MUMBAI METRO RAIL CORPORATION LIMITED

मुंबई मेट्रो रेल निगम लिमिटेड

ENVIRONMENTAL IMPACT ASSESSMENT FOR MUMBAI METRO RAIL CORRIDOR LINE- III (COLABA-BANDRA-SEEPZ)

FINAL REPORT

SEPTEMBER 2012

MMRDA

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RITES
THE INFRASTRUCTURE PEOPLE

(A GOVERNMENTOFINDIA ENTERPRISE)
PLOT NO. 1, SECTOR-29,
GURGAON, HARYANA, INDIA

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ABBREVIATIONS AND ACRONYMS

ATP	:	Automatic Train Protection
BEST	:	Brihanmumbai Electric Supply and Transport
BIS	:	Bureau of Indian Standards
BKC	:	Bandra Kurla Complex
BOD	:	Biochemical Oxygen Demand
CBI	:	Computer Based Interlocking
CER	:	Certified Emission Reductions
CGWB	:	Central Ground Water Board
cm	:	Centimeter
CO	:	Carbon Mono Oxides
COD	:	Chemical Oxygen Demand
CPCB	:	Central Pollution Control Board
CRZ	:	Coastal Region Zone
CSIA	:	Chatrapati Shivaji International Airport
CTE	:	Consent to Establish
cum	:	Cubic Meter
dB	:	Decibel
^{o}C	:	Degree Centigrade
DMRC	:	Delhi Metro Rail Corporation
DPR	:	Detail Project Report
E	:	East
ECR	:	Environmental Compliance Report
EIA	:	Environmental Impact Assessment
EMP	:	Environmental Management Plan
EPA	:	Environmental Protection Agency
EPR	:	Extended Producer Responsibility
ETP	:	Effluent Treatment Plant
GHG	:	Green House Gases
GIS	:	Geographical Information System
gm	:	Grams
Ha	:	Hectare
HC	:	Hydro Carbon
Hz	:	Hertz
ICCROM	:	International Centre for the study of Preservation and Restoration of Cultural Property
ICOMOS	:	International Council on Monuments and Sites
IET	:	International Emission Trading
IMD	:	India Meteorological Department
IMP	:	Independent Monitoring Panel
IS	:	Indian Standards
IUCN	:	International Union for the Conservation of Nature and Natural Resources
JBIC	:	Japan Bank for International Cooperation
JICA	:	Japan International Cooperation Agency
JPD	:	Joint Project Director
Kg	:	Kilogram
KLD	:	Kilo Liter per Day
km	:	Kilo Meter
km/h, Kmph	:	Kilo Meter per Hour
Km/L	:	Kilo meter per Meter
KV	:	Kilo Volt
KWh	:	Kilo Watt Hour
LCD	:	Liquid Cristal Display
LED	:	Light-Emitting Diode
m	:	Meter
MCGM	:	Municipal Corporation of Greater Mumbai
mg	:	Milligram

mg/l	:	Milligram per Liter
m/Hr	:	Meter per Hour
MIDC	:	Maharashtra Industrial Development Corporation
MLD	:	Million Liter Per Day
mm	:	Millimeter
Mm^3	:	Million Cubic Meter
MMR	:	Mumbai Metropolitan Region
MMRC	:	Mumbai Metro Rail Corporation
MMRDA	:	Mumbai Metropolitan Region Development Authority
mm/s	:	Millimeter per Second
μm^3	:	Micro Cubic Meter
MoEF	:	Ministry of Environment and Forest
MPL	:	Maximum Permissible Limit
MPN	:	Most Probable Number
MRTS	:	Mass Rapid Transit System
MSL	:	Mean Sea Level
MT	:	Metric Ton
MTNL	:	Mahanagar Telephone Nigam ltd.
N	:	North
NATM	:	New Austrian Tunnelling method
NFC	:	National Facilitation Committee
NGO	:	Non Government Organisation
mg/m^3	:	Milligrame per cubic Meter
NHAI	:	National Highway Authority of India
NO_x	:	Nitrous Oxides
OCC	:	Operation Control Centre
OP	:	Operation Policy
PAP	:	Project Affected People
%	:	Percentage
PHPDT	:	Peak Hour Peak Direction Traffic
PIA	:	Project Implementation Agency
PiP	:	Pipe in Pipe
PM	:	Particulate Matter
PMC	:	Project Management Consultant
PSD	:	Power Spectral Density
RMC	:	Regional Meteorological Centre
RO	:	Reverse Osmosis
ROW	:	Right of Way
R&R	:	Rehabilitation and Resettlement
SEAC	:	State Level Expert Appraisal Committee
SEDH	:	Subway Environment Design Handbook
SEIAA	:	State Environmental Impact Assessment Authority
SES	:	Socio-Economic Survey
SO_2	:	Sulfur di Oxide
SPCB	:	State Pollution Control Board
SPM	:	Suspended Particulate Matter
sq.	:	Square
TBM	:	Tunnel Boring Machine
UNESCO	:	United Nations Educational, Scientific and Cultural Organization
VOC	:	Vehicle Operating Cost
WHO	:	World Health Organization
WWF	:	World Wildlife Fund

