Rs 212 Lakh in year 2021, Rs 369 Lakh in year 2026, Rs 505 Lakh in year 2035 and Rs 678 Lakh in year 2045.

Reduced air pollution: The major vehicular pollutants that define the ambient air quality are: Particulate matter, Nitrogen oxides, Carbon monoxide, Hydro Carbons and Carbon dioxide. There are significant reductions of air pollutants due to proposed metro corridors. The reduction in PM, CO, HC and NOx will be expected as 98.17 tons/year, 1550.91tons/year, 606.14 tones/year and 3715.89 tons/year respectively in year 2021.

Traffic Noise Reduction: Reduction in traffic volume of 10% & 50% reduces noise at the tune of 0.5 dB & 3.0 dB respectively.

0.6 ENVIRONMENTAL MANAGEMENT PLAN

The impacts will be mitigated or reduced by incorporating environmental management plan into the project cycle i.e. due to location & design, during construction and during operation are as follows:

0.6.1 Management Plan for Location and Design

Compensatory Afforestation: About 934 trees are likely to be lost along the two priority corridors and one depot. Hence 11208 trees need to be planted. Estimated compensatory afforestation cost is about **Rs 51.98 Lakh** for Corridor-3 and **Rs 124.55**

Lakh for Corridor-5. The native plant species and miscellaneous indigenous tree species area recommended for afforestation.

Right of Way, Alignment and Architecture: Alignment is kept elevated where adequate width of right of way on roads is available. Viaduct and elevated stations shall be shaped to minimize visual intrusion.

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

Provision for Green Buildings: In accordance with the *GRIHA (version 2015)* norms, the measures shall be implemented to a feasible degree at the stations and depot. For the utilization of renewable energy, wherever feasible, installations for solar power can be implemented on roof of elevated stations. Solar energy generation per year is estimated to be 8.97 Giga-watt-hr for Corridor 3 and 3.70 Giga-watt-hr for Corridor 5. The installation cost for solar system is about **Rs 505.81 Lakh** and **Rs 208.65 Lakh** for Corridor 3 and Corridor 5 respectively

Use of Energy and Water: Requirement of electrical energy for climate control, lighting and other facilities at stations shall be optimized by proper use of natural day/night light and design of passenger flow inside stations and on streets outside stations. Rain water harvesting and installations for solar power shall be implemented in stations and Depot where feasible.

0.6.2. Management Plan during Construction

Measures to mitigate impacts observed during construction shall be implemented by Contractor and duly monitored by Owner in accordance with approved method statements. Their cost is part of engineering and track cost.

Construction Material Management and Housekeeping: Procedures for storage, handling and transport of construction material shall be prescribed in SH&E method statement approved for construction.

Hazardous Waste Management: It shall be stored and disposed of by the Contractor as per Hazardous and Other Wastes (Management, Handling & Trans-boundary movement) Rules 2016.

Construction and Demolition Waste Management: The construction contractor is required to take the following measures in accordance with Construction and Demolition Waste Management Rules 2016.

Energy Management: The contractor shall use and maintain equipment and employ recommended practices so as to conserve energy.

Labour Camp and Workplace Facilities: The following facilities shall be provided by the Contractor: Water supply, waste water and sewage treatment, Solid Waste ManagementShelter at Workplace, Canteen Facilities, First aid facilities, Day Crèche Facilities, Health care awareness and clinics.

Welfare and Safety of Labour: Construction works shall be executed as laid down in the Safety Health and Environment (SH&E) Manual prepared by the Contractor and approved by the Implementing Agency.

Utility Plan: The proposed Metro alignment run along major roads of the city and is required to negotiate sub-surface, surface and overhead utility services. Prior to the execution of work at site, detailed investigation of all utilities will be undertaken and plans for their retention in situ with precautions or temporary/permanent diversions prepared and got approved by respective agencies.

Air Pollution and Noise Pollution Control: Mitigation measures as per SH&E manual shall be adopted during the construction period. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

Vibration Control: Vibration can be reduced by system maintenance, improving track geometry, elastic fastenings, and separation pads. At locations where the alignment is close to sensitive structures, the contractor shall prepare a monitoring scheme prior to construction at such locations.

Traffic Diversion/Management: Measures such as road widening, traffic segregation, one-way movements, traffic diversions, acquisition of service lanes, etc. will be employed.

Soil Erosion Control: Excavation shall be limited; temporary berms and use of temporary mulches, fabrics, mats, seeding, or other control devices or methods shall be implemented.

Muck Disposal: Mitigation measure proposed are cleaning of disposal sites and then treated so that leached water does not contaminate the ground water, controlling the height from which soil will be dropped, stockpiling of earth in the designated locations with suitable slope, sufficient equipment, water and personnel shall be available on dumping sites at all times to minimise dust suppression, filling of muck in dumping site in layers and compacted mechanically.

Dewatering of Underground works and Drainage: Dewatering should be ensured as prescribed in the construction method statement.

0.6.3 Management Plan during Operation

Noise management: In addition to track-related measures**,** parabolic noise barriers are proposed on each side of the track. Noise barriers shall be placed along the curved portion of the viaduct and at stations during operation.

Water Supply and Sanitation at Stations: Water supply for drinking, washing of stations, air conditioning and other uses will be procured from municipal authorities. Wastewater from station will be discharged to the existing sewage network. Non-hazardous solid waste generated in stations will be collected and transported to local municipal bins for onward disposal to disposal site by municipality. Municipal water supply will be supplemented by rain water harvesting along viaduct and at elevated stations.

Rain Water Harvesting: To conserve and augment the storage of groundwater, it has been proposed to construct roof top rainwater harvesting structure of suitable capacity at the elevated stations and in the elevated alignment. The annual rainwater harvesting potential of elevated stations and elevated section is estimated as 2,02,513 cubic meter per year. Estimated cost for rainwater harvesting for viaduct and elevated stations is **Rs 163.48 Lakh** for Corridor-3 and **Rs 87.59 Lakh** for Corridor-5.

0.6.4 Management Plan for Depot

Water supply: Water will be required for operation of depot which will be sourced from municipal supply or tube well. This will be supplemented by rain water harvesting in case of other purposes like horticulture/green belt development.

Sewage Treatment and Effluent Treatment: For Madhavaram depot cost of Sewage Treatment Plant (STP) is estimated to be **Rs 78.11 Lakh.** Effluent will be generated from maintenance activities and cost of Effluent Treatment Plant (ETP) is estimated as **Rs 95.70 Lakh**.

Rain water Harvesting: To conserve and augment the storage of groundwater, it has been proposed to construct roof top rainwater harvesting structure of suitable capacity in the proposed depots. Rainwater harvesting potential of depots is calculated as 42,839 cubic meter per year. The estimated cost for rainwater harvesting for both the depots is **Rs 15.06 Lakh**.

Oil Pollution Control: Oil spilled in Depot will be trapped in oil and grease trap and disposed of to authorised collectors so as to avoid any underground/ surface water contamination. Oil that is mixed in water shall be removed in the ETP. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

Solid Waste Disposal: The solid waste generated from the Depot will be taken by the cleaning contractor weekly and disposed to the municipal waste disposal sites in accordance with relevant National and State laws and regulations. Cost is not included in EMP.

Surface Drainage: The Storm water will be collected through the drains and led to rain water harvesting pits and the drainage system. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

Green Belt Development: The greenbelt development/ plantation in the depot area not only functions as landscape features resulting in harmonizing and amalgamating the physical structures of proposed buildings with surrounding environment but also acts as

pollution sink noise barrier. The estimated cost of afforestation is incurred the cost of green belt development at Madhavaram depot.

Training and Extension: The training for engineers and managers will be imparted by CMRL on regular basis to implement the environmental protection clauses of the tender document and to implement the best environmental practices during the construction phase and ensure preparedness for disaster prevention. The cost involved for such programme is estimated to be **Rs 12.60 Lakh** each for Corridor-3 and Corridor-5.

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

0.7 ENVIRONMENTAL MONITORING PLAN

Environmental monitoring during pre-construction phase is important to know the baseline data and to predict the adverse impacts during construction and operations phases.

During construction stage environmental monitoring will be carried out for air quality, noise levels, vibration, water quality and ecology. Lumpsum provision has been made in the cost estimate. The estimated environmental monitoring cost during construction and operation phases are **Rs 136.32 Lakh** for Corridor 3 and **Rs 62.34 Lakh** for Corridor 5.

0.7.1 Construction Phase

Water Quality: The water quality parameters are to be monitored during the entire period of project construction. Monitoring should be carried out by NABL Accredited/MoEFCC recognized private or Government agency. Parameters for monitoring will be as per BIS: 10500. The monitoring points could be ground and surface water.

Air Quality: Air quality should be monitored at the locations of baseline monitoring. The parameter recommended is Particulate Matter ($PM_{2.5}$ and PM_{10}), SO_2, NOx, CO and HC. The contractor will be responsible for carrying out air monitoring during the entire construction phase.

Noise and Vibration: The noise and vibration will be monitored at construction sites for entire phase of construction by the site contractor.

Ecological Monitoring: The project authority in coordination with the Department of Forest shall monitor the status of ecology/trees along the project corridors at least 4 times in a year during construction phase in order to maintain the ecological environment. The plantation/afforestation of trees by Department of Forest, Government of Tamil Nadu will be reviewed four times a year during construction phase.

Workers Health and Safety: Regular inspection and medical checkups shall be carried out to workers health and safety monitoring. Contractor will be responsible to take care of health and safety of workers during construction and project proponent is responsible to review/audit the health and safety measures/plans. Monitoring schedule is recommended.

0.7.2 Operation Phase

The parameters monitored during operation will be Particulate Matter ($PM_{2.5}$ and PM_{10}), SO_2, NOx, CO and HC for ambient air quality. Water quality parameters that will be monitored will be as per BIS 10500. Lumpsum provision has been made in the cost estimate. The results of Air quality, water quality, waste water will be submitted to management quarterly during construction phase and semi annually during operation phase. Monitoring schedule is recommended.

0.7.3 Establishment of Environmental Division

It is recommended that establishment of an Environment Division at the initial stage of the project itself. This division should have an Environmental Officer and an Environment Engineer. The task of the division would be to supervise and coordinate studies, environmental monitoring and implementation of environmental mitigation measures, and it should report directly to Chief Engineer of the Project Authority. The estimated cost for the corridor is **Rs 171.45 Lakh** each for Corridor 3 and Corridor 5.

0.8 ENVIRONMENTAL COST

Estimated environmental management cost for the priority corridors of Chennai Metro Phase-II is about **Rs 1945.69 Lakh.**

Chapter –1

Introduction

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Chennai is located on the Coromandel Coast off the Bay of Bengal. Chennai is divided into four broad regions: North, Central, South and West. North is primarily an industrial area. South and West, previously mostly residential, are fast becoming commercial, home to a growing number of information technology firms, financial companies and call centres. The city is expanding quickly along the Old Mahabalipuram Road and the Grand Southern Trunk Road (GST Road) in the south and towards Ambattur, Koyambedu and Sriperumbudur in the west. Central Madras comprises residential elements, but is primarily home to the downtown area,

1.2 TRANSPORT

Chennai is a busy airport and houses two major ports, Chennai Port, and Ennore Port. Chennai is connected by the Golden Quadrilateral and by four major National Highways (NH).

The city has two mainline railway terminals. Chennai Central and Chennai Egmore. Urban Mass Rapid Transit System (MRTS) of 19.75 km is in operation while construction on 5 km long extension is in progress. Chennai Metro of 18.6 km is in operation while balance 35.45 km is under construction. The Chennai suburban railway network, one of the oldest in the country, facilitates transportation within the city. It consists of four broad gauge sectors terminating at two locations in the city, namely Chennai Central and Chennai Beach. While three sectors are operated on-grade, the fourth sector is majorly an elevated corridor, which links Chennai Beach to Velachery and is interlinked with the remaining rail network.

1.3 OBJECTIVE AND SCOPE OF THE EIA STUDY

The priority corridors are as follows: **Corridor-3:**Madhavaram Milk Colony to Sholinganallur and **Corridor- 5:**Madhavaram Milk Colony to CMBT.

The scope of EIA includes establishing environmental baseline, assess impacts resulting from pre-construction, construction and operation phases and propose safeguard measures for protection of environment. MoEFCC Government of India Notification of 14th September 2006 and its amendment dated 1st December 2009 lists projects that require environmental clearance: railways are not included in this list. However clearances and other permissions are required from Local building permission authority for environmental clearance, State Pollution Control Board for consent to establish and operate, CMDA for landuse clearance, SEIAA and State Planning Authority for CRZ clearance ;Regional Office (linear projects) in context of forest land, MOEFCC/HO for wildlife clearance; and Central or State Wetlands Authorities (Rules of 2010 and 2017), National Monuments Authority for archaeological permissions, tree cutting and afforestation permissions from tree/forest/ municipal Authority. Other permissions relevant to construction are in addition.

1.4 LEGALAND POLICY FRAMEWORK

The Acts, Rules and Norms which are generally relevant to Metro rail projects are listed below. Of those listed below, Wetlands (Conservation and Management) Rules are not required for this Metro project.

- Amendment dated 9 December 2016 to EIA Notification 2006: Integration of environmental Conditions in local building byelaws
- The Air (Prevention and Control of Pollution) (Union Territories) Rules 1982, 1983 (Consent to establish and operate)
- The Water (Prevention and Control of Pollution) Rules 1975 (Consent to establish and operate)
- National Ambient Air Quality Standards 2009
- Guidelines for Ambient Air Quality Monitoring , CPCB, 2003
- The Water (Prevention and Control of Pollution) Act 1974 amended 1988
- Guide Manual – Water and waste water analysis, CPCB
- Drinking water – Specifications IS 10500: 2012 and CPHEEO Manual 2012
- Energy Conservation Building Code 2017 & IGBC Green MRTS Abridged reference guide
- Protocol for Ambient Level Noise Monitoring, CPCB, 2015
- Noise Pollution (Regulation and Control) Rules, 2000 amendment in 2010
- ISO/ TC 108 (vibration)
- Metro Rail Transit System, Guidelines for Noise and Vibrations, RDSO, Ministry of Railways, September 2015
- Construction and Demolition Waste Management Rules 2016
- Hazardous and Other Wastes (Management and Transboundary Movement) Rules 2016
- Solid Waste Management Rules 2016
- Coastal Regulation Zones Rules 2011 with amendment dated 8 December 2014
- Forest (Conservation) Act, 1980, amended 1988.
- Forest (Conservation) Rules 2003 and Forest (Conservation) Amendment Rules, 2014 (procedure for FC)
- The Indian Wild Life (Protection) Act 1972 and The Wildlife (Protection) Amendment Act 2002
- Wetlands (Conservation and Management) Rules, 2010 (wetlands falling in areas covered under the Indian Forest Act, 1927, the Wild Life (Protection) Act, 1972, the Forest (Conservation) Act, 1980, the State Forest Acts, and the Coastal Regulation Zone Notification, 2011 as amended from time to time and Wetlands (Conservation and Management) Rules, 2017 (Ramsar wetlands and wetlands notified by Central & State Governments and UTs)
- The Metro Railways (Operation and Maintenance) Act 2002 as amended vide The Metro Railways (Amendment) Act 2009 (disaster management)
- The Ancient Monuments and Archaeological sites and Remains (Amendment and Validation Act) 2010
- Chennai Metropolitan Area Groundwater (Regulation) Act, 1987 as amended till 2008 and Guidelines/Criteria for evaluation of proposals/requests for ground water abstraction (With effect from 16.11.2015), Central Ground Water Authority
- Annexure XXV, Special Rules for conservation of Heritage Buildings Vol II: Second Master Plan for Chennai Metropolitan Area 2026 amended May 13

1.4.1 Water and Water Pollution

The use of water resources and also the discharge of polluted water (sewerage) are primarily regulated by the Water (Prevention and Control of Pollution) Act, 1974 as amended.

Water supplied to users for drinking shall conform to the National Drinking Water Standard, IS-10500**(Appendix 1.1)**. **Appendix 1.2** summarizes the general standards for discharge effluent in Inland Surface Water Bodies. To ascertain and categorize the existing water quality, the results of the analysis of water quality need to be compared with the water quality standards given in **Appendix 1.3.**

The Central Ground Water Board,(CGWB) the statutory authority set up by the Central Government has restricted the drilling of tube wells and bore wells in certain water scarce areas in the country. Although Chennai does not figure in the list of Notified areas where permission to abstract ground water through any energized means will not be accorded for any purpose other than drinking water, extraction of ground water for use in construction and operation of metro railway is not proposed in this report. Through Tamil Nadu Municipal Laws ordinance, 2003, dated July 19, 2003, the government of Tamil Nadu has made rainwater harvesting mandatory for all the buildings, both public and private, in the state.

1.4.2 Air Quality

The Air (Prevention and Control of Pollution) Act, 1981 and amended in 1987 including Rules 1982 and 1983 was enacted to prevent, control and reduce air pollution. According to Section 21 of the Act, no person shall establish or operate any activity, which can cause air pollution without obtaining Consent to Establish (CTE). The Act also lays down national ambient air quality standards for pollutants like PM_{10}, $PM_{2.5}$ Sulphur dioxide, Nitrogen dioxide, Carbon monoxide, Lead, Ozone, Ammonia, Benzene and Benzo pyrene, Arsenic and Nickel with the intent of managing air quality for different category of areas (Industrial, Residential, Rural & Ecological sensitive areas). Ambient Air Quality Standards have been notified by the CPCB vide Gazette Notification dated 16th November 2009, refer **Appendix 1.4.**

1.4.3 Noise Quality

With the objective of regulating ambient noise quality in the environment, the Central Government has notified the Noise Pollution (Regulation and Control) Rules, 2000 as amended. The notified ambient noise standards are presented in **Appendix 1.5.**

1.4.4 Solid Waste Management

Construction and Demolition Waste Management Rules, 2016 identify roles of waste generator, service provider, local authorities, SPCB, State Government, CPCB, BIS and Central Government. The Rules specify procedure for reporting accidents during waste processing or treatment or disposal, roles and criteria for site selection for storage and processing or recycling facilities, applications of waste made from waste materials.

Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 specify the following:

- Occupier`s responsibility for safe and environmentally sound management of hazardous and other wastes in terms of sending or selling to an authorized actual user or disposal in an authorized disposal facility.
- Responsibilities of State Government,
- Rules for grant of authorization to manage wastes and for utilization of wastes.
- Roles of waste processor and State Government in treatment, storage and disposal facility for hazardous and other wastes.
- Procedures for packaging, labeling, and transport of hazardous and other wastes.

Solid Waste Management Rules, 2016 are applicable to every domestic, institutional, commercial and any other non residential solid waste generator except industrial waste, hazardous waste, hazardous chemicals, bio medical wastes, e-waste, lead acid batteries and radio-active waste. Duties of waste generators, manufacturers, local authorities, various Officers and ministries of Government, Pollution Control agencies are stipulated in these Rules.

1.4.5 The Ancient Monuments And Archaeological Sites And Remains (Amendment and Validation) Act, 2010

The Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010 states that the limits of prohibited area and regulated area around the monuments, archaeological sites and remains declared by the Central Government as protected have been specified as 100 m and 200m respectively. The limits so fixed may be further extended on the basis of gradation and classification of the monuments, archaeological sites and remains to be done by the National Monuments Authority. The Act defines regulated area and prohibited area as follows:

Prohibited Area: It is the areas of the protected monuments or protected areas, declared as of national importance, which has been defined as beginning at the limit of the protected area or the protected monument, as the case may be, and extending to a distance of 100 m in all directions.

Regulated Area: It is the area beginning at the limit of the prohibited area in respect of every ancient monument and archaeological site and remains and extending to a distance of 200 m in all directions. The regulated area has extent not only horizontally but also vertically and covers even below the surface.

The Act provides that none other than an archaeological officer can carry out any construction in any prohibited area. The Act provides that no permission, including carrying out any public work or project essential to the public or other constructions, shall be granted in any prohibited area on and after the date on which the Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010 comes in to force.

This provision does not include cleansing of drains and drainage works and of public latrines, urinals and similar conveniences, or, the construction and maintenance of works meant for providing supply of water for public, or the construction or maintenance, extension, management for supply and distribution of electricity to the public or provision for similar facilities for public.

This provision has barred all construction activities in the prohibited area to be taken up by all public bodies even if the purpose is related to public works or project essential to the public. *There is no provision for grant of any relaxation in this regard by any authority.*

1.5 INSTITUTIONAL FRAMEWORK

The Ministry of Environment Forest and Climate Change (MoEFCC) is the nodal agency in the administrative structure of the central government for planning, promotions, co-ordination and overseeing the implementation of India's environmental and forestry policies and programs. The major responsibilities of MoEFCC include:

- Environmental resource conservation and protection, including environmental impact assessment, clearance of developmental projects;
- Co-ordination with the other ministries and agencies, voluntary organizations and professional bodies for environmental action plans;
- Promotion of research and development, manpower planning and training and creation of environmental awareness;
- Liaison and coordination with international agencies involved in environmental matters.

1.5.1 Central and State Pollution Control Boards

The Central Pollution Control Board is responsible for pollution control throughout the country. In addition to the control of air, noise and water pollution it is also responsible to ensure effective control of disposal of hazardous wastes and storage and handling of hazardous chemicals and substances. With the enactment of air and water pollution laws, states have set-up their own State Pollution Control Boards (SPCBs) to monitor industrial emissions and effluents and to approve the operation of new industries after careful scrutiny. The functions of the SPCBs include:

- The planning of comprehensive state programs for the prevention and control of air and water pollution and to ensure the implementation thereof;
- Inspection of pollution control equipment/ plants for monitoring of their efficiency.

The SPCB in consultation with the Central Pollution Control Board may establish norms for air quality, gaseous emission and noise level etc.

1.6 APPROACH AND METHODOLOGY

The approach is to ascertain the existing baseline conditions and assess the impacts as a result of construction and operation of the project. The changes likely to occur in different components of the environment viz. physical, biological and socio-economic etc. were

studied, analyzed and quantified wherever possible. Baseline condition was ascertained using primary and secondary data for various parameters of ecology (Flora & Fauna), environmental pollution (air, water and noise) and socio-economic conditions. The primary sources include site visits, field studies and instrument-based monitoring. The secondary sources include the publications and documents from various government and non-government organizations on subject matter.

The National Acts, Legislation and Laws were consulted with a view to ensure compliance. The methodology adopted for data collection, impact analysis, preparation of environmental management and monitoring plans is highlighted in brief in the following paragraphs and elaborated in subsequent sections. The approach and methodology of the EIA study is depicted in **Figure 1.1**.

1.6.1 Data Collection

The existing **land-use** pattern of the area was identified as urban human settlements, roads, trees and water bodies.