CHAPTER-0
EXECUTIVE SUMMARY

0.1 INTRODUCTION

Mumbai Metropolitan Region (MMR) is one of the fast growing metropolitan regions in India. In MMR, public transport systems are overcrowded and the road network is congested as there is a large gap between the demand and supply. To decongest the existing public transport systems and increase mobility across the Region, MMRDA through MMRC commissioned the services of RITES to prepare a DPR and Environmental/Social Impact Assessment study for the corridor of Colaba – Bandra – SEEPZ covering total length of 33.508 km.

MMRDA has planned to get fund from Japan International Cooperation Agency (JICA) for the construction of Mumbai Metro Line III. The scope of the study is framed as per JICA guidelines for Environmental and Social considerations, 2011.

0.2 SALIENT FEATURES OF PROJECT

The salient features of the project are discussed below:

- Design Speed: 80 kmph
- Scheduled speed: 30 kmph
- Power Demand (MVA): 89.46 MVA (2016)
- Sub Station: Colaba, Race course & Dharavi
- Capacity of 8 coach unit: 2406 Passengers
- Signaling & Train Control: Computer Based Interlocking signaling, automatic train control /Protection.
- Fare Collection: Automatic Fare collection system
- Depot location: Arey Milk Colony (26.407 Hac)
- Train operation: 19 hours of the day (5 AM to 12 PM, i.e. midnight)
- Headway: 4.3 minutes (Colaba-Bandra), 6.7 minutes (Bandra-SEEPZ)
- Max.PHPDT: 25700 (2016)
- Project Cost: Rs. 243,400 Million
- Power requirement: 89.46 MVA (2016), 105.99 MVA (2021), 119.38 (2031)

Construction of the underground running section shall be done by Tunnel Boring Machine (TBM) and stations will be constructed either by Cut and Cover or NATM method. The proposed project would be completed in 60 months and the completion cost of the project is **Rs. 243400.00 millions**.

Two alternatives were studied left of Cuffe Parade Road (Alt-I) and through Vidhan Bhawan (Alt-II) for analysis. Alternative II has been selected to serve additional catchment areas and avoid the sea route coming in Alternative I.

Alternative sites studied for the depot location are Mahalaxmi Race Course, Kalina University land and Aarey milk colony land. Aarey milk colony land is found to be more suitable in view of future expansion.

0.3 ENVIRONMENTAL BASELINE DATA

The baseline data has been collected through primary and secondary sources. The core area of study is considered 100 m on either side of proposed alignment.

Land Environment: Parameters involved in land environment are, physiography, geology and soils, and seismicity. **Geology and Soils:** The entire Greater Mumbai area is occupied by Deccan basalt flows and the associated pyroclastics and the plutonic rocks of upper cretaceous to palaeogene age. The predominant soil cover in Mumbai city is sandy whereas in the suburban district, the soil cover is alluvial and loamy. The six soil samples[1] were collected and tested for the quality of soil in the vicinity of the project site. The test result shows that soil texture is sandy silt and having medium content of nitrogen, phosphors & potassium. **Seismicity:** Mumbai lies in Seismic Zone III of the Bureau of Indian Standards (BIS), which means the city is at moderate risk.