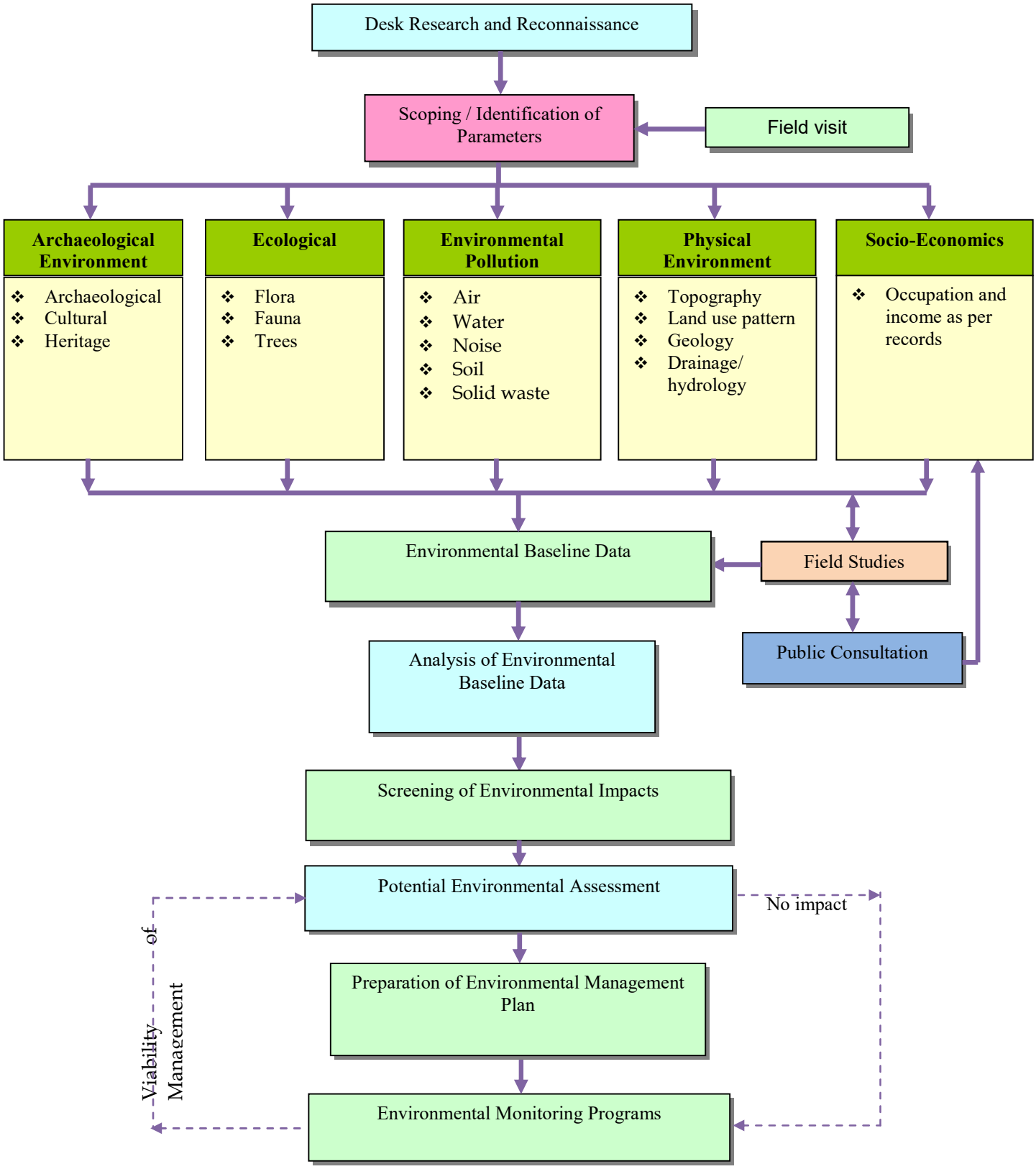
Data on **water** resources in the project area in terms of sources and quantity was adopted from secondary sources and data on quality of water from sample field monitoring. Water samples were analyzed as per IS: 10500-2012.

Air and Noise: Ambient air quality and noise levels were monitored at sample locations in and around project area. Recorded air pollution and noise levels in the project area were adopted from available secondary data.Locations for Air & Noise monitoring were identified so as to represent various landuse along the project corridors.

Terrestrial vegetation types were documented through visual inspection and past research. Tree count was carried out in the project area. The list of birds, animals, aquatic **ecology** etc. of the area was compiled from secondary data along with record of existence of any rare and endangered species.

Meteorological data for temperature, relative humidity, wind speed, wind direction, wind rose, rainfall and cloud cover was obtained from the Indian Meteorological Department (IMD).

Figure 1.1 Approach & Methodology for EIA Study



1.6.2 Environmental Impact Assessment

Based on projected and existing environmental conditions, potential impacts of the project were identified and wherever possible these are quantified. Both positive and negative impacts are evaluated. These impacts were assessed for various phases of project cycle namely location, design, construction and operation. The environmental impact of the project was evaluated in terms of change in land use, solid waste, air quality and noise levels. Baseline quality of water and soil were recorded.

1.6.3 Environmental Management Plan

An environmental management plan was developed to mitigate the adverse impacts during construction and operation phases of the project.

1.6.4 Environmental Monitoring Program

A post project environmental monitoring program was designed for implementation.

1.7 FORMAT OF THE REPORT

Chapter2presents project description. **Chapter3** summarises environmental baseline conditions. Potential negative and positive impacts are presented in **Chapters4 and 5** respectively. Environmental management plan has been presented in **Chapter6. Chapter7** covers environmental monitoring programmes. A summary of the costs of environmental management and monitoring programmes is presented in **Chapter8.**

Social Impact Assessment and preliminary Resettlement Action Plan will **be presented as part** of a separate Report.

Appendix 1.1 -1.5

Appendix 1.1

Drinking Water Quality Standards (IS 10500:2012)

S. No.	Characteristic	Requirement (Acceptable Limit)	Permissible limit in the absence of alternate source	Remarks
Essential Characteristics				
1	Colour, Hazen units, Max	5	15	Extended to 15 only, if toxic substances are not suspected in absence of alternate source
2	Odour	Agreeable	Agreeable	a) Test cold and when heated b) Test at several dilutions
3	pH Value	6.5 to 8.5	No relaxation	-
4	Taste	Agreeable	Agreeable	Test to be conducted only after safety has been established
5	Turbidity NTU, max	1	5	-
6	Total dissolved solids, mg/l, Max	500	2000	-
7	Aluminium (as Al), mg/l Max	0.03	0.2	-
8	Ammonia (as total ammonia-N), mg/l Max	0.5	No relaxation	-
9	Anionic detergents (as MBAS), mg/l, Max	0.2	1.0	-
10	Barium (as Ba), mg/l, max	0.7	No relaxation	-
11	Boron (as B), mg/l Max	0.5	1.0	-
12	Calcium (as Ca) mg/l, Max	75	200	-
13	Chloramines (as Cl_2), mg/l, Max	4.0	No relaxation	-
14	Chloride (as Cl) mg/l, Max	250	1000	-
15	Copper (as Cu) mg/l, Max	0.05	1.5	-
16	Fluoride (as F) mg/l, Max	1.0	1.5	-
17	Free residual Chlorine, mg/l, Min	0.2	1	To be applicable only when water is chlorinated. Tested at consumer end. When protection against viral infection is required, it should be minimum 0.5 mg/l
18	Iron (as Fe) mg/l, max	0.3	No relaxation	Total concentration of manganese (as Mn) and iron (as Fe) shall not exceed 0.3mg/l
19	Magnesium (as Mg) mg/l, Max	30	100	-
20	Manganese (as Mn) mg/l, Max	0.1	0.3	-
21	Mineral oil, mg/l Max	0.5	No relaxation	-
22	Nitrate (as NO_3) mg/l, Max	45	No relaxation	-
23	Phenolic compounds (as C_6H_5OH) mg/l, Max	0.001	0.002	-
24	Selenium (as Se), mg/l, Max	0.01	No relaxation	-

S. No.	Characteristic	Requirement (Acceptable Limit)	Permissible limit in the absence of alternate source	Remarks
25	Silver (as Ag), mg/l, Max	0.1	No relaxation	-
26	Sulphate (as SO_4) mg/l, Max	200	400	May be extended to 400 provided that Magnesium does not exceed 30
27	Sulphide (as H_2S) mg/l, max	0.05	No relaxation	-
28	Total alkalinity as calcium carbonate, mg/l Max	200	600	-
29	Total Hardness (as $CaCO_3$) mg/l, Max	200	600	-
30	Zinc (as zn), mg/l, Max	5	15	-
31	Cadmium (as Cd), mg/l, Max	0.003	No relaxation	-
32	Cyanide (as CN), mg/l, Max	0.05	No relaxation	-
33	Lead (as Pb), mg/l, Max	0.01	No relaxation	-
34	Mercury (as Hg) mg/l, Max	0.001	No relaxation	-
35	Molybdenum (as Mo) mg/l, max	0.07	No relaxation	-
36	Nickle (as Ni), mg/l, max	0.02	No relaxation	-
37	Polychlorinated biphenyls, mg/l, max	0.0005	No relaxation	-
38	Polynuclear aromatic hydrocarbons (as PAH) mg/l, Max	0.0001	No relaxation	-
39	Total Arsenic (as As), mg/l, Max	0.01	0.05	-
40	Total Chromium (as Cr) mg/l, Max	0.05	No relaxation	-
41	Trihalomethanes Bromoform, mg/l, max Dibromochloromethane, mg/l, max Bromodichloromethane, mg/l, max Chloroform, mg/l, max	 0.1 0.1 0.06 0.2	 No relaxation No relaxation No relaxation No relaxation	-
42	Radioactive materials a) Alpha emitters Bq/l max b) Beta emitters pci/l, Max	 0.1 1.0	 No relaxation No relaxation	-

Appendix 1.2

Effluent Discharge Standards (Inland Surface Water)

S.No.	Parameter	Unit	Standards
1	Colour & Odor	--	All efforts should be made to remove colour and unpleasant odor as far as practicable.
2	Suspended Solids Max.	mg/l	100
3	Particle size of Suspended Solids	--	Shall pass 850 micron IS Sieve
4	pH value	--	5.5 to 9.0
5	Temperature, Max.	°C	Shall not exceed 5°C above the receiving water temperature
6	Oil and grease, Max.	mg/l	10
7	Total residual Chlorine, Max.	mg/l	1.0
8	Ammonical Nitrogen (as N), Max.	mg/l	50
9	Total Kjeldah Nitrogen (as N), Max.	mg/l	100
10	Free Ammonia (as NH_3), Max.	mg/l	5
11	Biochemical Oxygen Demand (5 days at 20°C), Max.	mg/l	30
12	Chemical Oxygen Demand Max.	mg/l	250
13	Arsenic (as As), Max.	mg/l	0.2
14	Mercury (as Hg), Max.	mg/l	0.01
15	Lead (as Pb), Max.	mg/l	0.1
16	Cadmium (as Cd), Max.	mg/l	2.0
17	Hexavalent Chromium (as Cr^{+6}), Max.	mg/l	0.1
18	Total Chromium (as Cr) Max.	mg/l	2.0
19	Copper (as Cu), Max.	mg/l	3.0
20	Zinc (as Zn), Max.	mg/l	5.0
21	Selenium (as Se), Max.	mg/l	0.05
22	Nickel (as Ni), Max.	mg/l	3.0
23	Cyanide (as CN), Max.	mg/l	0.2
24	Fluorides (as F), Max.	mg/l	2.0
25	Dissolved phosphates (as P), Max.	mg/l	5.0
26	Sulphides (as S), Max.	mg/l	2.0
27	Phenolic compounds (as C_6H_5OH), Max.	mg/l	1.0

S.No.	Parameter	Unit	Standards
28	Radioactive Materials α Emitters, μcurie/ml, Max. β Emitters, μcurie/ml, Max.	mg/l	 10^{-7} 10^{-6}
29	Bio-assay test	mg/l	90% survival of fish after 96 hours in 100% effluent
30	Manganese (as Mn)	mg/l	2.0
31	Iron (as Fe)	mg/l	3.0
32	Vanadium (as V)	mg/l	0.2
33	Nitrate Nitrogen	mg/l	10.0

Appendix 1.3

Tolerance Limits for Inland Surface Water Quality

Characteristic	Designated Use Class of Inland Waters				
	A	B	C	D	E
pH value	6.5 to 8.5	6.5 to 8.5	6.5 to 8.5	6.5 to 8.5	6.0 to 8.5
Dissolved Oxygen, mg/l, Min.	6	5	4	4	-
Biochemical Oxygen Demand (5 days at 20^0C), mg/l	2	3	3	-	-
Total coliform organisms, MPN/100 ml. Max.	50	500	5000	-	-
Colour Hazen units	10	300	300	-	-
Chlorides (as Cl), mg/l Max.	250	-	600	-	600
Sodium Adsorption ratio Max.	-	-	-	-	26
Boron (as B), mg/l. Max.	-	-	-	-	2
Sulphates (as SO_4), mg/ l	400	-	400	-	1000
Nitrates (as NO), mg/l Max.	20	-	50	-	-
Free Ammonia (as NH_3), mg/l	-	-	-	1.2	-
Conductivity at 25° C microhm / cm Max.	-	-	-	1000	2250
Arsenic (as As), mg/l. Max.	0.05	0.2	0.2	-	-
Iron (as Fe), mg/l	0.3	-	50	-	-
Fluorides (as F), mg/l	1.5	1.5	1.5	-	-
Lead (as Pb), mg/l. Max.	0.1	-	0.1	-	-
Copper (as Cu), mg/l	1.5	-	1.5	-	-
Zinc (as Zn) mg/l/ Max.	1.5	-	1.5	-	-
Manganese (as Mn), mg/l	0.5	-	-	-	-
Total Dissolved Solids, mg/l	500	-	1500	-	2100
Total Hardness ($CaCO_3$), mg/l	300	-	-	-	-
Magnesium (as Mg), mg/l	100	-	-	-	-
Chlorides (as Cl), mg/l	250	600	-	-	600
Cyanides (as CN), mg/l	0.05	0.05	0.05	-	-

A: Drinking Water Source without conventional treatment but after disinfections;
B: Outdoor bathing organized;
C: drinking water source with conventional treatment followed by disinfections;
D: propagation of wildlife and fisheries;
E: irrigation, industrial cooling, controlled waste disposal.
Source: Central Pollution Control Board

Appendix 1.4

National Ambient Air Quality Standards

Pollutant	Time Weighted Average	Industrial, Residential, Rural & Other Area	Ecologically Sensitive Area (notified by Central Government
Sulphur Dioxide (SO_2), μm^3	Annual 24 Hours**	50 80	20 80
Nitrogen Dioxide as NO_2, μm^3	Annual 24 Hours**	40 80	30 80
Particulate Matter (size less than 10μm) or PM_{10} μm^3	Annual 24 Hours**	60 100	60 100
Particulate Matter (size less than 2.5μm) or PM2.5 μm^3	Annual * 24 Hours**	40 60	40 60
Ozone (O3) μm^3	8 hours** 24 Hours**	100 180	100 180
Lead (Pb) μm^3	Annual * 24 Hours**	0.50 1.0	0.50 1.0
Carbon Monoxide (CO) mg/m^3	8 Hours** 1 Hour**	02 04	02 04
Ammonia (NH_3) μm^3	Annual * 24 Hours**	100 400	100 400
Benzene (C_6H_6) μm^3	Annual *	05	05
Benzo (a) pyrene (BaP)particulate phase only nm^3	Annual *	01	01
Arsenic (AS) μnm^3	Annual *	06	06
Nickle (Ni) nm^3	Annual *	20	20

Source: Central Pollution Control Board Notification dated 18th November 2009

** Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week hourly at uniform intervals*

*** 24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.*

Appendix 1.5

National Ambient Noise Standards

Category of Zones	Leq in dB (A)	
	Day Time	Night Time
Industrial	75	70
Commercial	65	55
Residential	55	45
Silence Zone	50	40

Source: Central Pollution Control Board

Day time shall mean from 6.00 a.m. to 10.00 p.m.

1. Night time shall mean from 10.00 p.m. to 6.00 a.m.
2. Silence zone is an area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority
3. Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

* dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.

A “decibel” is a unit in which noise is measured.

“A”, in dB(A) Leq, denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear.

Leq: It is an energy mean of the noise level over a specified period

Chapter –2

Project Description

CHAPTER 2
PROJECT DESCRIPTION

2.1 STUDY AREA

Chennai is located on the Coromandel Coast off the Bay of Bengal. Chennai is divided into four broad regions: North, Central, South and West. North is primarily an industrial area. South and West, previously mostly residential, are fast becoming commercial, home to a growing number of information technology firms, financial companies and call centres. The city is expanding quickly along the Old Mahabalipuram Road and the Grand Southern Trunk Road (GST Road) in the south and towards Ambattur, Koyambedu and Sriperumbudur in the west. Central Madras comprises residential elements, but is primarily home to the downtown area.

Chennai is a busy airport and houses two major ports, Chennai Port, and Ennore Port. Chennai is connected by the Golden Quadrilateral and by four major National Highways (NH). The city has two mainline railway terminals. Chennai Central and Chennai Egmore. Urban Mass Rapid Transit System (MRTS) of 19.75 km is in operation while construction on 5 km long extension is in progress. Chennai Metro of 18.6 km is in operation while balance 35.45 km is under construction

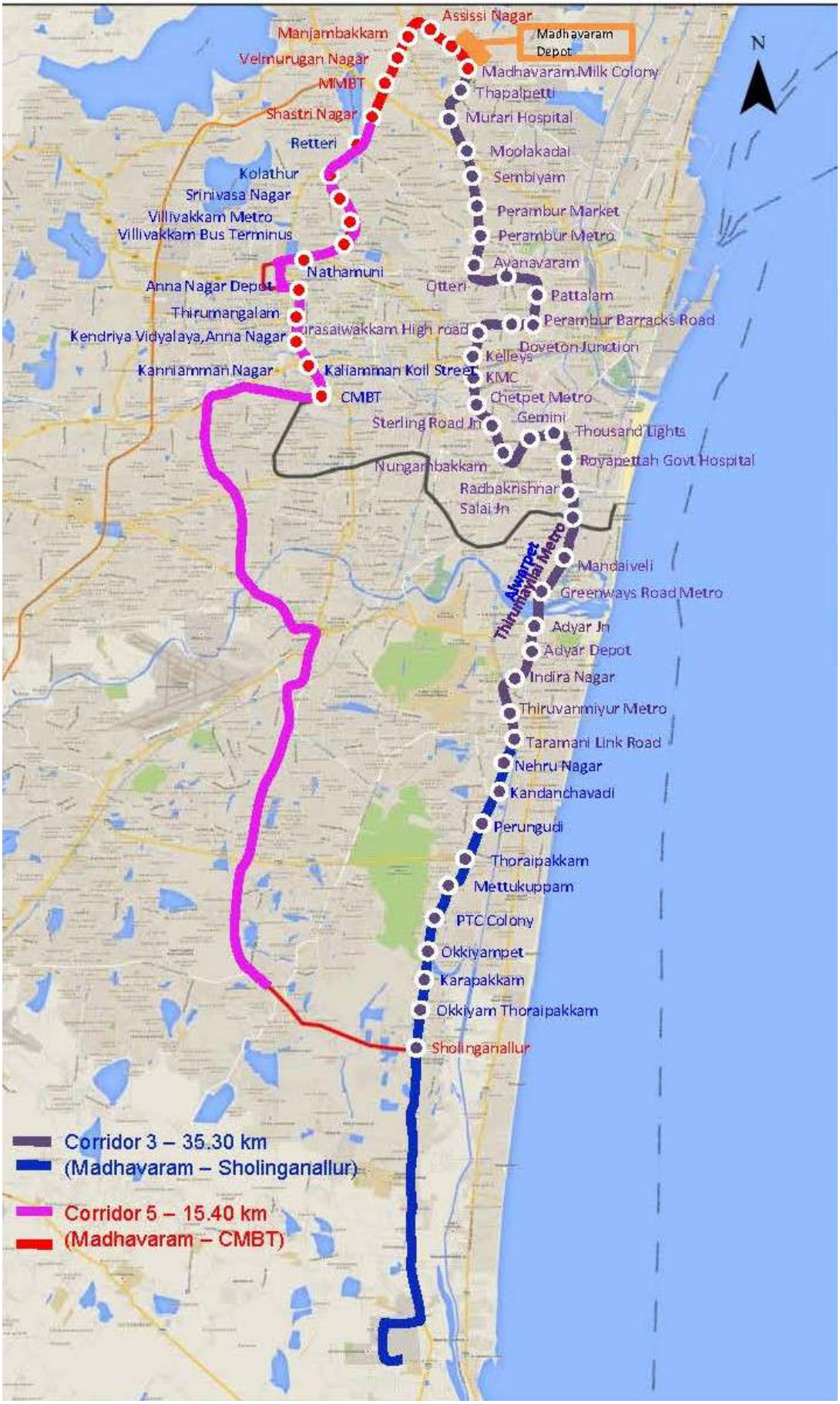
With a view of developing effective and efficient mass transit system in addition to the existing public transportation and Phase-I Metro rail system, the Government of Tamil Nadu has decided to introduce 2 priority corridors as a part of Phase-II Metro rail network and engaged RITES Ltd. to prepare a Detailed Project Report for Chennai Metro Rail Phase-II Corridors.

The Study Area (**Figure 2.1**) for the EIA study is the area along the Metro corridors and depot locations.

2.2 PROPOSED METRO SYSTEM

Priority corridors of Phase-II of Chennai Metro Rail Project comprise the following corridors: **Corridor 3:** Madhavaram Milk Colony to Sholinganallur (35.30 km), and **Corridor 5**: Madhavaram Milk Colony to CMBT (15.40 km)**.** Relevant features of the project as mentioned in the Engineering Report are summarised in the following section.

Figure 2.1 Study Area and Priority Corridors



2.3 ROUTE ALIGNMENT

The priority corridors are as follows:

- Corridor 3: Madhavaram Milk Colony to Sholinganallur
- Corridor 5: Madhavaram Milk Colony to CMBT

2.3.1 Corridor 3: Madhavaram Milk Colony to Sholinganallur

Summary is presented in **Table 2.1** and list of stations in **Table 2.2**. The alignment plan is shown in **Figure 2.1**.