Water Environment: Ground Water: The shallow water levels between 2 and 5 m bgl are observed in southern part, whereas moderate water levels in the range of 5 to 10m bgl are observed in northern part of the area during pre-monsoon. The water levels during post-monsoon in major part of the district range between 2 and 5 m bgl. **Water Quality:** Five water samples[2] from different locations along the metro alignment have been collected and analyzed. Most of the parameters tested for Mahim Creek are more than permissible limit. At rest of the locations, the parameters are within limit as per IS 10500:1991.

Meteorology: The normal annual rainfall over the district varies from about 1800 mm to about 2400 mm. The mean minimum temperature is 16.3°C and the mean maximum temperature is 32.2°C at Santacruze observatory. The predominant wind direction is south/south-west in monsoon and north/north-east in winter.

Air Quality: The atmospheric concentration of air pollutants has been monitored at 5 locations[3] in January 2012. Air Monitoring was carried out for parameters $PM_{2.5}$, PM_{10}, NOx, SO_2, CO, and HC. The results show that except PM_{10} and $PM_{2.5}$, all the parameters are within permissible limits.

Noise Environment: The survey has been conducted at five locations along the alignment. The result indicates that the equivalent noise levels at all the five locations are more than the limit prescribed for residential areas (CPCB Standards).

[1] **Soil Samples:** 1- Caffe Parade, 2- Jacob Circle, 3- Worli, 4- International Airport, 5- SEEPZ & 6- Aarey Milk Colony.
[2] **Water Samples**:1-Caffe Parade, 2-Jacob Circle, 3-Mahim, 4-Aarey Milk Colony, 5-SEEPZ, 6-Andheri East, 7-Mithi River, 8-Parsi Well.
[3] **Air & Noise Quality Locations:** 1-Mahim, 2-BKC, 3-SEEPZ, 4-Colaba, 5-Airport

Vibration: The sources of the vibration are due to operation of Tunnel Boring Machine (TBM) during construction of tunnel and rolling stock during operation of Metro Rail. To know the impact of vibration due to TBM operation and metro train operation, the study has been conducted at six locations[4] by selecting the sensitive area (structures) falling on the proposed metro line alignment. The hard rock structure has been considered while predicting the vibration impact. The vertical vibration at all location is between 110 VdB to 126 VdB.

Ecology: Tree survey has been carried out along the alignment, at station locations and at depot. The type of species observed is Gulmohar, Peepal, Coconut Palms, Sirus, Pilkhan and Neem, etc. About 589 trees are observed along the station locations and about 1652 trees are observed at depot location (Aarey Milk Colony).

Landuse of Depot: The depot has been planned at Aarey Milk Colony covering an area of 26.407 Ha. A landuse map of 10 km radius with depot site at centre shows an area of Urbanisable zone 39.82%, Green zone 16.01%, Water body 14.38% and Industrial zone 7.14% etc.

Historical Sites: The proposed alignment is passing closer to three historical monuments viz, Chhatrapati Shivaji Terminus (formerly Victoria Terminus), Brihanmumbai Municipal Corporation Building and Western Railway Head Quarter located at 40 m, 22 m and 45 m from the centre of the proposed metro alignment.

Sensitive Receptors: The sensitive receptors within 100 m on either side of metro alignments have been identified, which are School (13), Hospitals (22), Temple (21), Mosque (05) Church (06), Monuments/Statue (08) and Nature Park (01).

0.4 NEGATIVE ENVIRONMENTAL IMPACTS:

Change of Land Use: The land requirement will be 45.81 hectare in which 4.72 hectare is private land and 41.08 hectare is government land.

Soil Erosion: Minor impact on soil erosion due to runoff from unprotected excavated areas may result in soil erosion.

Traffic Diversions: Partial road blocking will be required at some station locations during construction work.

Muck Disposal: About 5.40 Mm^3 of muck will be generated.

Impact on Ground and Surface Water: A detailed hydrological investigation needs to be undertaken prior to the construction of tunnel to locate the ground water aquifer if any falling in the alignment.

Loss of Trees: About 673 trees are likely to be cut which will reduce the oxygen production of about 32977 kg.

Air Pollution: The dust could be the problem during construction, as an ambient dust concentration is already 2.0 to 2.4 higher than the standard value.