Table 2.1 Summary of Sections of Corridor-3

Corridors	Length (km)			Number of Stations		
	Under ground	Elevated	Total	Under ground	Elevated/ At Grade	Total
Corridor-3	26.340	8.960	35.300	30	10/0	40

Table 2.2 List of Stations for Corridor-3

Sl. No.	Revised Station Name	Chainage (m)	Inter-station distance (m)	Station Type
1	Madhavaram Milk Colony	-	0	UG (190x44.60) 2L
2	Thapalpetti	980	980	UG (150x21.40) 2L with ext. concourse
3	Murari Hospital	720	1700	UG (190x21.80) 2L
4	Moolakadai	761	2461	UG (190x21.80) 2L
5	Sembiyam	960	3421	UG (190x21.80) 2L
6	Perambur Market	861	4282	UG (190x21.80) 2L
7	Perambur Metro	727	5009	UG (150x21.40) ML
8	Ayanavaram	957	5966	UG (190x21.80) 2L
9	Otteri	1110	7076	UG (190x21.80) 2L
10	Pattalam	776	7852	UG (190x21.80) 2L
11	Perambur Barracks Road	869	8721	UG (190x21.80) 2L
12	Doveton Junction	829	9550	UG (190x21.80) 2L
13	Purasaiwakkam High Road	614	10164	UG (150x21.40) 2L with ext. concourse
14	Kelleys	677	10841	UG (150x21.40) 3L
15	KMC	683	11524	UG (150x21.40) ML
16	Chetpet Metro	838	12362	UG (150x21.40) ML
17	Sterling Road Junction	845	13207	UG (150x21.40) 2L With ext. concourse

18	Nungambakkam	747	13954	UG (150x21.40) ML
19	Gemini	642	14596	UG (150x21.40) ML
20	Thousand Lights	1071	15667	UG (150x21.40) ML
21	Royapettah Govt. Hospital	1041	16708	UG (150x21.40) ML
22	Radhakrishnan Salai Jn	1082	17790	UG (190x21.80) 2L
23	Thirumayilai Metro	1021	18811	UG (150x21.40) ML
24	Mandaiveli	1163	19974	UG (150x21.40) 2L With ext. concourse
25	Greenways Road Metro	919	20893	UG (190x21.80) 2L
26	Adyar Junction	1323	22216	UG (150x21.40) ML
27	Adyar Depot	1070	23286	UG (190x21.80) 2L
28	Indira Nagar	708	23994	UG (190x21.80) 2L
29	Thiruvanmiyur Metro	731	24725	UG (190x21.80) 2L
30	Tharamani Link Road	993	25718	UG (190x21.80) 2L
31	Nehru Nagar	1077	26795	Elevated (140x32.35)
32	Kandanchavadi	962	27757	Elevated (140x37.04)
33	Perungudi	796	28553	Elevated (140x32.35)
34	Thoraipakkam	1051	29604	Elevated (140x32.35)
35	Mettukuppam	931	30535	Elevated (140x32.35)
36	PTC Colony	998	31533	Elevated (140x32.35)
37	Okkiyampet	860	32393	Elevated (140x32.35)
38	Karapakkam	872	33265	Elevated (140x32.35)
39	Okkiyam Thoraipakkam	808	34073	Elevated (140x32.35)
40	Sholinganallur	971	35044	Elevated (140x60.00)

2.3.2 Corridor-5: Madhavaram Milk Colony to CMBT

Summary is presented in **Table 2.5** and list of stations in **Table 2.6**. The alignment plan is shown in **Figure 2.1**.

Table 2.5 Summary of Sections of Corridor-5

Corridors	Length (km)			Number of Stations		
	Under ground	Elevated	Total	Under ground	Elevated/ At Grade	Total
Corridor-5	9.700	5.700	15.400	12	5/1	18

Table 2.6 List of Stations for Corridor-5

S. No.	Revised Station Name	Chainage (m)	Inter-station distance (m)	Station Type
1	Madhavaram Milk Colony	-	0	UG (190x44.60) 2L
2	Venugopal Nagar	870	870	At Grade(140X33.95)
3	Assissi Nagar	921	1791	Elevated (140x21.95)
4	Manjambakkam	874	2665	Elevated (140x21.95)
5	Velmurugan Nagar	800	3465	Elevated (140x21.95)
6	MMBT	816	4281	Elevated (140x21.95)
7	Shastri Nagar	944	5225	Elevated (140x21.95)
8	Retteri	1179	6404	UG (190x21.80) 2L
9	Kolathur	766	7170	UG (190x21.80) 2L
10	Srinivasa Nagar	1127	8297	UG (190x21.80) 2L
11	Villivakkam Metro	987	9284	UG (150x21.40) ML
12	Villivakkam Bus Terminus	748	10032	UG (150x21.40) 2L With ext. concourse
13	Nathamuni	853	10885	UG (190x21.80) 2L
14	Anna Nagar Depot	1037	11922	UG (150x21.40) 3L
15	Thirumangalam	1000	12922	UG (150x21.40) ML
16	Kendriya Vidyalaya, Anna Nagar	830	13752	UG (150x21.40) ML
17	Kaliamman Koil Street	782	14534	UG (150x21.40) ML
18	CMBT	730	15264	UG (150x44.60) 2L

2.4 STATION PLANNING

Station Design is dependent on the peak hour traffic load for each station. Accordingly maximum capacity required at any station for emergency evacuation has been adopted. The platform length is planned with the capacity of 6 cars/train.

2.5 SYSTEM DESIGN

2.5.1 Permanent Way

Gauge: Standard Gauge which is adopted for this metro railway permits sharper curves (120m), which is advantageous for metro alignment in urban scenario and results in minimized property demolition and property acquisition. The Land requirement for the maintenance depots is also lower in Standard Gauge. 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.

Formation: Ballastless track is proposed for elevated and underground stretches so as to optimize maintenance and risk to road vehicles. This will help reduce fugitive dust emissions during operation.

Welding: To minimize noise and vibrations, track joints are proposed to be welded.

2.5.2 Traction System

25 KV AC systems which have ability to carry high traffic at a reduced cost with higher efficiency of operation are proposed.

2.5.3 Rolling Stock

Rolling Stock is of light weight stainless steel / aluminium resulting in energy efficiency and improved life thus improving resource utilization and environmental quality.

2.5.4 Ventilation and Air-Conditioning System

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 odours and harmful gases
- Removing large quantity of heat dissipated by the train equipment like traction motors, braking units, compressors mounted below the under-frame, lights and fans inside the coaches, A/c units etc.
- Removing vapour and fumes from the battery and heat emitted by light fittings, water coolers, Escalators, Fare Gates, etc. working in the stations;
- Removing heat from air conditioning plant and sub-station and other equipment, if provided inside the underground station.

2.5.5 Signaling System

Communication based Train Control (CBTC) Signalling & Train Control system is proposed. This helps increase safety and reduces demand on passenger evacuation systems which ultimately improves environmental quality.

2.5.6 Fare Collection System

Automatic fare collection which enables ease of use / operation, issue of single/multiple journey tickets, amenability to quick fare changes and requires lesser manpower has been proposed. This system improves passenger egress from stations thus reducing power demand due to VAC and resulting environmental impact.

2.6 POWER SUPPLY SYSTEM

Energy efficient equipment is proposed to improve environmental quality.

2.7 DEPOT

A major depot is proposed at Madhavaram Milk colony.

2.8 CONSTRUCTION ACTIVITIES

Illustrative list of construction activities is placed below. These activities typically involve movement of earth and construction material, movement and placement of pre-cast elements:

- In-situ open foundations and piles of columns
- In-situ casting of columns
- Pre-cast segments or pre-cast non-segmental girders
- Boring of tunnels by Tunnel Boring Machine or open cut and cover / NATM.
- Cut and cover or NATM for in-situ construction of underground stations
- In-situ earth retaining structures like diaphragm walls, sheet piles, secant piles etc.

Chapter –3

Environmental Baseline Data

CHAPTER 3
ENVIRONMENTAL BASELINE DATA

3.1 ENVIRONMENTAL SCOPING

Environmental baseline data describes the existing environmental settings in the study area. The objective of Environmental Impact Assessment (EIA) is to ascertain the baseline environmental conditions and then assess the impacts as a result of the proposed project during various phases of the project cycle. The environmental baseline data has been compiled for:

- Land Environment (Physiography, Soils, Geology and Minerals)
- Water Environment (Water resources, water use and quality)
- Air Environment (Meteorology and Ambient Air Quality)
- Noise Environment (Noise level)
- Ecological Environment (Flora and Fauna)
- Socio-Economic environment (Demography and Socio-Economics, etc.)

A scoping matrix was formulated to identify the attributes likely to be affected due to the development of proposed project and is presented in **Table 3.1** in accordance with JICA's Guidelines.

Table 3.1 Scoping Matrix

No	Items	Evaluation (Scoping)		Evaluation (After survey)		Reason of evaluation
		Before/ under construction	Operation	Before/ under construction	Operation	
Pollution Control						
1	Air Pollution	B-	B+	B-	B+	Construction Phase: ·Construction works and operation of construction equipment will generate dust and exhaust gas. Operation Phase: ·Air pollution will be mitigated by reducing traffic congestion.

No	Items	Evaluation (Scoping)		Evaluation (After survey)		Reason of evaluation
		Before/ under construction	Operation	Before/ under construction	Operation	
2	Water pollution	B-	B-	B-	B-	Construction Phase: ·The project crosses the major water bodies by underground or viaduct structures. Therefore, there are few significant impacts of water pollution. However, corresponding to uncertainty of construction plan, monitoring of the water pollution should be introduced. Operation Phase: ·Waste water from the depot is treated to meet the standards of India, and discharged.
3	Soil pollution	B-	B-	B-	B-	Construction Phase: ·Bad maintenance construction machinery and vehicles may cause soil contamination by leak of oil. In case, the vicinity of the depot site may be contaminated. Operation Phase: ·Maintenance facility of depot may cause soil contamination by leak of oil.

No	Items	Evaluation (Scoping)		Evaluation (After survey)		Reason of evaluation
		Before/ under construction	Operation	Before/ under construction	Operation	
4	Waste	B-	B-	B-	B-	Construction Phase: ·Construction works will vast quantity of excavation soil. Suitable measure of the excavation soil should be proposed on D/D stage. Operation Phase: ·Illegal dumping from stations and depot will cause negative impacts on the environment.
5	Noise and Vibration	B-	B-	B-	B-	Construction Phase: ·Construction works will cause noise/ Vibration will be very small due to diaphragm wall method and cast-in-situ piling method. Operation Phase: ·Operation of trains may cause noise around viaduct sections. No complaint on vibration has come to CMRL, therefore the effect might be very small.
6	Ground subsidence	C	C	D	D	Construction Phase: Ground subsidence will occur if appropriate measures are not taken. Operation Phase: ·There might be a few negative impacts due ground subsidence.

No	Items	Evaluation (Scoping)		Evaluation (After survey)		Reason of evaluation
		Before/ under construction	Operation	Before/ under construction	Operation	
8	Bottom sediment	B-	D	D	D	Construction Phase: · The project crosses the major water bodies by underground structure. Therefore, there are few significant impacts of water pollution.
Natural Environment						
10	Ecosystem	B-	B-	B-	B-	Construction / Operation Phase: ·There are no negative impacts to rare species. However, monitoring survey of birds of which nesting are away from the marsh is recommended to minimize negative impacts to the ecosystem between PTC Colony and Okkiyampet Bus Terminal in Corridor 3entrusted to Department of Forest Tamil Nadu. Total number of 934 trees must be cut down however, 10 times of afforestation will conducted.
11	Hydrology	C	C	D	D	Construction / Operation Phase: · The project crosses the major water bodies by underground structure. Therefore, there are few significant impacts of water pollution.

No	Items	Evaluation (Scoping)		Evaluation (After survey)		Reason of evaluation
		Before/ under construction	Operation	Before/ under construction	Operation	
12	Groundwater	B-	D	C	D	Construction / Operation Phase: ·It is recommended to conduct groundwater monitoring at same places where base line data were obtained to confirm the impacts.
13	Geographical features	B-	D	D	D	Construction /Operation Phase: ·Geographical features will not significant due to project, therefore negative impacts might be very small.
Social Environment						
14	Resettlement/ Land Acquisition	A-	D	A-	B-	Pre-Construction Phase: ·1,004 PAFs and 3,424 PAPs are assumed due to land acquisition. Operation Phase: · Impact will remain if RAP is not applied appropriately.
15	Poor people	A-	A-	A-	A-	Construction Phase: ·Poor whose income might be affected are living in the project sites. Operation Phase: ·Further impacts will remain if RAP is not applied.
16	Ethnic minorities and indigenous peoples	C	C	D	D	Construction / Operation Phase: ·No ethnic minority or indigenous people is found, therefore Impacts is nil.

No	Items	Evaluation (Scoping)		Evaluation (After survey)		Reason of evaluation
		Before/ under construction	Operation	Before/ under construction	Operation	
17	Local economies, such as employment, livelihood, etc.	B-/B+	C	D	B+	Construction / Operation Phase: ·Some extent of negative impacts are assumed, however those will be small because of the new business opportunity created by MRT.
18	Land use and utilization of local resources	B-/B+	B+	B+	B+	Construction / Operation Phase: ·Some extent of negative impacts were assumed, however those will be very small.
19	Water usage	C	C	D	D	Construction / Operation Phase: · Supply of water from Chennai City will exceed the demand from sites; there will be few impacts on water usage.
20	Existing social infrastructures and services	C	C	B-	B-	Construction / Operation Phase: ·Affected utilities will be diverted/protected; therefore negative impacts will be small.
21	Social structure such as social capital and local decision-making institutions	C	C	D	D	Construction / Operation Phase: ·Negative impacts to local administrations will be assumed very small.

No	Items	Evaluation (Scoping)		Evaluation (After survey)		Reason of evaluation
		Before/ under construction	Operation	Before/ under construction	Operation	
22	Misdistribution of benefits and damages	B-	B-	D	D	Construction / Operation Phase: ·Since the benefits will be not distributed evenly, misdistribution were assumed, however "damage" will not arise among them. And benefits will be limited.
23	Local conflicts of interest	B-	B-	D	D	Construction / Operation Phase: ·Stations will be built within ROW, therefore impact will be very small.
24	Cultural heritage	C	C	D	D	Construction / Operation Phase: ·There is no cultural heritage in/around the project site.
25	Landscape	B-	B-	D	D	Before Construction / Construction Phase: ·So far there is no concern of stakeholders. However considerations on viaduct design is needed.
26	Gender	C	C	D	D	Construction / Operation Phase: · Measures to assist women groups during resettlement activity, including planning and implementation phases will be taken.

No	Items	Evaluation (Scoping)		Evaluation (After survey)		Reason of evaluation
		Before/ under construction	Operation	Before/ under construction	Operation	
27	Children's rights	C	C	B-	D	Construction / Operation Phase: ·There is a lot of educational facility. The structures of the project are underground and viaduct. Therefore school-commuting road will be divided by the project. However, on the construction period, considerations to secure the school-commuting road are required.
28	Infectious diseases such as HIV/AIDS	B-	D	B-	D	Construction Phase: ·Infection risks of HIV/AIDS may be increased among construction workers. Operation Phase: ·Since the Project aims improvement of urban traffic, the project will not directly concern spread of infection risks of HIV/AIDS.
29	Working conditions (including occupational safety)	B-	B-	B-	B-	Construction Phase: ·Inappropriate safety measures of contractor will deteriorate occupational safety. Operation Phase: ·Inappropriate safety measures of railway operator will deteriorate occupational safety.
Others						

No	Items	Evaluation (Scoping)		Evaluation (After survey)		Reason of evaluation
		Before/ under construction	Operation	Before/ under construction	Operation	
30	Trans-boundary impacts or climate change	B-	B+/-	B-	B+	Construction Phase: ·Operation of construction machinery and vehicles will cause greenhouse gas (CO_2). Operation Phase: ·Modal shift to from vehicles to railway will reduce greenhouse gas.
31	Accidents	B-	B-	B-	B-	Construction Phase: ·There is a risk of accident on construction activity. Operation Phase: ·Collision of vehicle and viaduct, and accident in depot are expected.
32	Risk of flood	C	C	C	C	Construction / Operation Phase: ·Since the project site is a food prone area, proven measures against inundation will be installed. Details of the measures will be studied in D/D phase.

A+/-:Significant positive/negative impact is expected ; B+/-:Positive/negative impact is expected to some extent. C:Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses); D:No impact is expected

* Impact Items refer to "JICA Guidelines for Environmental and Social Considerations April 2010"

Source: Inputs from JICA Study Team, November 2017

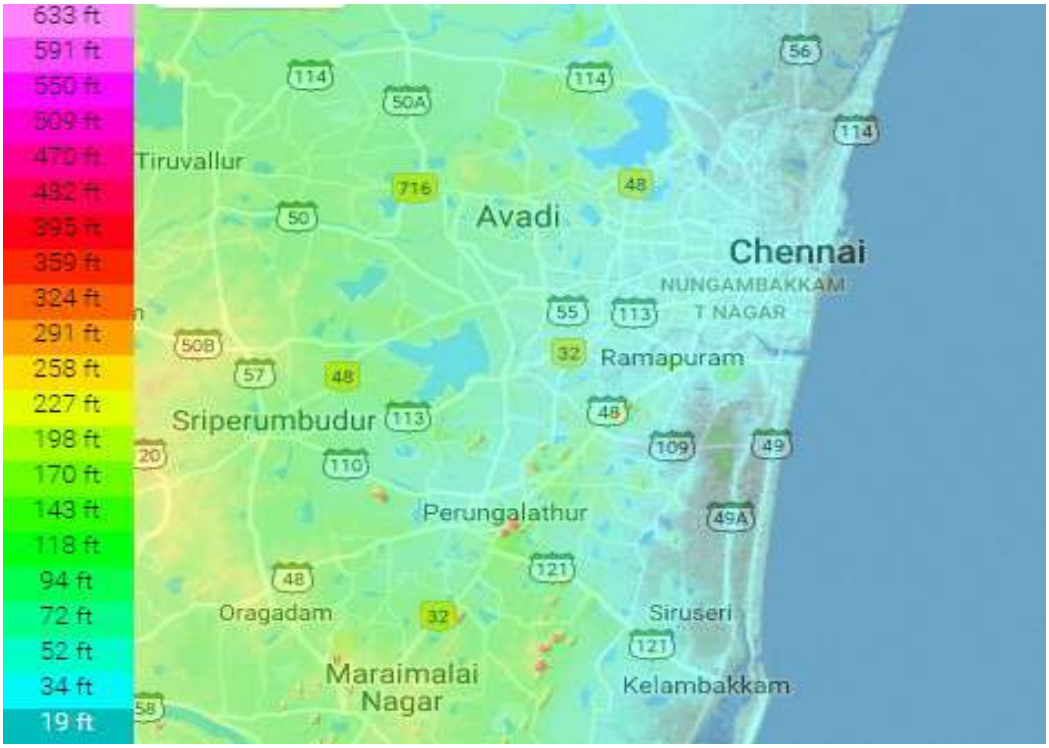
3.2 LAND ENVIRONMENT

The land environment primarily consists of physiography, soil,geology & minerals, and land use pattern.

3.2.1 Physiography

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. It is bounded by the Bay of Bengal on the east. 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 like a pancake. It rises slightly as the distance from the sea-shore increases but the average elevation of the city is not more than 22 ft above mean seal-level, while most of the localities are just at sea-level and drainage in such areas remains a serious problem. The topographical map of the study area is shown in **Figure 3.1**.

Figure 3.1 Topographical Map of Study Area



3.2.2 Soil

The recent 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 (**Table 3.2**). 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.

Table 3.2 Major Soil Types in Chennai District

Sl. No	Name of Taluk	Major Soil Types
1	Saidapet	Alfisols
2	Ponneri	Inceptisols
3	Gummudipoondi	Inceptisols
4	Uthukottai	Inceptisols and Entisols
5	Pallipet	Inceptisols and Entisols
6	Thiruthani	Inceptisols
7	R.K. Pet	Inceptisols
8	Thiruvellore	Inceptisols and Altisols
9	Sriperumbudur	Inceptisols and Altisols
10	Kancheepuram	Alfisols
11	Walajapet	Inceptisols and Entisols
12	Arakanom	Inceptisols and Altisols

Source: cpheeo.nic.in

To know the actual condition of soil, samples were collected along the metro corridors, name of sampling locations are provided in **Table 3.3** and sampling location map is shown in **Figure 3.2**. The laboratory analysis results so obtained are reported in **Table 3.4**. The soils are slightly alkaline in nature. Organic matter content in soils varies from 1.02% to 1.29%.

Table 3.3 Sampling Locations for Soil, Air and Noise

S. No	Corridor – 3 Madhavaram Milk Colony to SIPCOT	Corridor – 5 Madhavaram Milk Colony to CMBT
A	Mulakadai to Madhavaram Milk Colony (Tapal Peti Bus stop)	Srinivasa Nagar
B	Purasaivalkam (Tana Road)	Anna Nagar West
C	Good Shepherd school	
D	Royapettai Government Hospital	
E	MGR Janaki College	
F	Sholinganallur Junction	

Figure 3.2 Monitoring Location Map for Air, Noise, Water and Soil

A, B, C, D, E, F – Represents location name (Refer Table 3.3)

Table 3.4 Results of Laboratory Analysis of Soil Sample

S No	Parameters		Corridor 3						Corridor 5	
			A	B	C	D	E	F	A	B
1	pH (at 25^{0}C)	-	7.96	7.97	7.27	7.17	7.19	7.66	7.56	7.02
2	Conductivity (1:2 soil water sus.)	mS/cm	0.21	0.17	0.11	0.15	0.13	0.16	0.68	0.18
3	Chloride	mg/kg	38.14	19.07	33.37	38.13	28.60	38.13	57.20	38.13
4	Available Nitrogen	Kg/hec	30.92	23.82	21.05	30.13	28.72	25.92	27.82	28.12
5	Total Zinc as Zn	mg/kg	14.96	12.27	14.65	13.55	15.02	14.76	13.25	12.98
6	Manganese as Mn	mg/kg	201.97	176.21	166.32	173.85	199.57	177.92	177.55	188.62
7	Total Lead as Pb	mg/kg	8.45	8.24	9.57	10.31	10.72	10.38	9.78	9.89
8	Total Copper as Cu	mg/kg	16.23	18.69	18.21	17.49	16.19	20.06	15.38	17.85
9	Organic Carbon	%	0.66	0.66	0.74	0.73	0.68	0.73	0.63	0.58
10	Water Soluble Sulphate	mg/kg	25.04	21.88	20.77	20.39	20.44	26.15	22.12	22.57
11	Boron	mg/kg	1.33	1.74	1.64	1.29	1.61	2.07	1.98	2.16
12	Iron	mg/kg	256.81	378.36	379.21	456.0	369.56	436.21	424.5	442.61
13	Nickel	mg/kg	12.63	15.98	12.36	20.01	20.37	18.64	18.32	16.18
14	Bicarbonate	mg/kg	92.16	142.08	126.47	141.30	138.47	148.52	127.91	138.26
15	Calcium	mg/kg	167.83	120.06	146.25	118.63	76.02	80.40	176.04	155.55
16	Magnesium	mg/kg	36.63	19.51	26.77	31.45	23.36	27.71	35.97	19.88
17	Sand	%	32.64	34.71	33.42	35.55	34.08	36.41	34.44	38.46
18	Silt	%	41.05	39.30	39.81	40.64	38.02	41.95	39.97	39.10
19	Clay	%	26.31	25.99	28.77	25.81	28.90	23.64	26.59	22.44
20	Sodium	mg/kg	53.05	57.20	234.10	51.05	46.20	76.05	231.75	41.75
21	Potassium	kg/hec	94.16	93.18	98.03	96.99	93.34	98.21	98.68	110.22
22	Sulphur	mg/kg	30.21	27.12	26.17	23.62	26.53	19.86	30.18	28.02
23	Organic Matter	%	1.03	1.14	1.29	1.28	1.26	1.15	1.09	1.12
24	Orthophosphate	mg/kg	73.58	72.64	75.03	70.65	72.08	73.20	67.23	74.27
25	Carbonate	mg/kg	4.12	4.92	3.98	5.01	5.02	4.28	3.58	4.95
26	Arsenic	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
27	Mercury	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
28	Cadmium as Cd	mg/kg	1.20	1.39	1.27	1.07	1.69	1.62	1.08	1.22

29	Molybdenum	mg/kg	0.65	0.58	0.70	0.48	0.68	0.75	0.66	0.69
30	Available Nitrogen	Kg/hec	278.12	308.17	318.62	261.31	298.33	301.47	267.60	298.73

Corridor 3- Madhavaram Milk Colony to Sholinganallur, Corridor 5 – Madhavaram(MMC) to CMBT
A, B, C, D, E, F – Represents location name (Refer Table 3.3)

3.2.3 Geology and Minerals

The geological formations in the region are from the Archaeans to the recent Alluvium (**Table 3.5**). 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.