Noise Pollution: No major impacts are anticipated due to noise pollution as the major construction works are underground. The Noise Level during operation at 15 m from track Centre Line at 25 km/h speed is 75.0± 10.0 while interior noise level is about 78.0±8.0.

[4] **Vibration Monitoring Locations:**1-Lady Willington Building, 2-Narutamdas Bhau Jewelers, 3-Mittal Towers, 4-Central Assurance Building, 5-Parsees Well, 6-Chatapati Shivaji Terminus

The noise generated due to metro is limited within the tunnel and station area , hence no impact of noise on above ground is anticipated.

Vibration Impact: The vibrations due to TBM operation is found to be in between 143 VdB to 147 VdB. The prediction of vibration due to operation of metro is in between 65 VdB to 95 VdB. The predicted vibration level during construction and operation is higher than the standard limits, due to consideration of worst case scenario of having the subsoil condition as rocky structure and may be expected actually less than the predicted value.

Metro Station Refuse: About 20 cum/day of solid waste will be generated from all metro stations @ 0.5-1.0 cum/day/station.

Water Supply: The water requirement at station for drinking purpose and for AC, cleaning, chiller will be 6912 KLD.

Impact due to Labour Camp: About 500 skilled labour will stay at labour camp. Other requirement will be met from local source. Three labour camps will be proposed at appropriate and suitable locations. The water requirement at camp will be 63 KLD, waste water generation 50.4 KLD & Municipal solid waste generation 315 Kg per day.

IMPACTS DUE TO DEPOT

Water Supply: About 159 KLD of fresh water will be required at Depot for different uses which will be taken from borewell/Municipal Water Supply.

Effluent Treatment: About 130 KLD of waste is to be generated at depot, which will be treated at 160 KLD effluent treatment plant.

Solid Waste: It is estimated that about 1.8 Ton per month of solid waste will be generated from the Depot.

Oil Pollution: The spilled oil should be trapped in oil and grease trap. The collected oil would be disposed off through authorised collectors, so as to avoid any underground/ surface water contamination.

0.5 POSITIVE ENVIRONMENTAL IMPACTS

Employment Opportunities: The project is likely to be completed in a period of about five years. About 5,000 persons are likely to work during construction and about 1510 persons @ 45/km for operation and maintenance of the proposed system.

Benefit to Economy: The reduction in number of buses and private vehicles due to operation of Mumbai metro rail will result in significant social and economic benefits.

Mobility: Passenger average time saved will be about 60 minutes by year 2031.

Safety: Mumbai accounts for 18.5% of total accidents in the country. Operation of Mumbai Metro Rail will provide improved safety and lower the number of accidents.

Traffic Congestion Reduction: There will be reduction in road traffic due to operation of Mumbai metro. Reduction in road vehicle trips will be 3.73 lakhs in the year 2016, 4.56 lakhs in the year 2021, 5.54 lakhs in the year 2031 and 6.65 lakhs in the year 2041 respectively.

Reduction in fuel consumption: The reduction in road traffic will save petrol & diesel consumption significantly. The petrol saved will be 2.25, 2.72 & 3.27 lakh litre in the year

2021, 2031 & 2041 respectively. The saving in diesel consumption will be 0.19, 0.23 & 0.27 lakh litre in the year 2021, 2031 & 2041 respectively.

Reduction in Air Pollution: Reduction in traffic due to proposed metro rail could lead to reduced air pollution. An estimated reduction in pollution like CO_2 will be 6,800 tonnes in the year 2021, 8,256 tonnes in the year 2031 and 9,907 tonnes in the year 2041. Similarly, CO will also get reduced by 4,327 tonnes in the year 2021, 5,254 tonnes in the year 2031 and 6,304 tonnes in the year 2041.

Reduction in Number of Buses: The requirement of buses is estimated to be 450 numbers to cater the additional ridership due to increase in traffic on road in absence of metro. This will save an amount equal to Rs. 2203 million towards capital cost of bus system.

Saving in Road Infrastructure: There will be net saving of 182 km road infrastructure which otherwise would require to cater the additional load over the present 1889 km road network. About 10% of road infrastructure will be saved.