3.2.4 Land Use Land Cover

There are uneven distributions of land use pattern in the city. The north and west of the Fort and older city are most congested areas, while the density of population is comparatively much low on the semi circular belt around these crowded areas. During last two to three decades, the settlement patterns at outskirts of city limits are on increase, which is encouraged growth of rapid transport and increasing sub-urban conglomerations.

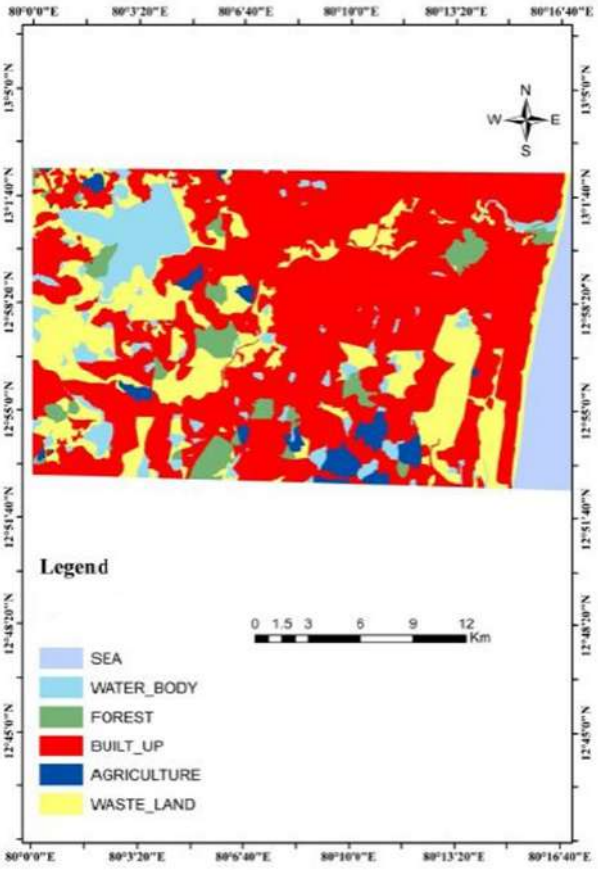
The land use land cover map (**Figure 3.3**) was prepared with the help of satellite imagery of 2006.It depicts that the built-up area is 58.05%, forest area 4.48%, water body 8.51%, agricultural land 2.75% and waste land is 20.27%.

Table 3.5 Geological Formation in the Project Area

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

Source: cpheeo.nic.in

Figure 3.3 Land Use Land Cover Map

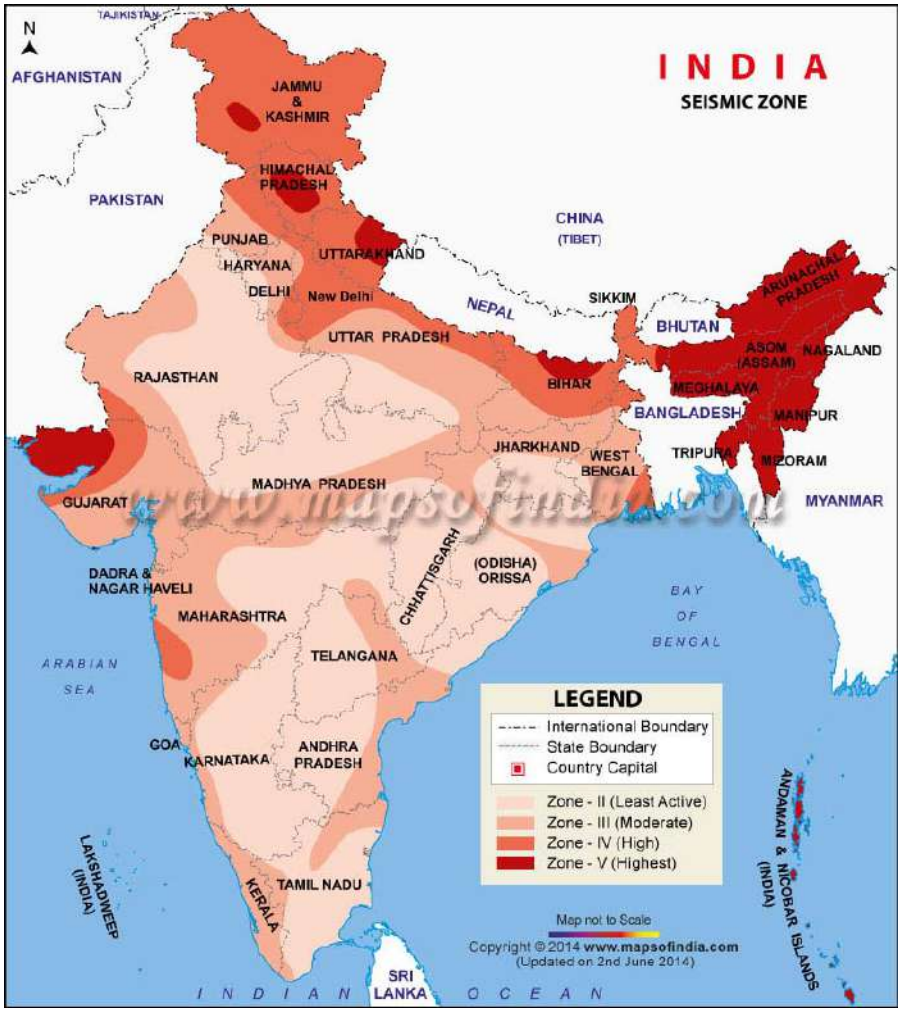


Source: IJETT–Volume1, Issue2–May 2011

3.2.5 Seismicity

Chennai is located in Moderate Seismic Hazard Zone (Zone III–BIS: 1893 (2001)). The seismic zoning map of India is shown at **Figure 3.4.**

Figure 3.4 Seismic Zone Map of India



3.3 WATER ENVIRONMENT

Water environment consists of water resources and its quality. Its study is important from the point of view to assess the sufficiency of water resources for the needs of in its various stages of the project cycle and also to assess the impact of the project activities on water environment.

3.3.1 Water Resources

Chennai is entirely dependent on ground water resources to meet its water needs. Ground water resources in Chennai are replenished by rain water and the city's average rainfall is 1,276 mm. Chennai, after having grown into a metropolis, is now the Chennai Metropolitan Area (CMA) for planning purposes. The CMA has 22 water courses, including three rivers, a canal, and four reservoir tanks. This also includes 16 minor waterways. Supply of ground water to the residents and sewage management in Chennai

is taken care of by the Chennai Metropolitan Water Supply and Sewage Board (MetroWater).The city supplies 830 million litres of water per day. The city will get additional 880 mld from sources such as Minjur desalination plant (100 mld), Krishna water (500 mld), Nemeli desalination plant (100 mld), and Cauvery water from Veeranam Tank (180 mld).

3.3.2 Drainage

Adyar River originates at the confluence (Thiruneermalai) of two streams that drains theupstream area of Chembarambakkam tank. It is a small river of 42 km length and acatchment of 800 Sq. km. The river carries flow all through 365 days of a year with anaverage discharge of 89.43 MCM/Year at Kattipara cause way. It drains the southern partof the district and remains flooded during monsoon. During the high tides, the backwaterfrom the Bay of Bengal enter inland up to 3 – 4 km.

Cooum is the other main river flowing through the central part of the district and carriesonly drainage water, which is highly polluted. It originates from the surplus waters fromthe Cooum tank in Tiruvallore taluk and the tanks, which are in enroute, discharge theirsurplus water into the river during flood season. The flow of Cooum River at Korattur is40.2 MCM/year for an average duration of 31 days in a year.

Otteri Nulla is another small stream flowing in the northern part of the city. Buckinghamcanal is the man made one for navigation purposes earlier, but now it act as seweragecarrier in the city.

3.3.3 Water Quality

Water quality includes the physical, chemical and biological characteristics of water. An understanding of the various factors influencing water quality is thus very important as human health is largely dependent on the quality of water available for use.

In order to assess the baseline water quality status of the study area, 8 samples along the two proposed priority corridors were collected. Description of water sample locations is given in **Table 3.6** and geographical locations are shown in **Figure 3.2**. The analysis of water samples is presented in **Table 3.7.**Laboratory analysis of water sample depicts that all parameters are in acceptable limit except some parameters viz turbidity, calcium, chloride, hardness, magnesium, mercury, lead are exceeded the permissible limit at six locations. Bacteriological contamination found at all locations. The water at six locations will be safe for drinking after proper treatment.

Table 3.6 Sampling Locations for Water

S. No.	Location	Remark
Corridor 3		
A	Mulakodai to Madhavaram Milk Colony (Tapal Petti)	Bore water
B	Purasaivalkam (Tana Road)	Bore water
C	Good Shepherd School	Bore water
D	Royapetai Govt. Hospital	Supply water/Tap water
E	MGR Janaki College	Bore water
F	Sholinganallur	Surface water
Corridor 5		
A	Srinivasa Nagar	Bore water
B	Anna Nagar West	Bore water

Table 3.7 Results of Laboratory Analysis of Water Sample

S. No.	Parameter	Unit	Result								Acceptable/Permissible Limit
			Corridor 3						Corridor 5		
			A	B	C	D	E	F	A	B	
1	pH at 25^{O}C	-	7.75	7.65	7.97	7.61	7.54	8.62	7.18	7.17	6.5-8.5/no relaxation
2	Turbidity	NTU	<1	<1	2.7	4.5	7.5	19.6	<0.1	<0.1	1/5 max
3	Total Dissolved Solids	mg/l	928	845	561	365	811	2686	818	656	500/2000 max
4	Aluminium as Al	mg/l	BDL	BDL	0.121	0.07	BDL	0.063	BDL	BDL	0.03/0.02 max
5	Free Amonia (as NH3)	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<1	-
6	Barium (as Ba)	mg/l	BDL	BDL	0.07	0.07	0.051	0.097	BDL	BDL	0.7 max/ no relaxation
7	Boran (as B)	mg/l	BDL	BDL	BDL	0.075	BDL	BDL	BDL	BDL	0.5/1
8	Calcium as Ca	mg/l	123.8	94.9	37.2	37.2	86.7	90.8	123.8	61.9	75/200
9	Chloride as Cl	mg/l	226.7	118.3	83.8	61.4	138	1261.5	192.2	147.8	250/1000
10	Copper as Cu	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05/1.5
11	Fluoride as F	mg/l	>1	>1	<1	<1	<1	>1	<1	<1	1.0/1.5
12	Iron as Fe	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.3/ no relaxation
13	Magnesium (as Mg)	mg/l	10	27.6	12.5	61.8	17.6	125.4	12.5	25.1	30/100

14	Manganese as Mn	mg/l	BDL	0.007	0.02	0.008	0.076	0.009	0.13	0.006	0.1/0.3
15	Nitrate as NO3	mg/l	10.1	2	BDL	BDL	2.7	1.8	BDL	BDL	45/ no relaxation
16	Phenolic Compounds	mg/l	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	0.01/ no relaxation
18	Silver (as Ag)	mg/l	BDL	BDL	BDL	0.0026	BDL	0.007	BDL	BDL	0.01/ no relaxation
19	Sulphate as SO4	mg/l	22.2	29.5	25.9	37.8	37.4	78.2	30	56.1	200/400
20	Sulphide (as S)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05/ no relaxation
21	Total Alkalinity as CaCO3	mg/l	245	411.6	215.6	117.6	294	313.6	343	245	200/600
22	Total Hardness as CaCO3	mg/l	350.2	350.2	144.2	154.5	288.4	741.6	360.5	257.5	200/600
23	Zinc as Zn	mg/l	0.062	BDL	BDL	BDL	BDL	BDL	0.23	BDL	5/15
24	Cadmium (as Cd)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.003/ no relaxation
25	Cynide (as CN)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05/ no relaxation
26	Lead as Pb	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01/ no relaxation
27	Mercury (as Hg)	mg/l	BDL	0.00025	BDL	0.0002	0.003	BDL	BDL	BDL	0.001/ no relaxation
28	Nickel	mg/l	0.0024	BDL	BDL	BDL	0.0024	0.003	BDL	BDL	0.02/ no relaxation
29	Total Arsenic as As	mg/l	BDL	0.015	0.006	BDL	BDL	0.005		0.0024	0.01/0.05
30	Total Chromium (as Cr)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05 max/no relaxation
31	Total Suspended Solids	mg/l	4	4	7	5	6	37	7	5	-
32	Vanadium (as V)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	-
33	Amonical Nitrogen (as N)	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<1	0.5/No relaxation
34	Total Kjeldahl Nitrogen (as N)	mg/l	12.6	3.1	0.11	0.14	3.6	2.5	0.56	0.73	-
35	Chromium (as Hexavalent Cromium)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	-
36	Oil and Grease	mg/l	<1	<1	<1	<1	<1	<1	<1	<1	-
37	Dissolved Oxygen	mg/l	5.3	5.5	5.5	5.4	5.3	3.9	5.6	5.8	-
38	Chemical Oxygen Demand	mg/l	28	12	20	20	28	100	12	8	-
39	Biochemical Oxygen Demand (3 day 27 deg C)	mg/l	11	6	7	7	11	35	5	2	-
40	Total Phosphate as P	mg/l	0.2	0.54	0.14	0.12	0.15	BDL	0.24	1.8	-
41	Dissolved Phosphate (as P)	mg/l	0.2	0.54	0.14	0.12	0.15	BDL	0.24	1.8	
42	Sodium as Na	mg/l	160	145	130	83.5	290	775	125	135	-

43	Potassium as K	mg/l	14.1	14.3	10.1	5.3	25	38	2.8	13.5	-
44	Nitrate Nitrogen	mg/l	2.3	0.45	BDL	BDL	0.61	0.41	BDL	BDL	-
45	Total Nitrogen	mg/l	12.6	3.1	0.11	0.14	3.6	2.5	0.56	0.73	-
46	Organic Phosphorus	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.002 max
47	Coliform Count	MPN/100 ml	<1	<1	<1	<1	28	<1	<1	22	Absent
48	Fecal Coliform	MPN/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	Absent
49	Total Coliform Organism	MPN/100 ml	<1	<1	<1	<1	9	<1	<1	15	Absent

Corridor 3- Madhavaram Milk Colony to Sholinganallur, Corridor 5 – Madhavaram(MMC) to CMBT
A, B, C, D, E, F – Represents location name (Refer Table 3.6)

3.4 METEOROLOGY AND AIR ENVIRONMENT

The ambient environment is responsible for the health of human beings, animals, wildlife and vegetation. The ambient environment covers climate, atmospheric pollution and noise pollution. All air pollutants emitted by point and non-point sources are transported, dispersed or concentrated by meteorological and topographical conditions. The meteorological parameters regulate the transport and diffusion of pollutants into the atmosphere. In order to assess the impact on existing ambient environment due to the project, it is necessary to have baseline status of ambient environmental parameters. Meteorological data on rainfall, wind, humidity, and temperature were collected from Indian Meteorological Department (IMD) for last five years. The ambient air quality and noise level had been monitored during the month of July 2016.

3.4.1 Meteorology

Meteorology is an important parameter in environmental impact assessment study. It is responsible for the movement of air and air pollutants. 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, windrose and relative humidity of the Chennai for a period of Jan 2011 to Dec 201 5collected from Indian Meteorological Department (IMD). Table 3.8and Table 3.9depicts that the hottest part of the year is May with maximum.

temperature varies 41.7°C to 42.8°C. The coolest part of the year is January, with minimum temperature varies 30.6°C to 31.2°C. Mean Relative Humidity at 0830 hrs and 1730 hrs are given in **Table 3.10** and **Table 3.11** respectively. It depicts that it varies 56% to 88% at 0830 hrs and 57% to 81% at 1730 hrs. The monthly rainfall is given in **Table 3.12**. The city gets most of its seasonal rainfall from the north–east monsoon winds, from mid–October to mid–December. Cyclones in the Bay of Bengal sometimes hit the city. The highest annual rainfall recorded is 1049.3mmin November 2015. Prevailing winds in Chennai are usually south-westerly between April and October and north-easterly during the rest of the year.

Table 3.8 Monthly Highest Maximum Temperature (Deg C)

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

Source: Regional Meteorological Centre, Chennai

Table 3.9 Monthly Lowest Minimum Temperature (Deg C)

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

Source: Regional Meteorological Centre, Chennai

Table 3.10 Monthly Mean Relative Humidity at 08:30 Hrs (%)

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

Source: Regional Meteorological Centre, Chennai

Table 3.11 Monthly Mean Relative Humidity at 17:30 Hrs (%)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2011	60	61	59	67	65	58	57	69	74	80	76	67
2012	68	61	68	70	65	59	61	70	73	77	73	78
2013	75	72	69	77	74	60	76	76	78	81	81	73
2014	69	67	64	68	68	66	65	74	75	80	77	76
2015	73	71	67	69	69	65	70	71	75	78	87	78

Source: Regional Meteorological Centre, Chennai

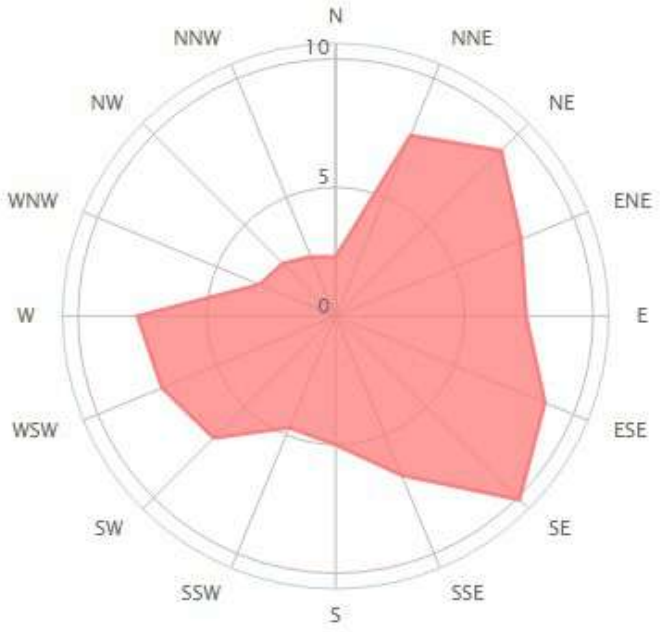
Table 3.12 Monthly Total Rainfall (mm)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2011	10.8	88.9	0.0	18.5	12.6	130.2	67.4	368.9	286.2	260	457.2	134.8
2012	16.3	0.0	1.6	0.2	0.0	24.7	79.9	89.5	214.1	422.6	47.0	125.5
2013	Trace	14.3	11.9	3.6	3.6	34.0	146.6	195.1	240.1	157.2	193.7	85.9
2014	0.1	9.9	0.0	0.0	13.5	96.2	69.7	222.6	130.8	405.5	196.9	149.9
2015	2.8	0.0	0.0	12.3	7.9	20.3	205.9	106.5	75.0	159.9	1049.3	454.7

Source: Regional Meteorological Centre, Chennai

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 3.5.**

Figure 3.5 Wind Rose Diagram for Chennai



3.4.2 Air Quality

The monitoring stations were selected to generate the representative samples for air quality covering residential, institutional and industrial area along the corridors.Location details are provided in **Table 3.3** andlocation map for air monitoring stations are shown in **Figure 3.2.** The monitoring results for ambient air quality of the study area are presented in **Table 3.13**.24 hour air quality monitoring results indicates that SO2, NO2, PM10 and PM2.5 were within the limits for residential, Industrial and rural areas. However CO exceeds prescribed limits. The National Ambient Air Quality Standard (NAAQ) laid down by Central Pollution Control Board (CPCB) given in **Table 3.14.**

Table 3.13 Ambient Air Quality of the Study Area

Sl No	Parameters	Unit	Concentration of Pollution							
			Corridor–3						Corridor-5	
			A	B	C	D	E	F	A	B
1	Sulphur Dioxide (SO_2)	$\mu g/m^3$	7.76	6.7	7.45	7.6	11.56	12.31	6.54	10.34
2	Nitrogen Dioxide (NO_2)	$\mu g/m^3$	15.21	9.3	9.9	9.84	10.20	14.85	9.66	14.67
3	Particulate matter (PM_{10})	$\mu g/m^3$	52.12	63.62	59.85	54.77	62.24	65.7	55.3	54.47
4	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	37.5	29.17	37.72	29.62	29.25	25.1	28.46	26.28
5	Carbon Monoxide (CO)	mg/m^3	5	4	9	9	8	9	4	9

Corridor 3- Madhavaram to Sholinganallur, Corridor 5- Madhavaram to CMBT
A, B, C, D, E, F – Represents location name (Refer Table 3.3)

Table 3.14 National Ambient Air Quality Standards

Pollutant	Time weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural &Other Area	Ecological Sensitive Area
Sulphur Dioxide (SO_2) µg/m3	Annual	50	20
	24 Hours	80	80
Oxides of Nitrogen (NO_2) µg/m3	Annual	40	30
	24 Hours	80	80
Particulate Matter (size less than 10µm) or PM_{10}µg/m3	Annual	60	60
	24 Hours	100	100
Particular Matter (size less than 2.5µm) or $PM_{2.5}$µg/m^3	Annual	40	40
	24 Hours	60	60
Carbon Monoxide (CO) mg/m3	8 Hours	02	02
	1 Hour	04	04
Ozone (O_3) µg/m^3	8 Hours	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

3.5 NOISE ENVIRONMENT

The noise data was collected over 24 hours in July 2016at hourly interval during morning, afternoon and evening such that peak and off peak hours are covered.The locations are listed in **Table 3.3** and marked in **Figure 3.2.**

Table 3.15 Ambient Noise Level Monitoring Results

Monitoring Location	Leq	L_{10}	L_{50}	L_{90}	L_{max}	L_{min}	L_{day}	L_{night}	L_{DN}
Corridor-3									
A	82.42	85.49	77	67.45	99.4	66.3	80.16	69.35	74.76
B	75.52	79.54	73.34	68.10	80.07	67.35	75.96	69.09	72.52
C	79.33	80.25	77.99	71.29	81.14	68.86	78.50	73.62	76.06
D	75.93	80.44	72.49	66.07	80.77	64.55	74.64	70.02	72.33
E	75.88	77.25	74.97	69.87	80.19	66.54	75.88	71.10	73.49
F	81.82	79.35	75.36	59.66	81.51	59.33	76.77	64.34	70.56
Corridor-5									
A	80.20	80.88	77.48	68.10	81.04	66.16	78.81	71.91	75.36
B	72.34	72.90	69.65	60.21	73.36	59.11	70.70	62.30	66.50

A, B, C, D, E, F – Represents location name (Refer Table 3.3)

The noise monitoring results are given in **Table 3.15**. The Ambient Noise Quality standards laid down by CPCB has been given in **Table 3.16**.The Noise Monitoring results shows that noise level at all locations are exceeding the noise level standards prescribed by CPCB either day or night or both for Residential Zone, Commercial Zone and Silence Zone as well except it is within permissible limit at Sholinganallur Junction at night.