Traffic Noise Reduction: Reduction in traffic volume of 10% & 50% reduces noise at the tune of 0.5 dB & 3.0 dB respectively. An introduction of proposed metro reduces the vehicular traffic substantially which ultimately reduces noise level.

0.6 ENVIRONMENTAL MANAGEMENT PLAN

Compensatory Afforestation: 673 trees are likely to be removed and 1072 trees are to be transplanted. Double the number of tree will be planted for each tree cut. The permission for cutting of tree will be taken from the Tree Authority of Mumbai under Maharashtra (Urban Areas) Protection and Preservation of Trees Act 1975. The total cost of compensatory afforstation and fencing is about **Rs. 10.595 million**. The recommended native plant species for afforstation includes gulmohar, neem, Pilkhan, Ashoka, Jamun, Desi Badam etc. The cost of transplanting 1072 number of trees is about **Rs. 53.60 million** @ Rs. 50,000/- per tree. The location of trees to be transplanted will be done in consultation with MCGM. The management plans for transplantation of trees includes Preliminary root investigation, Health diagnosis, Soil condition, regular monitoring for fertilizer schedules, etc.

Safety Management Measures: Project Authority has to establish the safety programmes following rules, regulations and guidelines prior to the construction. These would help to avoid and reduce the number of accidents.

Labour Camp: Labour camps with adequate health care facilities, sanitation facilities, shelter at workplace, canteen facilities, first aid facilities, preventive measures from infectious diseases like HIV/AIDS, day crèche will be provided. The waste water will be treated before disposal or may be connected to nearby sewerage network. A provision of **Rs. 0.955 million** would be made for water supply and sewerage system. A provision of **Rs. 1.201 million** would be made for disposal of 315 kg/day municipal solid waste.

Energy Management: Energy Management measures to conserve energy includes use of energy efficient motors and pumps, use of energy efficient lighting, energy efficient luminaries, adequate and uniform illumination level suitable for the task, and use of energy efficient air conditioner.

Hazardous Waste Management: The contractor shall approach only Authorized Recyclers with MPCB for disposal of Hazardous Waste, under intimation to the MMRDA.

Environmental Safeguard: General environmental sanitation shall be carried out by the contractor to ensure for good environmental sanitation at Work Site, Construction Depot, Labour Camp, Stores, Offices and toilets/urinals.

Utility: Utilities like sewers, water mains, storm water drains, telephone cables, electrical transmission lines will be maintained in working order during different stages of construction by temporary / permanent diversions or by supporting in position.

Historical & Cultural Monuments: Prior to the initiation of construction, MMRDA will conduct condition survey of important historical structures in the vicinity of alignment to identify the impact on the structures during construction and operation of the project. Any impact would be compensated by adequate management plan to preserve the structures.

Air Pollution Control Measures: During construction period, the impact on air quality will be mainly due to increase in Particulate Matter (PM) and emission due to construction vehicles and construction machineries. Transportation during non-peak hours, use of RMC and pre-cast panels, optimisation of construction machinery's use, silent DG sets with pollution control device, sprinkling of water and covered Lorries are some measures which will be taken to reduce the air pollution during construction.

Noise Control Measures: The noise generated during construction will be minimized by using silent DG sets, acoustic enclosures, temporary noise barriers, job rotation to the extent possible for construction workers, and scheduling of truck loading, unloading and hauling operation.

Vibration Control Measures: Measures will be taken to minimize the vibration impact by continuous vibration monitoring during construction, periodic vibration during operation, vibration monitoring at site and at the top of building mainly for old structures and heritage buildings, pre-construction structural integrity inspections of historic and sensitive structures.

Traffic Diversion/ Management: The traffic at some station locations during construction needs to be diverted to avoid congestion situations. The traffic management plan includes advance traffic information on communication systems and partial blocking of road etc.

Muck Disposal Plan: About 5.40 million m^3 of muck will be disposed by adopting five options as 1. Use as fill material for JNPT Terminal 4, 2. Use as fill material for minor ports in Maharashtra. 3. Filling of abandoned quarries in Raigad and Thane district. 4. Recycle and Reuse and 5. Deep Sea Dumping. The cost of Muck Disposal will be kept as **3725.60 million** which includes Environmental Study/Clearances, Transportation Cost (via road & sea), Plantation and Beautification works.