Table 3.16 Ambient Noise Standards Criteria

Area Code	Category of Area	Limits in dB (A) Leq	
		Day time*	Night time
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence Zone**	50	40

Source: CPCB guideline(as per The Noise Pollution (Regulation and Control) Rules, 2000)
** Day timeisfrom 6.00 AM to 9.00 PM, *****Silence Zone*** *is defined as an area up to 100m around premises of Hospitals, Educational Institutions and Courts.*

3.6 ECOLOGICAL ENVIRONMENT

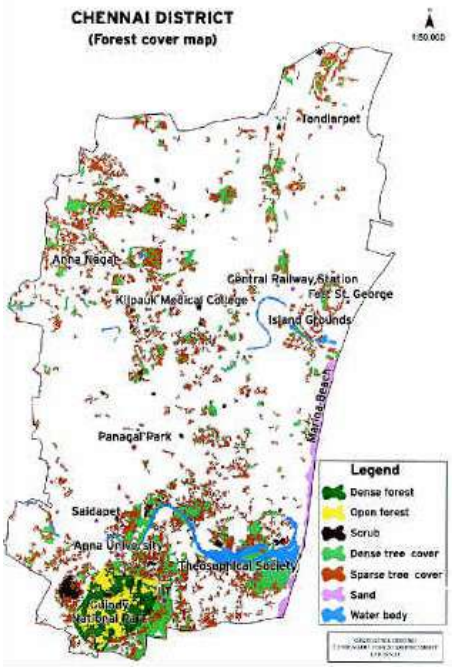
3.6.1 Forest

Chennai district is not endowed with many forest resources except the Guindy National Park with an area of 2.70 sq km, which is under Reserve Forest category. In terms of density of vegetation cover, the area falls under sparse category. The GuindyNational Park is classified under tropical dry evergreen forests of the Coromandal coast and is being used for recreational purposes. However, much of this park area botanically represents dry deciduous scrub jungle of the southern dry zone interspersed with more than 30 species of trees. The entire vegetation looks dry during summer months. But trees acquire a verdant look with the onset of monsoons.

3.6.2 Flora and Fauna

Tree count was carried out along the proposed alignment. Most of the trees exist along the road on sides and median. The predominant tree species along the two priority corridors are Plam, Eucalyptus, Tamarind (Tamarindus indica), Neem (Azadirachta indica), Banyan (Ficus Bangalensis) Vagai (Albizzia Lebhak), Mavalingam Tree (Creteva Religiosa) and country trees along the alignments. The output of tree count is presented in **Table 3.17.**

Figure 3.6 Forest Cover Map of Chennai District



Site construction activities will results in loss of about 934 trees. No rare or endangered species of trees were noticed during field studies. 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 3.17 Summary of Tree Count

S. No	Description	Number of Trees
Corridor-3		
1	Alignment	275
2	Madhavaram Depot	541
	Sub-Total	**816**
Corridor-5		
1	Alignment	118
	Sub-Total	**118**
	Total	**934**

3.7 ARCHAEOLOGICAL SITES OR MONUMENTS

No archaeological monuments/sites are located on or along the proposed corridors.

The Ancient Monument and Archaeological Sites and Remains (Amendments and Validation) Act, 2010specifies the prohibited area of 100 m from site whereas regulated area is 200m from the limit of prohibited area. No construction is allowed in prohibited area while construction can be taken up in regulated area after getting the approval from the Archaeological Survey of India (ASI).

Chapter –4

Negative Environmental Impacts

CHAPTER 4
NEGATIVE ENVIRONMENTAL IMPACTS

4.1 GENERAL

Negative impacts likely to result from the proposed development have been listed under the following headings:

- Impacts due to Project Location;
- Impacts due to Project Design;
- Impacts due to Construction; and
- Impacts due to Project Operation.

For each of these headings, potential impacts have been considered, while recommendations for mitigating measures have been included in **Chapter 6.**

4.2 ENVIRONMENTAL IMPACTS

Negative impacts on the following environmental aspects have been identified.

- Land Environment
- Water Environment
- Air Environment
- Noise Environment
- Biological Environment
- Socio-Economic Environment

4.3 IMPACTS DUE TO PROJECT LOCATION

These impacts are:

- Displacement and loss of livelihood and impact on community assets
- Loss of bio-mass and bio-diversity
- Diversion of utilities
- Impact on Historical and Cultural Monuments.

4.3.1 Displacement and loss of livelihood and impact on community assets

This is dealt in the separate Social Impact Assessment (SIA)report.

4.3.2 Change of Land Use

Land will be required permanently for stations, Depot, Ramp and running sections. Both government and private land will be acquired for the project the detail of which is given in the section on civil engineering in the DPR.

4.3.3 Loss of Trees

The relative impact of urban forests and their management is much more significant for carbon dioxide than for oxygen (Oxygen Production by Urban Trees in the United States,

David J. Nowak, Robert Hoehn, and Daniel E. Crane, Arboriculture & Urban Forestry 2007). From this study amount of oxygen produced per tree per year for urban forests was adopted as 11 kg. 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.

There are approximately 934 trees which are likely to be cut during construction. With removal of these trees, the process for CO_2 conversion will get effected and the losses are reported below:

i)	Total number of Trees	:	934
ii)	Decrease in CO_2 absorption due to loss of trees	:	2,808 kg/year
iii)	Decrease in Oxygen production due to tree loss	:	10,274 kg/year

4.3.4 Diversion of Utilities

The alignment of the metro will negotiate a number of utilities which will have to be maintained in working order during different stages of construction.

4.3.5 Impact on Archeological Monuments/Sites

No archaeological monuments / sitesare directly affected due to proposed project.

4.4 IMPACTS DUE TO PROJECT DESIGN

Impacts due to project design are seen in following ways;

- Right of Way,
- Alignment and Architectural Design,
- Inter-modal integration,
- Uses of Energy and Water at stations.

4.4.1 Right of Way

Impact due to project design shall be vary depending upon whether the alignment is located underground, elevated or at-grade. In case of underground metro the space at ground level and above can continue to be used for roads and light structures and visual intrusion will be minimized. Underground metro also allows the advantage of low noise as compared to elevated line during construction and operation. However energy consumption in underground metro is higher compare to elevated metro.

4.4.2 Alignment and Architectural Design

An alignment with less number of curves improves average speed and system capacity resulting in economical operation. In elevated metro sleek structural elements provide aesthetic appeal. The space planning of stations has significant impact on safely of passengers, time spent in ingress & egress from station and energy consumption in stations.

4.4.3 Inter Modal Integration

Integration of metro with other modes especially walk, public transport and intermediate public transport (hired modes) is found to increase ridership and lesser congestion inside and outside the stations.

4.4.4 Use of Energy and Water at stations and depots

Consumption of energy for climate control, lighting and other facilities at stations is significantly reduced by proper design of passenger flow inside stations, space & facilities inside stations and multimodal integration facilities outside stations.

4.5 IMPACT DUE TO PROJECT CONSTRUCTION

- Air pollution due to construction,
- Noise Pollution
- Vibration Impacts and Risk to Existing Buildings
- Muck disposal,
- Transportation of construction material and soil,
- Impact due to Labour Camp
- Increased water demand,
- Impact on Ground water and Surface water Quality
- Impact due to land subsidence
- Soil erosion
- Impact due to Supply of Construction Material,
- Traffic diversions

4.5.1 Air pollution due to construction

Air pollution occurs due to excavation, loading and unloading of construction materials, vehicular and construction equipment emission and emission from the DG sets etc. Resulting pollution is short term.

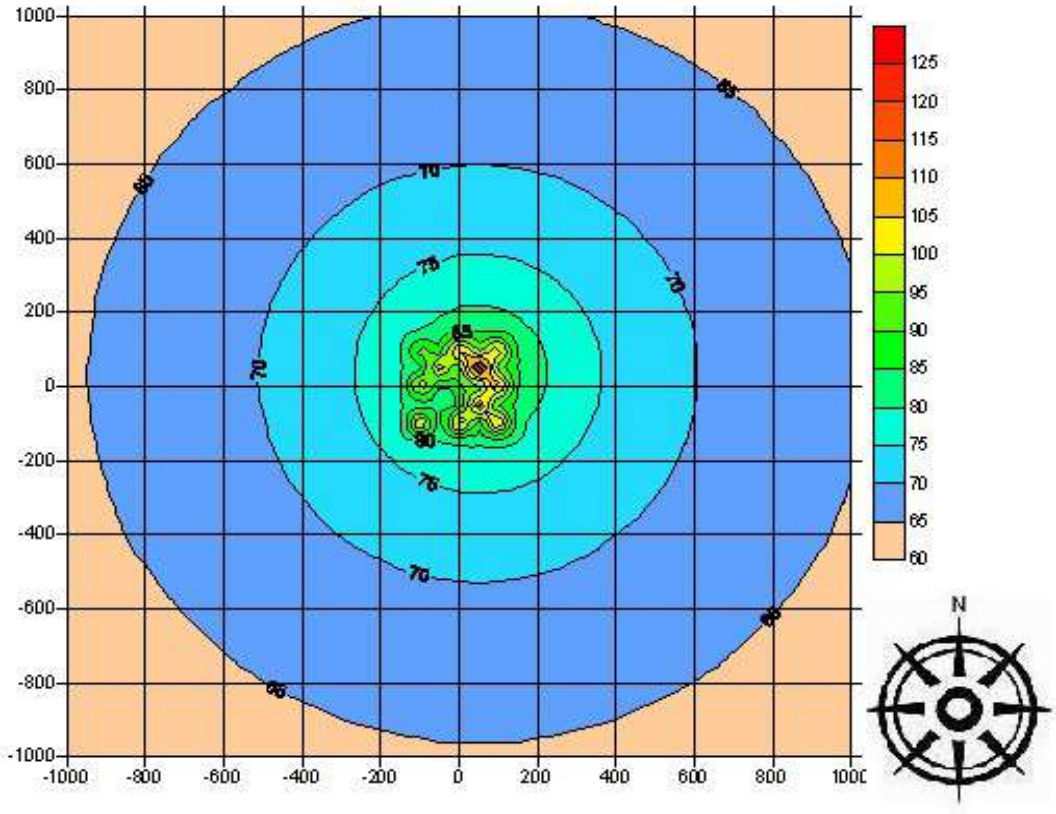
4.5.2 Noise Pollution

Noise is a contributing factor to degradation of human health. The major sources of noise pollution during construction are movement of vehicles for transportation of material and 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 overall noise during construction will be for short-term (for day time).

Noise modeling during construction phase was carried out using CPCB/MoEFCC approved noise model “DHAWANI” assuming that all the above equipments 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 4.1**.

Modeling 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 900 m. 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 specified for limited construction equipment reflect 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 modeling results it can beconcluded that all sensitive receptors (i.e. labour colonies) should be located beyond 125 meters from the noise generating source location during construction activities.

Figure 4.1 Spatial Variation of Construction Equipment Noise Levels dB(A)



4.5.3 Vibration Impacts and Risk to Existing Buildings

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

Damage to structures is a possibility in case of pile driving or trains passing within 7.5 m from normal buildings or unreinforced structures or between 15m to 30m from historical buildings or buildings in poor condition; heavy truck traffic within 30m, major construction within 60m, freight trains within 90m or pile diving within

180m can cause disruption of operation of sensitive instrumentation. Threshold criteria are listed in **Table 4.1.**

Table 4.1 Guideline Vibration Damage Threshold Criteria

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

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

Source: Transportation and Construction Vibration Guidance Manual, Caltrans, September 2013

4.5.4 Muck Disposal

The metro lines are a mix of elevated and underground right of way. The construction activity involves cut and cover, tunnel (bored and rock), foundation, fill and embankment. All these activities will generate about 4.06 Mm^3 of soil. Out of this, about 1.37 Mm^3 is likely to be reutilized in backfilling in underground stations and depot. The balance 2.69 Mm^3 shall be disposed in environmental friendly manner. The soil disposal site will be identified by CMRL/CMDA such that displacement of persons is not involved.

4.5.5 Pre-casting yards and Material stockpiling

Sites for casting of structural concrete elements and material stockpiling will be decided before start of construction. Land for these sites will be temporarily acquired from the owner like Municipal Corporation.The sites will be identified by CMRL/CMDA such that displacement of persons is not involved to the extent possible.

4.5.6 Pollution due to Transportation of Construction Material and Soil

Trucks and cranes are required to transport civil construction material from pre-cast yards and batching plants to construction site and between construction site and soil disposal site/source.

During the period of construction emission due to truck movement on account of transportation of civil construction material and disposal/backfill of earth is estimated to be as follows: CO, HC, NOx and PM will be about 78 tons, 2.5 tons, 162 tons and 3 tons respectively. Such transportation is estimated to result in fugitive dust emission of about 19 tons during the period of construction.

4.5.7 Impacts due to Labour Camps

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.

Based on recent metro construction practices observed in India. It is estimated that about 4837 persons comprising skilled labour (2419) and unskilled labour (2419) will work during peak construction activity on 50% sections of the two priority metro corridors on site, in casting yards and depots. Assuming that 30% labour are local (Chennai) and remaining 70% unskilled workers live at the labour camps and 80% of them are married of whom 80% have average family size as 4. Hence, total population in the labour camps will be 2472. The water requirement at camps will be 333 KLD, waste water generation 267 KLD & municipal solid waste generation 742 kg per day. This is tentative and will vary depending on the construction schedule during construction.

4.5.8 Increased Water demand

The demand for water and energy will increase during construction phase. The demand for water and energy will increase during construction phase. Water consumption during construction is of the order of 1657 KLD.

4.5.9 Impact on Ground and Surface Water Quality

Ground water contamination can take place if chemical substances get leached by precipitation of water and percolate to the ground water table. Dumping of construction materials which could result in hazardous leachate percolating into ground water; dumping of used water from the RMC plant; oils and greases from construction sites and labour camp are sources of water pollution.

4.5.10 Impact due to Land Subsidence

Land subsidence is anticipated at stations which will be constructed by cut and cover method. Suitable measures including maintaining adequate distance of the trench from existing structures adjacent the trench, measures to support the walls of the trench as well strengthen soil underneath adjacent structures will be required.

4.5.11 Soil Erosion

Run off from unprotected excavated areas, can result in excessive soil erosion, especially when the erodability of soil is high. Suitable engineering measures will be required.

4.5.12 Impact due to Supply of Construction Material

The procurement source of the construction materials will be decided by the Contractor, but it will be from existing licensed supplier.

4.5.13 Traffic Diversions

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

4.5.14 Impacts of Ambient Pollution on Human Health

Air pollution from road based vehicles especially particulates are found to cause diseases of brain, heart, lungs and kidneys:

- Higher levels of exposure to ambient PM are associated with worse cognitive decline (*Exposure to Particulate Air Pollution and Cognitive Decline in Older Women, Jennifer Weuve et al, JAMA Internal Medicine, February 2012*).

- Increased risk of fatal CHD associated with each 10 µgm/m^3 increase in annual PM(2.5) exposure. (*Chronic fine and coarse particulate exposure, mortality, and coronary heart disease in the Nurses' Health Study, Puett RC et al , Environ Health Perspect. November 2009*)

- Significant association between exposure to PM2.5 and risk of incident CKD, eGFR decline, and ESRD. (*Particulate Matter Air Pollution and the Risk of Incident CKD and Progression to ESRD, Benjamin Bowe et al, Journal of the American Society of Nephrology, September 2017*)

- The mortality rate advancement attributable to traffic pollution was similar to that associated with chronic respiratory and pulmonary diseases and diabetes (*Traffic Air Pollution and Mortality Rate Advancement Periods, Murray M. Finkelstein et al, American Journal of Epidemiology, July 2004*)

In addition to noise induced hearing loss, stress hormone increases and increase in the risk of myocardial infarction are caused by noise. (*Health effects caused by noise: Evidence in the literature from the past 25 years, H Ising, B Kruppa, Noise & Health, 2004)*

4.6 IMPACTS DUE TO PROJECT OPERATION

Along with many positive impacts the project may cause the following negative impacts during operation of the project:

- Noise pollution,
- Vibration,
- Energy supply at stations,
- Water supply and Sanitation at Stations,
- Pedestrian and Traffic Congestion around stations,
- Impacts due to Depot.

4.6.1 Noise Pollution

Airborne noise is radiated from at-grade and elevated structures, while ground-borne noise and vibration are of primary concern in underground operations.

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 at-grade and elevated structures, while

ground-borne noise and vibration are of primary concern in underground operations. Basic sources of wayside airborne noise are:

i) Wheel / Rail Noise : Due to wheel /rail roughness
ii) Propulsion Equipment: Traction motors, cooling fans for TM, reduction gears etc.
iii) Auxiliary Equipment: Compressors, motor generators, brakes, ventilation systems, other car mounted equipment
iv) Elevated Structure Noise
- At low speed(<15 km/h) auxiliary equipment may predominate
- At speeds up to approx. 50 km/h, W/R noise predominates
- At speeds greater than 50 km/h, the propulsion equipment noise predominates
- For light weight steel elevated structures, the structure noise can predominate at all speeds above 15 km/h

US data shows that the noise levels inside the rail transit cars range from about 65 to 105 dB(A) during normal operation. Wide range of noise levels depends on following factors:

i) Train speed (V): Car interior noise levels vary from 15 $\log_{10}$ V to 40 $\log_{10}$ V.
ii) Type of Way structure: Noise levels lowest on AG ballast and tie-welded track and highest for operations on light-weight structures and in tunnels with concrete track bed and no acoustic treatment.
iii) Sound Insulations of car body: Singleleaf or Sandwich construction.
iv) Type & Design of Mechanical Equipment: Propulsion system & Auxiliary Equipment (A/c system, compressors and motor generator sets).
v) Wheel and Rail conditions: Rail corrugations and wheel flats can increase the noise levels by 10-15 dB(A)

Predicted noise levels for the Project area were modeled in accordance with the Federal Transit Administration (FTA) guidelines. Predicted future noise levels in the Project area were based on existing measured sound levels and future daily metro rail operations. To provide a baseline for the analysis of potential noise effects caused by the metro operations, long-term (24-hour) measurements were conducted at 15 sites along the metro corridors, which include residences and other buildings where people normally sleep. During operation phase metro trains would run on corridors 3, 4 and 5. Corridors alignment and receptors locations with respect to the each corridor are shown in **Figure 4.2.**

Table 4.1 provides general information about Metro Rail operations considered for predicting noise level at all the 15 identified receptors location. The predicted noise levels were compared to the site-specific criteria to determine if there would be No Effect, a Moderate Effect, or a Severe Effect at each site as provided in **Table 4.2** respectively.

Table 4.2 Inputs to Noise Prediction

Alignment	Train Type	Train Speed (Kmph)	Length of Train (m)	Length of Power Unit (m)	Length of Leading unit (m)	Track Configuration	Trains per Hour per direction	Trains per day (7Am-10Pm)	Trains per Night (10Pm-7 Am)
Corridor-3	Electric	34	150	25	25	Viaduct	6	18	Nil
Corridor-5	Electric	34	150	25	25	Viaduct	8	22	Nil

Figure 4.2 Receptor Locations on Corridors

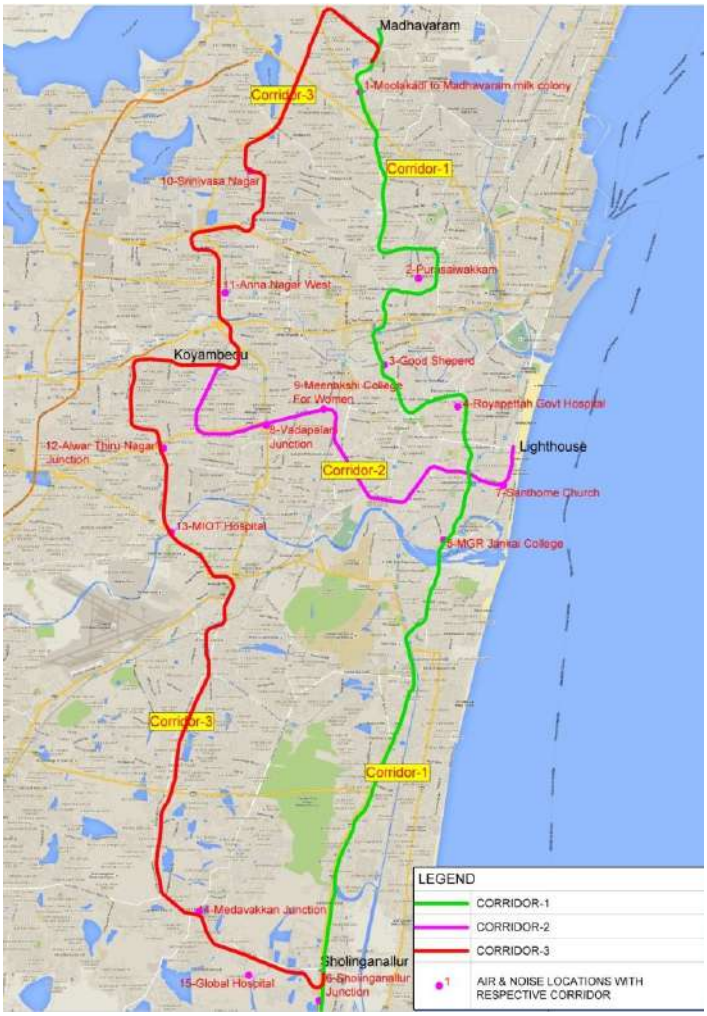


Table 4.3 Noise Levels from Metro Train Operations

S No.	Receptor Location	Receptor Distance from Corridor (m)	Existing Ld	Project Noise Exposure (Ld)	Combined N Noise Exposure (Ld)	Project Noise Effect
Corridor-3						
1	Mulakadai to Madhavaram Milk colony (TapalPeti Bus stop)	40	80.16	52.52	80.17	Low
2	Purasaivalkam (Tank Bus stop	469	75.96	36.49	75.96	Low
3	Good shephered school	67	78.50	49.17	78.51	Low
4	Rayapetai Government Hospital	266	74.64	40.18	78.50	Low
5	MGR Janaki College	65	75.88	49.35	75.89	Low
6	Sholinganallur Junction	92	76.77	47.09	76.77	Low
Corridor-5						
10	Srinivas Nagar	22	78.81	56.96	78.33	Low
11	Anna Nagar West	197	70.70	42.72	70.71	Low

Based on the noise modeling results it can be inferred that the effect of predicted day-time noise level have low impact with respect to the existing ambient noise environment.

4.6.2 Vibration

Passing of trains on elevated section as well as underground section causes vibrations. The dominant component of vibration due to passing on elevated section is horizontal while in tunnel vertical component is dominant. Impact is more in solid rock.

4.6.3 Energy Consumption at Stations

Energy is required at stations for facilities like lighting, passenger information, access, security, climate control, escalators/elevators etc.

4.6.4 Water Supply and Sanitation at Stations

The water demand at station comprising drinking, toilet, cleaning and air conditioning in Chennai will be of the order of magnitude indicated in **Table 4.3.**

Table 4.4 Water Requirement

S. No.	Particular	Water Demand at Each Station (KLD)	Total Water Demand (KLD)
2	In Underground stations	72	3024
3	In Elevated stations	14	224
		Total	**3248**

The water requirement for the stations will be met through the public water supply system. Municipal water supply will be supplemented by rain water harvesting along viaduct and at elevated stations. Solid waste generation from operational staff at stations is likely to be 15 ton per month. Sewage at stations is estimated to be 70 KLD. This will be led into the municipal network.

4.6.5 Road Congestion

Commencement of metro services results in passenger rush at stations which in turn results in congestion around stations.

4.7 IMPACTS DUE TO DEPOT

Construction of the one proposed depots will involve bringing in earth from outside. The earth from underground metro corridor tunnelling and cut and cover will be utilised to fill the depot sites. Problems anticipated at depot sites are:

- Water supply,
- Sewage and Effluent,
- Oil Pollution,
- Noise Pollution,
- Surface Drainage,
- Solid waste

- Loss of bio-mass and
- Loss of livelihood.

4.7.1 Water Supply

The water demand at Madhavaram depot for 3-day wash cycle is estimated to be 59 KLD for train washing and 42 KLD for domestic purpose including staff quarters.

4.7.2 Sewage and Effluent

About 37 KLD sewage from domestic activities and 53 KLD effluent from train washing will be generated at Madhavaram Depot.

4.7.3 Oil Pollution

Oil spillage during change of lubricants, cleaning and repair processes, in the maintenance Depot cum workshop for maintenance of rolling stock, is very common. The spilled oil should be trapped in oil and grease trap. The collected oil would be disposed off to authorised collectors, so as to avoid any underground/ surface water contamination.

4.7.4 Noise Pollution

The main source of noise from depot is the operation of workshop. The roughness of the contact surfaces of rail and wheel and train speed is the factors, which influence the magnitude of rail - wheel noise.

4.7.5 Surface Drainage

Due to the filling of the low-lying area for the construction of depots, the surface drainage pattern may change specially during monsoon. Suitable drainage measures form part of the engineering cost.

4.7.6 Solid Waste

Sludge will be generated from ETP/STP, oil, grease and metal shavings will be produced from car maintenance. It is estimated that municipal solid waste of about 3.6 ton per month will be generated from Madhavaram Depot including staff colony, office and workshop.

4.7.7 Cutting of Trees

As already discussed in **section 3.6.2 of Chapter 3**, about 541 number of trees are observed at Madhavaram Depot. These trees are tree likely to be cut; afforestation cost is given in the Environmental Management Plan.

4.7.8 Loss of livelihood

Loss of livelihood if any is dealt in SIA Report.

Based on above negative impacts, a summary of impacts has been prepared along with positive impacts in **Chapter 5.** The management plan to mitigate the negative impacts is reported in **Chapter 6.**

Chapter –5

Positive Environmental Impacts

CHAPTER 5
POSITIVE ENVIRONMENTAL IMPACTS

Various positive impacts have been listed under the following headings:

- Employment Opportunities,
- Benefits to Economy,
- Direct benefits to passengers,
- Traffic Noise Reduction,
- Reduction of Traffic on Road,
- Less Fuel consumption and
- Reduced Air pollution

5.1 EMPLOYMENT OPPORTUNITIES

During the period of construction manpower will be needed for various project activities. In post-construction phase, about 1715 people will be employed for operation and maintenance of the system. Thus, the project would provide substantial direct employment equal to the above number. In addition to these, more people would be indirectly employed in allied activities.

5.2 BENEFITS TO ECONOMY

The project will facilitate movement of people from different parts of Chennai. These corridors 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, improvement in quality of life and reduction in loss of productivity due to health disorders resulting from pollution.
However, in this study only savings in fuel consumption and reduction in air pollution have been quantified.

5.3 DIRECT BENEFITS TO PASSENGERS

The project will result in direct benefits to users of Metro and other modes: reduction in vehicle operating costs, savings in travel time, improvement in quality of life, reduction in loss of productivity due to health disorders resulting from pollution and reduction in road accidents.

5.4 TRAFFIC NOISE REDUCTION

A 50% reduction of the trafficvolume may result in a 3 dB reduction in noise levels, regardlessof the absolute number of vehicles.Reduction in traffic volume of 10% & 50%reduces noise at the tune of 0.5 dB & 3.0 dB[1]respectively.

[1]Relation between traffic volume & noise levels, Ellebjerg (2013)

5.5 REDUCTION OF TRAFFIC ON ROAD

The basis of reduction of vehicle is shift of ridership from road vehicle to the metro railway. The reduction in number of vehicles gives benefits to economy by reduction in Vehicle Operating Cost (VOC), Fuel Consumption, Pollution Load, Accidents and Travel Time etc.On implementation of the project, the consumption of petrol, diesel and CNG will get reduced. The estimated daily vehicle-kilometre that will be reduced due to the metro rail is given in **Table 5.1**.

Table 5.1 Reduction in Daily Vehicles Kilometer

Vehicle Type	2021	2026	2035	2045
Car	400775	622624	839745	955141
2W	578023	863578	995628	1406767
Auto (3W)	197914	344358	419085	621466
Bus	1008909	1781681	2516973	3411659

5.6 LESS FUEL CONSUMPTION

Based on number of daily vehicle kilometre reduction, daily reduction in fuel (diesel and petrol) consumption is reported in **Table 5.2**. It is estimated that about 3 Lakh litres of diesel and 0.44 Lakh litres of petrol will be saved in year 2021. These reductions will increase to 10 Lakh litres of diesel and 1.10 Lakh litres of petrol in year 2045. The saving of Diesel and Petrol will directly benefit the country in monetary terms. Daily net saving on fuel expenditure at current price level (November 2017) is given in **Table 5.3** and graphically represented in **Figure 5.1**. The estimated daily savings will be of about Rs 212 Lakh in year 2021, Rs 369 Lakh in year 2026, Rs 505 Lakh in year 2035 and Rs 678 Lakh in year 2045.

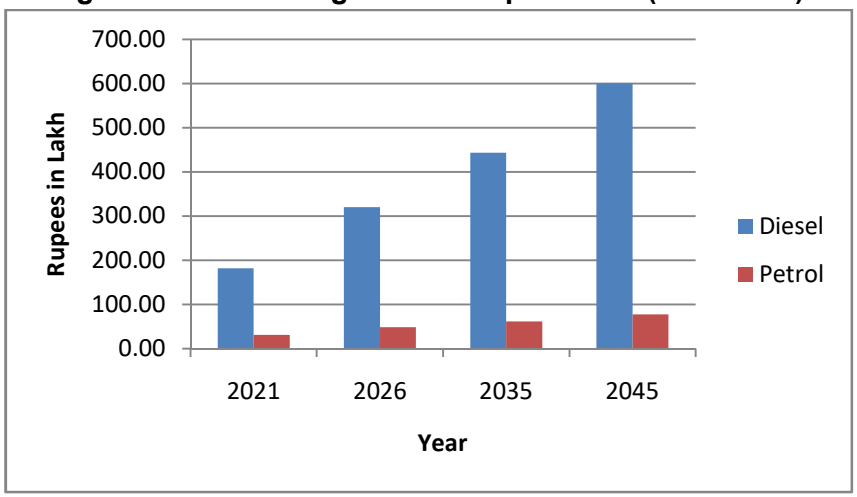
Table 5.2 Daily Reduction in Fuel Consumption (liter)

Mode/Year	2021	2026	2035	2045
Bus (Diesel)	302612	534397	738548	1001074
Car + Taxi (Petrol	27306	42422	56770	64571
2 Wheeler (Petrol)	7820	11683	13424	18968
3 Wheeler (Petrol)	8395	14606	17180	25476

Table 5.3 Daily Net Saving on Fuel Expenditure (Rs lakh)

Mode/Year	2021	2026	2035	2045
Bus (Diesel)	181.57	320.64	443.13	600.64
Car + Taxi (Petrol)	19.35	30.06	40.23	45.76
2 Wheeler (Petrol)	5.54	8.28	9.51	13.44
3 Wheeler (Petrol)	5.95	10.35	12.18	18.05
Total	**212.41**	**369.33**	**505.05**	**677.90**

Figure 5.1 Net Saving on Fuel Expenditure (Rs in lakh)



5.7 REDUCED AIR POLLUTION

Deaths per 1, 00,000 people from ambient PM 2.5 in South Asia (Bangladesh, India, Nepal and Pakistan) in year 2013 was 51. Welfare losses from ambient PM 2.5 in South Asia in year 2013 was estimated at USD 256 billion or 3.1% of GDP; respective labour output foregone was estimated at USD 31.4 billion or 0.39% of GDP.

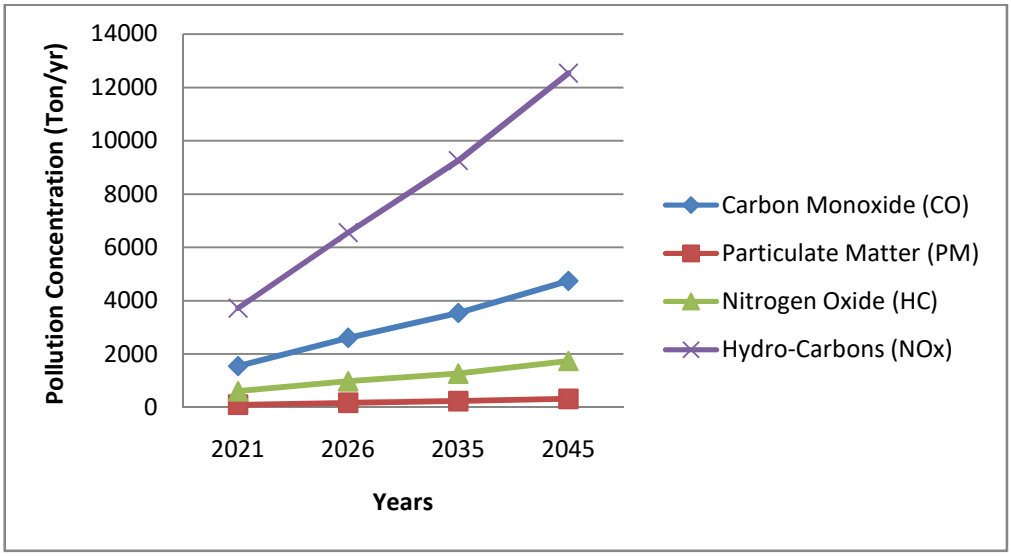
Welfare losses from air pollution in India in year 2013 was estimated at USD 505 billion and labour output foregone was estimated at USD 55 billion (*The cost of air pollution - Strengthening the Economic Case for Action, World Bank IHME 2016*).

The major vehicular air pollutants are Particulate matter, Nitrogen oxides, Carbon monoxide, Hydro Carbons and Carbon dioxide. In addition, un-burnt products like aldehydes, formaldehydes, acrolein, acetaldehyde and smoke are byproducts of vehicular emissions. The reduction of air pollutants with the proposed priority corridors with BS III vehicles is presented in **Table 5.4** and **Figure 5.2**. Benefits accruing from Metro in terms of reduction in fuel consumption, pollution and costs with emission factors and policy-related changes for BS V, BS VI and electric vehicles are summarized in **Annexure 5.1.**

Table 5.4 Pollution Reduction (Ton/Year)

Pollutant	Year			
	2021	2026	2035	2045
Carbon Monoxide (CO)	1550.91	2609.57	3543.50	4741.51
Particulate Matter (PM)	98.17	169.88	235.60	319.05
Nitrogen Oxide (HC)	606.14	984.00	1271.22	1742.84
Hydro-Carbons (NOx)	3715.89	6554.05	9250.99	12532.90

Figure 5.2 Pollution Reduction (Ton/Year)



5.8 SUMMARY OF IMPACTS

The anticipated environmental impacts are listed in **Table 5.5**.

Table 5.5 Summary of Impacts

S. No.	Parameter	Negative Impact	No Impact	Positive Impact
A.	**Impacts due to Project Location**			
i.	Displacement of People	*		
ii.	Change of Land use and Ecology	*		
iii.	Loss of Cultural and Religious Structures	*		
iv.	Drainage & Utilities Problems	*		
v.	Impact on Local Transport Utilities			*
B.	**Impact due to Project Design**			
i.	Right of way		*	
ii.	Alignment and Architectural design			*
iii.	Inter modal integration			*
iv.	Use of Energy and Water		*	
C.	**Impact due to Project Construction**			
i.	Soil Erosion	*		
ii.	Air Pollution and Noise Pollution	*		
iii.	Health risk at Construction site	*		
ii.	Traffic Diversions and Risk to Existing Buildings	*		
iii.	Problems of Soil Disposal and Seepage Risk	*		
iv.	Labour Camp	*		
v.	Dust Generation	*		
D.	**Impact due to Project Operation**			
i.	Oil Pollution	*		
ii.	Noise	*		
iii.	Water Demand	*		
iv.	Pedestrian Issues			*

S. No.	Parameter	Negative Impact	No Impact	Positive Impact
v.	Visual Impacts			*
vi.	Employment Opportunities			*
vii.	Enhancement of Economy			*
viii.	Mobility			*
ix.	Safety			*
x.	Traffic Congestion Reduction			*
xi.	Less fuel Consumption			*
xii.	Reduced Air Pollution			*
xiii.	Carbon dioxide Reduction			*
xiv.	Reduction in Buses			*
xv.	Reduction in Infrastructure			*

Appendix 5.1

Appendix 5.1

Based on number of daily vehicle kilometre reduction, daily reduction in fuel (diesel and petrol) consumption is reported in Table below**.** In accordance with the report commissioned by Niti Aayog, 100% of 3 wheelers and buses have been assumed to be electric from year 2030 onwards and so reduction in fossil fuel pollutants and reduction in CO2 emissions of 3 wheelers and buses due to Metro operation from 2030 onwards are nil. Reduction in pollutants as well as reduction in CO2 emissions from fossil fuel vehicles from this year onwards is likely to fall; reduction in CO2 emissions due to electric vehicles will manifest.

DAILY REDUCTION IN FUEL CONSUMPTION (LITRE)

Mode/Year	2021	2026	2035	2045
Bus (Diesel)	247585	437222	0	0
Car (Diesel)	1732	2690	1392	1584
Car (Petrol)	16111	25030	15868	18048
2 Wheeler (Petrol)	6077	9079	4806	6791
3 Wheeler (Diesel)	5908	10279	0	0

DAILY SAVINGS ON FUEL EXPENDITURE (Rs LAKH)

Mode/Year	2021	2026	2035	2045
Bus (Diesel)	149	262	0	0
Car (Diesel)	1	2	1	2
Car (Petrol)	11	18	11	13
2 Wheeler (Petrol)	4	6	3	5
3 Wheeler (Diesel)	4	6	0	0

Reduced Air Pollution

Emissions from passenger vehicles during operation of Metro were estimated using the following criteria:

Emissions from passenger vehicles during operation of Metro were estimated using the following: a) based on mode wise yearly number of registered vehicles from year 2005 to 2014 estimate yearly number upto year 2020-21 b) retiral of pre-BS VI vehicles without addition starting 2020 c) presence of BS VI vehicles as in 2030 d) presence of electric vehicles as in 2030 as per RMI-Niti Aayog report of May 2017 : 40% of cars and 2wheelers, all 3 wheelers and buses will be electric d) respective shares in vehkm ie., no impact of increased public transport or landuse changes e) emission factors and fuel efficiency factors from CMP Toolkit 2014 for sustainable transport scenario and draft BS VI emission factors issued in February 2016 converted to gm/km f) Co2 emissions from petrol and diesel consumed and from grid power produced to operate electric vehicles and Metro. CO2 emissions from manufacturing and operation of petrol cars are estimated to be twice as much as

BEVs. *(Cleaner cars from cradle to grave, Union of Concerned Scientists, Nov 2015).* However CO2 emissions from manufacturing have not been incorporated in this EIA.

Human Health cost of total lifecycle PM2.5 emissions caused by production and consumption of gasoline and cost of capturing carbon in GHG caused by production and consumption of gasoline was estimated by Hill et al (*Climate change and health costs of air emissions from biofuels and gasoline, Jason Hill et al, PNAS, 2008*). Based on these estimates, benefits for this project are estimated as follows.

DAILY BENEFITS

Benefit	Year			
	2021	2026	2035	2045
Reduction in Carbon Monoxide emission (ton)	6.89	12.88	1.08	1.39
Reduction in Particulate Matter (ton)	0.26	0.29	0.00	0.01
Reduction in Hydro-Carbons (HC) & Nitrogen Oxide (NOx) emission (ton)	9.96	11.51	0.18	0.23
Reduction in Carbon dioxide (CO_2) emission (ton)	743	1298	629	538
Net reduction in CO2 after accounting for CO2 added due to grid power generated for Metro operation	-	646	270	285
Reduction in cost of Human Health from lifecycle emissions of PM2.5 caused by gasoline and diesel (Rs lakh)	16	28	1.3	1.5
Reduction in cost of carbon capture from lifecycle emissions of GHG caused by gasoline and diesel (Rs lakh)	18	31	1.4	1.7

Chapter –6

Environmental Management Plan

CHAPTER 6
ENVIRONMENTAL MANAGEMENT PLAN

6.1 APPROVALS/CLEARANCES

Project Management Unit (PMU) will have to ensure that all necessary approvals/clearances are in place before start of implementation. Permissions necessary are listed in **Table 6.1.**

Table 6.1 Necessary Approvals/Clearances

S. No	Issues	Provision of Laws & Regulations	Due Date	Approving Authority
Pre-Construction Stage				
1.	Permission for felling of trees and compensatory afforestation	Tree removal will be guided as per state government rules.	Before Construction	Greater Chennai Corporation/Forest Department
2.	Environmental Clearance for Depot, stations, property development	Amendment dated 9 December 2016 to EIA Notification 2006		Greater Chennai Corporation
3.	Archaeological / heritage assets	The Ancient Monuments and Archaeological sites and Remains (Amendment and Validation Act) 2010		National Monuments Authority for protected Archaeological assets / Greater Chennai Corporation for heritage assets
4.	Utility / traffic diversion	Respective Acts and Rules		Local Offices of respective Agencies.
5.	Consent to Establish Depot	Water (Prevention and Control of Pollution) Act 1974 ; Hazardous Waste (Management and Handling and transboundary movement) Rules 2016		TN State Pollution Control Board; CMDA for landuse clearance
Implementation Stage				
6.	• Consent to Establish and Operate hot mix plant, crushers, batching plant etc and • Consent to Establishlabour camps	Air (Prevention and Control of Pollution) Act 1981	Before Construction	• TN State Pollution Control Board • Greater Chennai Corporation
7.	Permission for	Environment	Before	Regional Director, Central

S. No	Issues	Provision of Laws & Regulations	Due Date	Approving Authority
	drawalof groundwater for construction (**not recommended**)	(Protection) Act, 1986	Construction	Ground Water Board and CMWSSB
8.	Authorization for Disposal of Hazardous Waste	Hazardous Waste (Management and Handling and transboundary movement) Rules 2016	Before Construction	TN State Pollution Control Board
9.	Consent for disposal of waste water from construction sites and sewage from labour camps	Water (Prevention and Control of Pollution) Act 1974	Before Construction	TN State Pollution Control Board
10.	Labour employment, safety, welfare measures	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	Before Construction	District Labour Commissioner
11.	Permission for management of C&D waste and muck	Environment Protection Act 1956	Before Construction	Greater Chennai Corporation and TN State Pollution Control Board
Operation Stage				
12.	Consent to Operate Depot	Environment Protection Act 1956	After Construction	TN State Pollution Control Board
13.	Installation and operation of DG sets at stations	Air (Prevention and Control of Pollution) Act 1981	After construction	TN Pollution Control Board

6.2 MITIGATION MEASURES

The main aim of mitigation measures is to protect and enhance the existing environment of the project. This section includes measures for:

- **Location and Design**
  - Compensatory Afforestation,
  - Right of Way, Alignment and Architecture,
  - Spatial Planning of stations and Inter-Modal Integration
  - Provision for Green Buildings
  - Use of Energy and Water

- **During Construction**
  - Construction Material Management and Housekeeping
  - Hazardous Waste Management
  - Construction and Demolition Waste management
  - Energy Management
  - Labour Camp
  - Welfare of Labour on construction site
  - Safety of Labour
  - Utility Plan
  - Air Pollution Control Measures
  - Noise Control Measures
  - Vibration Control Measures
  - Traffic Diversion/Management
  - Soil Erosion Control
  - Muck Disposal
  - Dewatering of underground works

- **During Operation**
  - Noise and Vibration Management
  - Water Supply and Sanitation at stations
  - Rain Water Harvesting
  - Electro Magnetic Interference
  - Management Plan for Depot
  - Training & Extension

6.2.1 Location and Design

6.2.1.1 Compensatory Afforestation

Removal of air pollutants: Particulate matter in the atmosphere is intercepted by tree canopy. The particulates are retained on the plant surface or washed off by rain or dropped to ground with leaf fall. Urban trees have been found to remove PM10 and PM2.5 particulates from the atmosphere. Benefits in terms of reduced mortality. Removal of PM2.5 is lower than removal of PM10 but the health benefits are higher.*(Modeled PM2.5 removal by trees in ten US cities and associated health effects, David J Nowak, Satoshi Hirabayashi, Allison Bodine, Robert Hoehn, Elsevier, Environmental Pollution 178 (2013) 395-402).*

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.*
Location for afforestation will be decided by CMRL in consultation with owner of the land as well Forest Department such that displacement does not become necessary.

Increase in groundwater recharge: Quantity of rainfall percolating to a specified depth of soil was found to decrease with distance from canopy edge towards with minimum percolating quantity in open area. Soil infiltration is improved near trees due to litter and tree roots promoting activity of earthworms, insects etc. resulting in increased soil macro porosity. Under conditions where surface runoff of rain water is redistributed towards trees, net water stored in soil near trees increases. In case of trees in which at least 25% of their water intake from soil is from depth greater than 1.5m, 10 trees per hectare with canopy cover 5% provide the highest groundwater recharge: tree density greater than this optimal cover showed reduced groundwater recharge. *(Intermediate tree cover can maximize groundwater recharge in the seasonally dry tropics, U.LIstedtetal, February 2016, www.nature.com).*

The Department of Forests, Government of Tamil Nadu is responsible for the conservation and management of trees/forests in the project area. According to the results of the present study, it is found that about 934 trees are likely to be lost along the two priority corridors and Madhavaram depot. It is proposed to plant twelve saplings for each tree to be cut. Hence 11,208 trees need to be planted. Estimated compensatory afforestation cost is about **Rs 51.98 Lakh** for Corridor-3 and **Rs 124.55 Lakh** for Corridor-5. The afforestation cost for Madhavaram depot is included under Corridor 5. Native plant species are recommended for afforestation.

Cost of compensation of trees which are to be felled and which are located in the privately owned land is to be finalized by the Tamil Nadu Forest Department prior to start of construction. Budgetary provision @ Rs 5000 per tree has been included in Chapter of 8 of the SIA report.

6.2.1.2 Right of Way, Alignment and Architecture

Alignment is kept elevated where adequate width of right of way on roads is available. Viaduct and elevated stations shall be shaped to minimize visual intrusion.

6.2.1.3 Spatial Planning of Stations and Inter-Modal Integration

Adequate and well-laid out space shall be designed for concourses and platforms, escalators, elevators and staircases, lighting, turnstiles for normal and abnormal operating conditions; optimal height / depth of the stations, forced ventilation shall beprovided. Physical and operational integration of metro with other modes shall be planned. Adequate design of stations and multimodal integration prevents and mitigates congestion at stations. Safety is improved.

6.2.1.4 Provision for Green Buildings

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

Control annual heat gain through favorable orientation and design of facades and trees; 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 rain water harvesting ; reduced landscape water demand; Ensure zero SWD post-construction by means of ground water recharge and recharge of groundwater aquifers by rainwater ; low ODP building materials, indoor air quality and comfort, low-VOC paints and adhesives, 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. Solar energy generation per year is estimated to be 8.97 Giga-watt-hr for Corridor 3 and 3.70 Giga-watt-hr for Corridor 5. The installation cost for solar system is about **Rs 505.81 Lakh** and **Rs 208.65 Lakh** for Corridor 3 and Corridor 5 respectively.

6.2.1.5 Use of Energy and Water

Requirement of electrical energy for climate control, lighting and other facilities at stations shall be optimized by proper use of natural day/night light and design of passenger flow inside stations and on streets outside stations. Installations for solar power will be implemented in stations and Depot where feasible.

The water requirement for stations and depots will be met through the municipal water supply system. Municipal water supply will be supplemented by rain water harvesting along viaduct and at elevated stations and in depots.Sewage from stations and depots will be led into municipal network.Water required for horticulture and toilets at Depot will be sourced from recycling of used municipal water

6.2.2 EMP during Construction

Measures to mitigate impacts observed during construction shall be implemented by Contractor and duly monitored by Owner in accordance with approved method statements. Their cost is part of engineering and track cost.

6.2.2.1 Construction Material Management and Housekeeping

Procedures for storage, handling and transport of construction material shall be prescribed in SH&E method statement approved for construction.

Housekeeping is to keep the working environment cleared of all unnecessary waste, thereby providing a first-line of defense against accidents and injuries. It is the responsibility of Contractor and all site personnel. Some of the measures are listed below:

- Full height fence, barriers, barricades etc. shall be erected around the site in order to prevent the surrounding area from excavated soil, rubbish etc, which may cause inconvenience to and endanger the public.

- All stairways, passageways and gangways shall be maintained without any blockages or obstructions. All emergency exits passageways, exits fire doors, break-glass alarm points, fire-fighting equipment, first aid stations, and other emergency stations shall be kept clean, unobstructed and in good working order.

- All surplus earth and debris shall be removed/disposed off from the working areas to officially designated dumpsites. Trucks carrying sand, earth and any pulverized materials etc. shall be covered while moving.
    - Unused/surplus cables, steel items and steel scrap within the working areas shall be removed to identified locations.
    - All wooden scrap, empty wooden cable drums and other combustible packing materials, shall be removed from work place to identified locations.
    - Empty cement bags and other packaging material shall be properly stacked and removed.

Storage is another requirement:

- Proper and safe stacking of material is of paramount importance at yards, stores and such locations for future use. The storage area shall be well laid out with easy access and material stored / stacked in an orderly and safe manner.
- Flammable chemicals/compressed gas cylinders shall be safely stored.

6.2.2.2 Hazardous Waste Management

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.

It shall be the responsibility of the contractor to ensure that hazardous wastes 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 approach only Authorized Recyclers for disposal of Hazardous Waste, under intimation to the Project Authority.

6.2.2.3 Construction and Demolition Waste Management

Construction and Demolition (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 use after processing and grading.

- Segregation and temporary storage of reusable and recyclable materials at identified locations. Transport recyclable materials to construction sites.
- sale of metal scrap and other saleable waste to authorized dealers

- The construction and demolition waste generated should be disposed at site identified by CMRL away from any water body or river bank.
- Identification of intended transport means and route.
- Obtaining permission, where required, for disposal.

Sites for waste disposal will be decided by CMRL before start of construction in consultation with respective authority like Municipal Corporation etc. such that the sites are away from residential areas and do not require displacement

6.2.2.4 Energy Management

The contractor shall use and maintain equipment so as to conserve energy and shall be able to produce demonstrable evidence of the same upon the request of officer of the Project Implementation Unit.

Measures to conserve energy include the following:

- Optimizing the use of tools, plants and equipment to perform tasks with correct power,
- Optimizing cable size and joint can control voltage drops,
- Use of energy efficient motors (90% efficiency or more) and pumps (at least 80% efficiency),
- Replacing inefficient lamps with the most efficient lamp for the purpose, taking into account size, shape, colour and output of the lamp,
- Use of energy efficient motors, pumps, tools, cabling, lighting, emission standard
- Engine of DG set shall complies with CPCB norms
- Promoting employees awareness and training on energy conservation.
- Planning in advance and selecting location to receive and store material such that these are at the least distance from the place of use. Such an approach will result in less energy being consumed since optimum energy will be expended for transport of material,
- Maintenance schedule - setting up a maintenance schedule to clean and replace lamps on a regular basis,

6.2.2.5 Labour Camp

The Contractor during the progress of work will provide, erect and maintain necessary (temporary) living accommodation for construction workers at locations away from construction sites.

Water supply, waste water and sewage treatment: Uncontaminated water for drinking, cooking and washing, health care, latrines and urinals, system for conveyance, treatment and disposal of sewage and solid waste; adequate and clean washing and bathing places shall be provided. Wastewater shall be discharged to the existing sewage network.

Solid Waste Management: Solid waste generated will be collected and transported to local municipal bins for onward disposal to disposal site by municipality. Solid waste management facilities will be arranged by the construction contractors.

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, coordination with local health authorities.

6.2.2.6 Welfare of Labour on construction site

Shelter at Workplace: At every workplace, shelter shall be provided free of cost, separately for use of men and women labourers. The height of shelter shall not be less than 3m from floor level to lowest part of the roof. Sheds shall be kept clean and the space provided shall be on the basis of at least 0.5m^2 per head.

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.

First aid facilities: At every workplace, a readily available first-aid unit including an adequate supply of sterilized dressing materials and appliances will be provided. Suitable transport will 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 made so as to enable women workers to leave behind their children. At construction sites where 20 or more women are ordinarily employed, there shall be provided at least one temporary structure with sufficient openings for light and ventilation for use of children under the age of 6 years belonging to such women. There shall be adequate provision of sweepers and maid servants to keep the places clean.

6.2.2.7 Safety of Labour

Construction works shall be executed as laid down in the Safety Health and Environment (SHE) manual prepared by the Contractor and approved by PIU.

The SHE manual

- Describes the SHE interfaces between Employer and the Contractor.
- Details the processes by which the contractor shall manage SHE issues while carrying out the work under the contract.
- Describes by reference, the practices and procedures

The construction works shall be undertaken in accordance with all applicable legislation and Indian statutory requirements and guidelines-OHSAS 18001-1999: Occupational Health and Safety Management System and ISO 14001-2004: Environmental Management Systems.

The key elements of the SHE manual are as follows:

1. The unit responsible for co-ordinating and monitoring the Contractor's SHE performance;
2. Procedures for identifying and estimating hazards, and the measures for addressing the same; a list of SHE hazards anticipated
3. SHE training courses and emergency drills
4. SHE inspections to identify any variation in construction activities and operations, machineries, plant and equipment and processes against the SHE Plan and its supplementary procedures and programs: Planned General Inspection, Routine Inspection, Specific Inspection and Other Inspection
5. Safety Audit: SHE Audit to assess potential risk, liabilities and the degree of compliance of construction Safety, Health & Environmental plan and its supplementary procedures and programs against applicable and current SHE legalisation regulations and requirements of the employer.

   Electrical Safety Audit

   External SHE Audit
6. SHE Communication to communicate the Safety, Occupational health and Environment management measures through posters campaigns / billboards / banners / glow signs being displayed around the work site
7. SHE Reporting –reports, minutes, inspection reports, audit reports
8. Accident reporting and investigation
   - Reports of all accidents (fatal / injury) and dangerous occurrences to the Employer
   - Reporting to Govt. organisations
9. Investigations of Accidents and Dangerous Occurrences, Near misses and minor accidents
10. Prepare an Emergency Response Plan for all work sites including injury, sickness, evacuation, fire, chemical spillage, severe weather and rescue.

Workplace safety and occupational health shall be ensured with special focus on following areas:

a) Housekeeping
b) Working at Height and Falling objects and Danger areas
c) Lifting Appliances
d) Launching Operation
e) Construction machinery, tools equipment - Safe worthiness
f) employ qualified electrical personnel on site and requirements of electrical equipment, distribution etc
g) Lighting
h) Exposure of worker to use of exhaust or harmful gases in confined locations
i) Fire prevention, protection and fighting system
j) Corrosive substances
k) Demolition
l) Excavation and Tunnelling
m) Traffic Management
n) Personal Protective Equipment (PPEs)
o) Reporting which will contain results of monitoring and inspection

programs

p) Process of response to Inquiries, complaints and requests for information from private and government entities

q) Physical fitness of workmen

r) Medical Facilities on site : Occupational Health Centre, Ambulance van and room HIV/ AIDS prevention and control

s) Exposure to Noise – prevention measures

t) Ventilation and illumination

6.2.2.8 Utility Plan

The proposed Metro alignment run along major roads of the city and is required to negotiate sub-surface, surface and overhead utility services. Prior to the execution of work at site, detailed investigation of all utilities will be undertaken and plans for their retention in situ with precautions or temporary/permanent diversions prepared and got approved by respective agencies. As such, these may affect construction and project implementation time schedule/costs, for which necessary planning/action needs to be initiated in advance.

- Utility services shall be kept operational during the entire construction period and after completion of project. All proposals should therefore, ensure their uninterrupted functioning.
- The elevated viaduct does not pose any serious difficulty in negotiating the underground utility services, especially those running across the alignment. In such situation, the spanning arrangement of the viaduct may be suitably adjusted to ensure that no foundation need be constructed at the location, where, the utility is crossing the proposed Metro alignment. In case of utility services running along the alignment either below or at very close distance, the layout of piles in the foundations shall be suitably modified such that the utility service is either encased within the foundation piles or remains clear of them.

The Organizations / Departments responsible for concerned utility services are reported in **Table 6.2.**

Table 6.2 Organizations Responsible for Utilities and Services

S. No.	Organization/ Department	Utility/Services
1.	PWD	Road
2.	Chennai Municipal Corporation/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, street lights, high mast lights etc.
3.	NHAI	Roads
4.	Chennai Metro Water Supply and Sewerage Board (CMWSSB)	Water pipe lines
5.	BSNL (OFC)	Tele cables, junction boxes, telephone posts, O.H lines
6.	BSNL (Cables)	Tele cables, junction boxes, telephone posts,

S. No.	Organization/ Department	Utility/Services
		O.H lines
7.	Airtel, Aircel, Vodafone, Idea, Uninor	Telecommunications cables, junction boxes, telephone posts, etc.
8.	Power Grid Corporation of India Ltd.	HT towers, cables
9.	Irrigation Dept.	Canal
10.	BPCL	Gas pipe lines
11.	Gas Authority of India (GAIL)	Gas pipe lines
12.	Chennai Corporation and Tamil Nadu Generation and Distribution Corporation Limited (Tangedco)	HT/other overhead Power lines

6.2.2.9 Air Pollution Control Measures

During the construction period, the impact on air quality will be mainly due to increase in Particulate Matter (PM) along haul roads and emission from vehicles and construction machinery. Mitigation measures which shall be adopted to reduce the air pollution are presented below:

- The Contractor shall take all necessary precautions to minimize fugitive dust emissions from operations involving excavation, grading, and clearing of land and disposal of waste. He shall not allow emissions of fugitive dust from any transport, handling, construction or storage activity to remain visible in atmosphere beyond the property line of emission source for any prolonged period of time without notification to the Employer.
- Contractor's transport vehicles and other equipment shall conform to emission standards fixed by Statutory Agencies of Government of India or the State Government from time to time. The Contractor shall carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.
- The Contractor shall cover loads of dust generating materials like debris and soil being transported from construction sites. All trucks carrying loose material should be covered and loaded with sufficient free - board to avoid spills through the tailboard or sideboards.
- The temporary dumping areas shall be maintained by the Contractor at all times until the excavate is re-utilized for backfilling or as directed by Employer. Dust control activities shall continue even during any work stoppage.
- To extent feasible site shall be wetted during excavation and demolition
- Dust screens will be used especially where the work is near sensitive receptors.
- The Contractor shall provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from work sites such as construction depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt.

Capital and operating cost are included in engineering cost and therefore is not included in EMP.

6.2.2.10 Noise Control Measures

There will be an increase in noise level in the ambient air due to construction and operation of the Metro corridors. Exposure of workers to high noise levels need to be minimized by measures such as the following:

- Use of electric instead of diesel powered equipment,
- Use of hydraulic tools instead of pneumatic tools,
- Acoustic enclosures should be provided for individual noise generating construction equipment like DG sets,
- Scheduling work to avoid simultaneous activities that generates high noise levels,
- Job rotation,
- Sound proof control rooms etc.

The workers employed in high noise level area could be employed in low noise level areas and vice-versa from time to time. Automation of equipment and machineries, wherever possible, should be done to avoid continuous exposure of workers to noise. The workers employed in high noise level area should be provided with protective devices.

6.2.2.11 Vibration Management

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

At locations where the alignment is close to sensitive structures, the contractor shall implement a scheme to include:

- Pre-construction structural integrity inspections of historic and sensitive structures
- Information dissemination about the construction method, probable effects, quality control measures and precautions
- Monitoring during construction.

6.2.2.12 Traffic Diversion/Management

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.

- All construction workers should be provided with high visibility jackets
- Warn the road user clearly and sufficiently in advance.
- Provide safe and clearly marked lanes, buffer and work zones for guiding road users.

Various construction technologies like cut and cover can be employed to ensure that traffic impedance is minimized. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

6.2.2.13 Soil Erosion Control

The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. Works such as construction of temporary berms, slope drains and use of temporary mulches, fabrics, mats, seeding, or other control devices or methods as necessary to control erosion shall be implemented. Mitigation measures include careful planning, timing of cut and fill operations and re-vegetation. In general, construction works are stopped during monsoon season.

6.2.2.14 Muck Disposal

Measures need to be adopted for collection, transfer, temporary storage and disposal of excavated muck. Sites for muck disposal will be decided by CMRL before start of construction in consultation with respective authority like Municipal Corporation etc. such that the sites are away from residential areas and do not require displacement. The transfer and disposal of surplus soil may create air pollution and leached water problem. To mitigate these problems following mitigation measure are proposed to be adopted:

- The disposal sites will be cleaned and then treated so that leached water does not contaminate the ground water.
- Material will be stabilised each day by watering or other accepted dust suppression techniques. The muck shall be filled in the dumping site in layers and compacted mechanically.
- Stock-piling of earth with suitable slopes.
- Once the filling is complete, the entire muck disposal area shall be provided with a layer of good earth on the top and covered with vegetation.
- Before excavation, the Contractor will be required to test the soil quality including heavy metals and the results will be compared with US EPA standards. If the soil is contaminated, the polluter will be responsible for treatment and disposal.

6.2.2.15 Dewatering of underground works

Water from underground works shall be led by construction drains into sumps and then to trunk sewers or used to recharge groundwater or re-use for construction

6.2.3 EMP during Operation

6.2.3.1 Noise and Vibration Management

Use of ballast-less track with elastic and absorbent fittings is a standard provision for noise control. Vibration can be reduced by proper design and maintenance of track and rolling stock. Screening of noise shall be ensured by providing parabolic noise barriers on each side of the track along the curved portion of the viaduct and at stations during operation. Polycarbonate noise barriers 15 mm to 25 mm thick are known to reduce noise level by between 30 dB to 33 dB. No noise barriers are recommended along the elevated portion of both the corridors.

Deep and narrow trenches in the ground shall be tested at vibration-sensitive structures

6.2.3.2 Water Supply and Sanitation at Stations

Water supply for drinking, washing of stations, air conditioning and other uses will be procured from municipal authorities. Municipal water supply will be supplemented by rain water harvesting along viaduct and at elevated stations. Wastewater from station will be discharged to the existing sewage network. Non-hazardous solid waste generated in stations will be collected and transported to local municipal bins for onward disposal to disposal site by municipality.

6.3.3.3 Rain Water Harvesting

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 led into underground tanks; water collected will percolate down to the subsoil through layers of sand, gravel and boulders. Average annual rainfall of Chennai is 1541 mm. Considering a runoff coefficient of 0.85 the annual rainwater harvesting potential of elevated stations and viaduct is estimated as 2,02,513 cubic meter per year. Estimated cost for rainwater harvesting for viaduct and elevated stations is **Rs 163.48 Lakh** for Corridor-3 and **Rs 87.59 Lakh** for Corridor-5.

6.2.3.4 Electromagnetic Interference

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, signalling & telecommunication, traction power supply, E&M system etc) shall comply with the 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.

6.2.3.5 Management Plan for Depot

Management plan for Madhavaram Depot includes:

- Water Supply,

- Sewage/Effluent Pollution Control,
- Recycling of treated waste water.
- Oil Pollution Control,
- Solid waste disposal,
- Surface Drainage,
- Noise pollution mitigation

Water Supply: Water required for operation of depot shall be sourced from municipal supply. This shall be supplemented by rain water harvesting and recycled sewage.

Sewage Treatment and Effluent Treatment: Sewage will be generated from Madhavaram depot where maintenance staff work and their families reside. Sewage will be generated from depot which could be treated up to the level so that it could be used for horticulture purpose in the campus. For Madhavaram depot cost of Sewage Treatment Plant (STP) is estimated to be **Rs 78.11 Lakh.** Water required for horticulture at Depot will be sourced from recycling of used municipal water. Sludge from STP will be used as fertilizer. The waste water from depot will have oil, grease and, detergent as main pollutants. This has to be treated as per requirement of Tamil Nadu State Pollution Control Board. Effluent will be generated from maintenance activities and cost of Effluent Treatment Plant (ETP) is estimated as **Rs 95.70 Lakh.**

Rain water Harvesting: Rainwater harvesting potential of depots is calculated as 42,839 cubic meter per year. The estimated cost for rainwater harvesting for the depot is **Rs 15.06 Lakh**.

Oil Pollution Control: Oil spilled in Depot should be trapped in oil and grease trap and disposed to authorised collectors so as to avoid any underground/ surface water contamination.. Oil that is mixed in water shall be removed in the ETP. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

Solid Waste Disposal: The solid waste generated from the Depot will be taken by the cleaning contractor weekly and disposed to the municipal waste disposal sites in accordance with relevant National and State laws and regulations. Cost isnot included in EMP.

Surface Drainage: The Storm water will be collected through the drains and led to rain water harvesting pits andthe drainage system. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

Green Belt Development: 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 In addition to augmenting present vegetation, it will also check soil erosion, make the ecosystem more diversified. Estimated cost of green belt development for Madhavaram depot is included in cost of afforestation.

6.2.4 Training and Extension

The training for engineers and managers will be imparted by CMRL on regular basis to a) monitor implementation of approved EMS by Contractor b) monitor environmental status during operation and c) monitor disaster management during operation. The cost is estimated to be **Rs 12.60 Lakh** each for Corridor-3 and Corridor-5. Details are listed in **Table 6.3.**

Table 6.3 Cost for Training Programme

S. No	Item	Cost (Rs)	
		Corridor-3	Corridor-5
1	Curriculum Development and course preparation 1 months Rs.50000/month	50,000	50,000
2	Extension Officer (1 year) Rs. 20,000/month	7,20,000	7,20,000
3	Instructor 20 sessions of 10 days each	2,40,000	2,40,000
4	Demonstration/Presentation Aids	1,00,000	1,00,000
5	Material etc	1,50,000	1,50,000
Total		**12,60,000**	**12,60,000**

Apart from training, programme should include guidelines for safety, methods of disaster prevention, action required in case of emergency, fire protection, environmental risk analysis etc.

6.3 DISASTER MANAGEMENT

Disaster is an unexpected event due to sudden failure of the system, external threats, internal disturbances, earthquakes, fire and accidents. The first step is to identify the causes which develop/ pose unexpected danger to the structural integrity of Metro tunnel or overhead rail. The potential causes are excessive load, cracks, failure and malfunctioning of sensing instruments, accident, etc. These need to be looked into with care.

A disaster is a tragic event, be it natural or manmade, which brings sudden and immense agony to humanity and disrupts normal life. It causes large scale human suffering due to loss of life, loss of livelihood, damages to property and persons and also brings untold hardships. It may also cause destruction to infrastructure, buildings, communication channels essential services, etc.

Need for Disaster Management Measures: The effect of any disaster spread over in operational area of Chennai Metro is likely to be substantial as Project Authority deals with thousands of passengers daily in underground tunnels, viaducts and stations. Disaster brings about sudden and immense misery to humanity and disrupts normal human life in its established social and economic patterns. It has the potential to cause large scale human suffering due to loss of life, loss of livelihood, damage to property, injury and hardship. It may also cause destruction or damage to infrastructure, buildings and communication channels of Metro. Therefore there is an urgent need to provide for an efficient disaster management plan.

The first step is to identify the causes which develop/ pose unexpected danger to the structural integrity due to construction. The potential causes are excessive load, cracks, failure and malfunctioning of sensing instruments, accident, etc. These need to be looked into with care.

6.3.1 Preventive Action

Once the likelihood of a disaster is suspected, action has to be initiated to prevent a failure. Engineers responsible for preventive action should identify sources of repair equipments, materials, labour and expertise for use during emergency.

6.3.2 Reporting Procedures

The level at which a situation will be termed a disaster shall be specified. This shall include the stage at which the surveillance requirements should be increased both in frequency and details.

The Engineer-in-Chief should notify the officer for the following information:

- Exit points for the public,
- Safety areas in the tunnel/overhead rail, and
- Nearest medical facilities.

Procedures for reporting accidents during operation will take into account provisions contained in Metro Railways (Operation and Maintenance) Act, 2002

6.3.3 Communication System

An efficient communication system is absolutely essential for the success of any disaster management plan. This has to be worked out in consultation with local authorities. More often, the entire communication system gets disrupted when a disaster occurs. The damage areas need to be clearly identified and provided with temporary and full proof communication system.

6.3.4 Emergency Action Committee

To ensure coordinates action, an Emergency Action Committee should be constituted. The civic administrator may be the Chairman of this Committee. The committee may comprise of:

- Station Master concerned,
- Police Officer of the area,
- Chennai Transport Corporation Representative,
- Home Guard representative,
- Fire Brigade representative,
- Health Department representative,
- Department of Information and Publicity, and
- Non-Governmental Organization of the area.

Emergency Action Committee will prepare the evacuation plan and procedures for implementation based on local needs and facilities available. The plan should include:

- Demarcation of the areas to be evacuated with priorities,
- Safe route to be used, adequacy of transport for evacuation, and traffic control,
- Safe area and shelters,
- Security of property left behind in the evacuated areas,
- Functions and responsibilities of various members of evacuation teams,
- Setting up of joint control room.

All personnel involved in the Emergency Action Plan should be thoroughly familiar with all the elements of the plan and their responsibilities. They should be trained through drills for the Emergency Action Plan. The staff at the site should be trained for problem detection, evaluation and emergency remedial measures. Individual responsibility to handle the segments in emergency plan must be allotted.

Success of an emergency plan depends on public participation, their response to warning notifications and timely action. Public has to be educated on the hazards and key role in disaster mitigation by helping in the planned evacuation and rescue operations.
It is essential to communicate by whom and how a declared emergency will be terminated. There should be proper notification to the public on de-alert signals regarding termination of the emergency. The notification should be clear so that the evacuees know precisely what to do when re-entering or approaching the affected areas.

6.4 EMERGENCY MEASURES

The emergency measures are adopted to avoid any failure in the system such as lights, fire, means of escape, ventilation shafts etc. The aim of Emergency Action Plan is to identify areas, population and structures likely to be affected due to a catastrophic event of accident. The action plan should also include preventive action, notification, warning procedures and co-ordination among various relief authorities. These are discussed in following sections.

6.4.1 Emergency Lighting

The emergency lights operated on battery power should be provided at each station. The battery system should supply power to at least 25% of the lights at the station, platforms, tunnels/viaducts for a period of 2 hours. The underground station should have transformer at each end of the platform. Both the transformers need to be kept energized and should feed independently alternate rows of lights so that in case of failure of one transformer, there will not be complete darkness. The tunnels need to be provided with fluorescent incandescent lamps at a spacing of 20 m.

6.4.2 Fire Protection

The building materials should be of appropriate fire resistance standard. For underground structures the fire resistance period should be at least 4 hours, and 2 hours for surface or over head structures. Wood shall not be used for any purpose, excluding artificial wood products, which are flame resistant. The materials which have zero surface burning characteristics need to be used. The electrical systems shall be provided

with automatic circuit breakers activated by the rise of current as well as activated by over current. The design of a station will include provision for the following:

- Fire prevention measures,
- Fire control measures,
- Fire detection systems,
- Means of escape,
- Access for fireman, and
- Means of fire fighting.

Accumulations of refuse of any inflammable material like paper, plastic cartons constitute a major fire hazards and should not be permitted. Smoking should be strictly prohibited at all locations of MRTS.

All aspects of fire prevention and control will be dealt in close collaboration with the city fire fighting authority. Smoke control will be achieved by the following means:

- Down stand bulkheads of a minimum depth of 600 mm to provide smoke containment. These will be provided around openings for escalators, lifts and stairs in underground stations,
- In underground stations the ventilation system will be designed to extract smoke in the event of fire, and
- In enclosed public areas of above ground stations (e.g. a concourse located below a platform) arrangement for smoke extraction will be provided.

A minimum of 30 minutes supply of water is to be assured in the case of fire. The pumps/overhead tanks shall have the capacity to discharge the water at the rate of 1100 litres per minute at a head of 21 m at nozzle mouth.

The storage capacity in an underground or overhead tank may be divided into two parts i.e. dead storage and running storage. Fire fighting pumps shall be provided with a diesel pump as a standby arrangement, in case of power failure.

Fire of electrical origin, water cannot be used until the electric system has been made dead and earthened. For electrical fires, non-aqueous agents like ABC Power Chloro Bromo Methane or CO_2 gas are utilized for fire fighting. Fire extinguishers with these agents shall be liberally provided at static installations and on the rolling stock.

Generally there are often more casualties from smoke inhalation than from burning. Smoke need to be transported away from the site of the fire. In order to achieve this, both fresh air has to be introduced into the underground section and exhaust gases should be sucked out from other section.

Openings, including ducts and passages, between MRTS property and any adjoining structures which allow free access into the MRTS property will be protected by fire doors, fire shutters, fire dampers etc. as appropriate. Fire detection and alarm systems will be provided as per the prevailing state of art technology.

A. Fire Prevention and Safety Measures

Fire prevention measures will be designed and implemented to minimize the risk of outbreak of fire by appropriate choice, location and installation of various materials and equipment. In stations planning, potential sources of fire can be reduced by:

i. Fire Prevention

- Use of non-combustible or smoke retardant materials where possible,
- Rolling stock is provided with fire retarding materials, low smoke zero halogen type electric cable is also provide,
- Provision of layout which permits ease of maintenance for equipment and cleaning of the station premises,
- Provision of special storage spaces for combustible materials such as paint and oil,
- Prohibition of smoking in fire prone areas,
- Provision of cigarette and litter bins, and
- Good housekeeping.

ii. Safety

Following provisions will be required from fire safety point of view:

- Automatic sprinkler/detection system to be provided if floor area exceeds 750 sq.m
- One wet riser-cum-down comer per 1000 sqm floor area with static underground storage tank, overhead tanks and pumps of suitable capacity with hydrants, first-aid reel, etc.
- Portable fire non-aqueous extinguishers of Carbon di Oxide, chemical dry powder etc. at suitable places.
- Automatic smokes venting facilities.
- Two separate means of exit shall be provided, if more than 10 persons are working and the area exceeds 1400 sq.m
- Fire resisting doors shall be provided at appropriate places along the escape routes to prevent spread of fire and smoke.
- The travel distance for fire escape shall not exceed 20 m where escape is available in more than one direction; the distance could be upto 40 m.

B. Fire Alarm and Detection System

A complete fire detection system with equipment complying with the requirements of Chennai Fire Services shall be provided through out each station and ancillary buildings including entrance passageways, subways and adits etc. to give visual and audible indication of alarm conditions actuated by the operation of break glass contact or fire sensors e.g. detector heads, linear heat detecting cables etc. The system shall be operated from 24 V DC Power sources.

Manually operated call points shall be provided at every hydrant and nose reel points, station head wall, tail wall and other locations. Alarm bells shall be installed in each plant

room complex at both platform and concourse level and shall be clearly audible at all points in the room/area.

Beam detector or heat detector shall be installed at roof level, ceiling and floor cavity, whilst linear detecting cables shall be installed in under platform cable ducts and cable shafts.

Smoke probe units shall be installed in rooms/compartments. When an alarm point is operated, the fire pump shall start to operate automatically. A station fire control and indicating panel shall be provided an installed in the station controllers room, for the control, indication and monitoring of the whole detection and fire fighting systems. While designing the fire fighting system, the zone of Chennai Fire Services shall be taken into account for linking with the same.

C. Fire Control Measures

Control of the spread of fire and smoke will be achieved by partition of fire risk areas, planning for smoke extraction, and arrangement for smoke containment. Partition is aimed at limiting the extent of a fire. The openings must be capable of being sealed in the event of fire. With the exception of station public areas, a fire compartment will not exceed 1500 m^2. Partition of the public areas in stations is not practicable for operational reasons. The fire resistance period of this separated area should be about 3 hours.

D. Access for Fireman

A secondary access to the station, not used by passengers for evacuation, shall be available to fireman should the need arise. The entry point shall be easily accessible from the road. Access shall be available to all levels of the station. The minimum width of the stairs should be 1.0 m and maximum height should not exceed 60 cm.

6.4.3 Ventilation Shafts

The Environmental Control system for underground stations requires ventilation openings between various plants, plant rooms and the atmosphere. The tunnel vent shafts of approximately 20 sq. m. area shall be constructed at each end of the stations. There shall be supply shaft and exhaust shafts of similar dimensions at the stations

6.4.4 Emergency Door

The rolling stock is provided with emergency doors at both ends of the cab to ensure directed evacuation of passengers in case of any emergency including fire in the train.

6.5 SUMMARY OF ENVIRONMENTAL MANAGEMENT PLAN (EMP)

A preliminary EMP is presented in **Table 6.4,** which defines actions to be undertaken during the design stage, pre-construction, construction and operation stage of the project. The effectiveness of environmental considerations will, however, depend on appropriate inclusion of these in the work contracts.

Table 6.4Environmental Management Action Plan (EMAP)

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
DESIGN PHASE				
Metro Alignment	The proposed corridor alignment was selected to minimize the land disturbance to avoid environmentally sensitive areas in least.	During Design	DPR and design consultant	PIU
Cultural Heritage	Avoided by adjustment of alignment.	During Design	DPR and design consultant	PIU
Loss of Water Bodies	Utmost care taken to avoid alignment crossing water bodies	During Design	DPR and design consultant	PIU
Inadequate design provision for safety against seismological hazard	Make sure that design provides for safety of structures against worst combination of forces in the probability of an earthquake likely to occur in seismic zone-III.	DPR and detailed design stage	DPR and design consultant	PIU
PRE CONSTRUCTION STAGE				
Water requirement	The requirement of water shall be for construction purpose etc., shall be planned and shall be arranged in order to avoid digging of Tube wells.	Pre construction stage	Contractor	PIU/EMP implementing agency
Disposal of final treated effluent from treatment plat	Options for final disposal shall be studied and the suitable disposal route shall be decided carefully to minimize the impact of receiving bodies. As far as possible zero discharge rules may be adopted.	During design stage / and pre construction of treatment plant	Contractor	PIU/EMP implementing agency
CONSTRUCTION PHASE				
Environmental Management and Monitoring	This will include institutional requirements, training, environmental management and monitoring	During and after construction	Contractor	PIU/EMP implementing agency
Dust	Water should be sprayed during construction phase, wherever it is required to avid dust. Vehicles delivering materials should be covered to reduce spills and dust blowing off the load.	During construction	Contractor	PIU/EMP implementing agency
Air Pollution	Vehicles and machinery are to be regularly maintained so that emissions conform to National and State AAQ Standards.	Beginning with and continuing throughout construction	Contractor	PIU/EMP implementing agency
Equipment Selection maintenance and operation	Construction plants and equipment will meet recognized international standards for emissions and will be maintained and operated in a manner that ensures relevant air, noise, and discharge regulations are met.	During construction	Contractor	PIU/EMP implementing agency

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
Noise	Noise standard at processing sites, will be strictly enforced as per GOI noise standards. Workers in vicinity of strong noise will wear earplugs and their working time should be limited as a safety measure. At construction sites within 150m of sensitive receptors construction will be stopped from 22:00 to 06:00. Noise barriers (Stone walls and plantation) for silence zones including schools and hospitals, noise barriers at sharp curves.	Beginning and through construction	Contractor	PIU/EMP implementing agency
Vibration	The vibration level limits at work sites adjacent to the alignment shall conform to the permitted values of peak p velocity as given in article project SHE Manual	Beginning and through construction	Contractor	PIU/EMP implementing agency
WATER				
Contamination from Wastes	All justifiable measures will be taken to prevent the wastewater produced in construction from entering directly into river and irrigation system	Throughout construction period	Contractor	PIU/EMP implementing agency
Wastage of water	Measures shall be taken to avoid misuse of water. Construction agency shall be instructed accordingly to follow strict procedures while using the water for construction and drinking purpose.	Beginning with and continuing throughout construction	Contractor	PIU/EMP implementing agency
Sewerage disposal during construction at Service Centres	A minimum distance of any sewage or toilet facility from water sources should be 200 meters	Throughout construction period	Contractor	PIU/EMP implementing agency
Sanitation and Waste Disposal in Construction Camps	Sufficient measures will be taken in the construction camps, i.e. provision of garbage bin and sanitation facilities. Waste in septic tanks will be cleared periodically. Drinking water will meet Indian National Standards. Garbage will be collected in a bin and disposed of daily. Special attention shall be paid to the sanitary condition of camps. Camps will be located at a minimum distance of 200 m from water sources.	Before and during building of construction camps	Contractor	PIU/EMP implementing agency
SOIL				
Quarrying	Quarrying will be carried out at approved and licensed quarries only.	During construction	Contractor	PIU/EMP implementing agency

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
FLORA AND FAUNA				
Loss of trees and Avenue Plantation	Areas of tree plantation cleared will be replaced according to Compensatory afforestation Policy under the Forest Conservation Act. Trees will be planted against every tree cut as per norms (1:12 ratio).	After completion of construction activities	Forest Department	Forest Department
SOCIAL				
Loss of Access	Temporary access should be built at the interchange and other roads.	During construction	Contractor	PIU/ Traffic department
Traffic jams and congestion	If there are traffic jams during construction, measures should be taken to relieve the congestion with the co-ordination of transportation and traffic police department	During construction	Contractor	PIU/ Traffic department
Safety with vehicles, people and livestock and signage	• Safety education and fines. • Allow for adequate traffic flow around construction areas • Provide adequate signage, barriers and flag persons for safety precautions. • Communicate to the public through radio, TV & newspaper announcements regarding the scope and timeframe of projects, as well as certain construction activities causing disruptions or access restrictions	During construction	Contractor	PIU/ Traffic department
Increase in disease Water-borne Insect-borne Communicable diseases	• Make certain that there is good drainage at all construction areas, to avoid creation of stagnant water bodies. • Provide adequate sanitation and waste disposal at construction camps. • Provide adequate health care for workers and locate camps away from vulnerable groups	During construction At start-up Throughout construction	Contractor	PIU/EMP implementing agency
Location of camps depots and storage areas	Location of camps depots and storage areas shall be as per the contract specifications.	Throughout construction	Contractor	PIU/EMP implementing agency
OPERATION PHASE				
Noise and Vibration	Suitable measures should be considered where warranted. The public shall be educated about the regulations of noise and vibration pollution and its implications.	After completion of construction	PIU/EMP implementing agency	PIU/EMP implementing agency
WATER				
Oil pollution	Suitable treatment shall be taken for treatment oil before discharging the wastewater especially in depot areas.	During operation of the treatment plant	PIU/EMP implementing agency	PIU/EMP implementing agency
Maintenance of Storm Water Drainage	The urban drainage systems will be periodically checked and cleared so as to ensure adequate storm water flow.	Beginning and end of monsoon	PIU/EMP implementing agency	PIU/EMP implementing agency

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
System				
Disposal of final treated effluent from treatment plant	Options for final disposal shall be studied and the suitable disposal route shall be decided carefully to minimize the impact of receiving bodies. As far as possible zero discharge rules may be adopted.	During operation of the treatment plant	PIU/EMP implementing agency	PIU/EMP implementing agency
SOCIAL				
Safety and noise disturbances	New buildings should be prohibited within 50 m of the edge of carriageway. No new schools and hospitals should be allowed within 200 m of carriageway.	Throughout and after project development period.	Planning Department /PIU	PIU/EMP implementing agency

Chapter –7

Environmental Monitoring Plan

CHAPTER 7
ENVIRONMENTAL MONITORING PLAN

7.1 PRE-CONSTRUCTION PHASE

The environmental monitoring programme helps in signalling the potential problems resulting from the proposed project activities and will allow for prompt implementation of corrective measures. The environmental monitoring will be required during both construction and operational phases. The following parameters are proposed to be monitored:

- Water Quality
- Air Quality
- Noise and Vibration
- Ecological Monitoring and Afforestation
- Workers Health and Safety

Environmental monitoring during pre-construction phase is important to know the baseline data and to predict the adverse impacts during construction and operations phases. Pre-construction phase monitoring has been done for the proposed project for air, noise, water, soil quality and ecology. The results so obtained are documented in **Chapter 3**. The estimated environmental monitoring cost during construction and operation phases are **Rs 160.32 Lakh** for Corridor 3 and **Rs 86.34 Lakh** for Corridor 5.

7.2 CONSTRUCTION PHASE

Monitoring schedule for the entire period of construction is summarized in **Table 7.1**. The number of locations could be modified based on need when the construction commences. Monitoring should be carried out by NABL Accredited/MoEFCC recognized private or Government agency. The contractor will be responsible for carrying out monitoring during construction under the supervision of PIU. The results of air quality, water quality, waste water, vibration monitoring will be submitted to management quarterly during construction phase. The reporting formats of these results are presented at **Appendix 7.1.**

Table 7.1 Construction Stage Monitoring Schedule

Parameter	Frequency	Locations (number)	Reference/Standard	Implementation by / Approval by
Air	2x24 hours in a week for each season, four seasons in a year	8	• Guidelines for Ambient Air Quality Monitoring , CPCB, 2003 • National Ambient Air Quality Standards 2009	Contractor/CMRL& TNPCB
Noise	2x24 hours in a week for each season, four seasons in a year	8	• Protocol for Ambient Level Noise Monitoring, CPCB, May 2015 • ISO/ TC 108 (vibration)	Contractor/CMRL& TNPCB
Vibration	24 hours, once a two months	8		

Water (surface and ground water) and waste water	Once in a season, four seasons in a year	8	• Guide Manual – Water and waste water analysis, CPCB • Drinking water – Specifications IS 10500: 2012 and CPHEEO Manual 2012	Contractor/CMRL& TNPCB
Soil	Once in a season, four season in a year	8	US EPA test protocols	Contractor/CMRL& TNPCB
Ecology	Four time each year	Along corridor, at depots and afforestation sites.	As per Forest authorities	Contractor/CMRL& TN Forest Dept.
Worker safety	As per SH&E/EMS			

7.2.1 Ecological Monitoring

The Project Authority in coordination with the Department of Forest shall monitor the status of ecology/trees along the project corridors at least 4 times in a year during construction phase in order to maintain the ecological environment. The plantation/afforestation of trees by Department of Forest, Government of Tamil Nadu will be reviewed four times a year during construction phase.

7.2.2 Workers Health and Safety

Epidemiological studies at construction sites will be performed to monitor the potential spread of diseases. Regular inspection and medical checkups shall be carried out to workers health and safety monitoring. Any recurrence of health incidents shall be recorded and appropriate mitigation measures shall be taken. Contractor will be responsible to take care of health and safety of workers during construction and project proponent is responsible to review/audit the health and safety measures/plans.

7.3 OPERATION PHASE

The monitoring schedule is presented in **Table 7.2**. The results of air quality, water quality, waste water, vibration will be submitted to management bi-annually during operation phase.

Table 7.2 Operation Stage Monitoring Schedule

Parameter	Frequency	Locations (number)	Reference/Standard	Implementation by / Approval by	Period (years)
Air	2x24 hours in a week for each season, four seasons in a year	8	• Guidelines for Ambient Air Quality Monitoring , CPCB, 2003 • National Ambient Air Quality Standards 2009	CMRL / TNPCB	3
Noise	2x24 hours in a week for each season, four seasons in a year	8	Metro Rail Transit System, Guidelines for Noise and Vibrations, RDSO, Ministry of Railways, September 2015	CMRL / TNPCB	3
Vibration	24 hours, once a two month	8			
Water (surface and ground water)	Once in a season, two seasons in a year	1 depot	• Guide Manual – Water and waste water analysis, CPCB • Drinking water – Specifications IS 10500: 2012 and CPHEEO Manual 2012	CMRL/ TNPCB	3
Waste Water	Once in a season, two seasons in a year	1 depot			
Solid Waste	Once a year	1 depot	• Solid Waste Management Rules 2016	CMRL/ TNPCB	3
Soil	Once in a season, four season in a year	As required	US EPA test protocols	CMRL/ TNPCB	3
Ecology	Once a year	Afforestation sites	As per Forest authorities	CMRL / TN Forest Dept.	3

7.4 ESTABLISHMENT OF ENVIRONMENTAL DIVISION

It is recommended that Project Authority establishes an Environment Division at the initial stage of the project itself. This division should have an Environmental Officer and an Environment Engineer. The task of the division would be to supervise and coordinate studies, environmental monitoring and implementation of environmental mitigation measures, and it should report directly to Chief Engineer of the Project Authority. Progress of the division should be reviewed by an Environmental Advisor once in a year. The environmental Advisor should be an experienced expert familiar with environmental

management in similar projects. Cost for the first ten years (including 10% annual increase) is given in **Table 7.3**. The estimated cost for corridor is **Rs 171.45 Lakh** each for Corridor 3 and Corridor 5.

Table 7.3 Environmental Division Cost

S No	Head	Cost (Rs Lakh)	
A	**Capital Cost**	**Corridor-3**	**Corridor-5**
	Office Furnishings (Computer, furniture etc) LS	2.50	2.50
B	**Recurring Cost**		
	Man Power Cost (For 12 months)		
	Environmental Engineer @ Rs. 40,000/month	4.80	4.80
	Environmental Assistant @30000/month	3.60	3.60
	Office Maintenance @ Rs. 10,000/month	1.20	1.20
C	**Sub Total (A+B)**	**12.10**	**12.10**
	Miscellaneous expenses, LS (10 % of C)	1.21	1.21
	Total cost for 1 Year	**13.31**	**13.31**
	Total cost for 10 years with 10% annual increase	**171,45,700**	**171,45,700**

Appendix 7.1

Appendix 7.1

MONITORING FORMAT

1. Air Quality (Emission Gas/Ambient Air Quality)

Parameter	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)

2. A. Ground Water Quality (BIS : 10500)

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
As per BIS 10500						

2. B. Water Quality (Effluent / Wastewater / Water Quality)

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
pH						
TSS						
BOD						
COD						
Oil / Grease						
DO						

3. Noise / Vibration

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
Noise level	dB(A)					
Vibration level	dBV					

4. Solid Waste

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
pH						
Total Phenols						
lead						
cadmium						
chromium-VI						
Copper						
Nickel						
Mercury						
Zinc						
Fluoride						
Cyanide						
Calorific value						
Total Volatile						
Moisture						
Organic matter						
Total Ash						
Bulk Density						

5 Format for Flora Monitoring Report

Local Name of Species	Scientific Name of the species	Location	Height (m)	Girth (cm)	Quantity (No.)	Storage Detail

Chapter –8

Cost Estimates

CHAPTER 8
COST ESTIMATE

8.1 SUMMARY OF COSTS

The cost of STP, ETP, afforestation and Green belt development of Madhavaram depot is included in Corridor-5. All costs involved in Environmental mitigation, management and monitoring are summarized in **Table 8.1.** The total estimated environmental cost is about **Rs 1945.69 Lakh**.

Table 8.1 Cost of Environmental Management Plan

S No	Item	Amount (Rs in Lakh)	
		Corridor 3	Corridor 5
1	Compensatory Afforestation	51.98	124.55
2	Noise Barriers	0	0
3	Rainwater Harvesting	163.48	87.59
4	Solar Systems	505.81	208.65
5	Sewage Treatment Plant (STP) for Madhavaram Depot	-	78.11
6	Effluent Treatment Plant (ETP) for Madhavaram Depot	-	95.70
8	Green Belt Development for Depot	Set off under item 1	
9	Rainwater Harvesting for Depot	-	15.06
10	Environmental Monitoring		
10(a)	During Construction	107.40	55.80
10(b)	During Operation	52.92	30.54
11	Training and Extension	12.60	12.60
12	Environment Division	171.45	171.45
	Total	**1065.64**	**880.05**

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