Sensitive Receptors: Construction contractor must provide a mechanism for receiving and responding to any complaints arising due to impacts on sensitive receptors.

Management Plans for Depot: About 159 KLD of water will be met either from Municipal Corporation or through tube well. The estimated cost of water supply plant is about **Rs.5.0 million**. About 130 KLD of sewage/effluent is likely to be generated which has to be treated as per the requirement of regulatory pollution control agency of the state (MPCB). The estimated cost for sewage/effluent treatment plant is about

Rs.6.0 million. The storm water of the depot will be collected through the drain which will be connected to nearby disposal site. The solid waste of 1.8 tonne/ month will be taken by the cleaning contractor weekly and disposed to the Mumbai Municipal Corporation waste disposal site. The **Rs 4.0 million** has been kept in the cost estimate for the Green Belt Development. Treated sewage/ effluent in the best combination should be used for Green Belt Development. Roof top rainwater harvesting has also been proposed for 36,938 sq.m of Depot cum workshop area. A provision of **Rs. 1.5 million** has been kept in the cost estimate.

Training Programmes: The cost for National and International training programs will be kept as **Rs. 21.61 million** to acquire the latest know how about the construction, operation and maintenance of Metro Rail.

Environmental Enhancement Measures: Rs. 8.50 million has been kept for landscaping & beautification, solar energy, renovation of Heritage structures & religious places, environmental awareness programmes, Utility facilities to unprivileged people as environmental enhancement purpose.

EMP Reporting Arrangement:

- **Project Implementation Agency (PIA):** Implementation of environmental mitigation measures.
- **Project Management Consultant (PMC):** The PIA will get the EMP implemented through the Project Management Consultant (PMC).
- **Project Contractor:** Project Contractor will implement the EMP measures, enhancement measures and measures as directed by PIA and PMC.
- **Independent Monitoring Panel (IMP):** MMRC will appoint IMP with the objective to ensure that JICA's policies related to social and environmental issues are followed.

0.7 DISASTER MANAGEMENT PLAN: Disaster can occur due to subsidence, accidents, fire hazards, etc. during construction while system failure (power supply, break down etc), fire hazards and accidents during operation stage. The DMP should include Preventive Action, Full Proof Communication System, Emergency Action Committee and Emergency Measures.

0.8 PUBLIC CONSULTATION: Public consultations at project and city level have been organized to collect the opinion/ views of the stakeholders for the proposed project.

Consultation at Project Level: About 93 people from different community participated in public consultation. Issues raised by the stakeholders were replied and their valuable suggestions were noted down for consideration into the report.

Consultation at City Level: Consultation meeting was organized with officers of concerned government department and non-government organizations (NGO) of district on 11th April 2012 vide newspaper Notification dated 5th April 2012. Public hearing was attended by 200 stakeholders and about 27 stakeholders raised their objection with suggestions.

0.9 ENVIRONMENTAL MONITORING PLAN: Ground water quality, soil, Air quality & noise monitoring will be conducted for one year before construction, during the construction and at least three year after the completion of the project.

Quality of Ground Water: Monitoring shall be carried out at 10 locations as per decision of Engineer in Charge for the parameters pH, Dissolved Oxygen, BOD, COD, TDS, Chlorides, Nitrates, Sulphates, Total Nitrogen, Total Phosphates, oils and grease etc. The cost kept for the monitoring will be **Rs. 1.08 million.**

Soil Monitoring: Soil quality shall be tested from the site of Depot, Labour camp, station location, dumping site and at random sampling of soil from the muck coming out during tunneling. During operation, monitoring shall be carried out at Depot location. The parameters to be monitored are pH, Sodium, Potassium, Chloride, Nitrogen, Phosphorous, Organic Matter, Heavy Metals, Oil and Grease**.** The cost kept for the monitoring will be **Rs. 2.916 million.**

Muck Monitoring: Excavated muck shall be tested at every kilometer during tunneling. The parameters to be monitored are pH, Electrical conductivity, Alkalinity, Moisture Content, Texture, Heavy Metals and Specific gravity. The cost kept for the monitoring will be **Rs. 0.63 million.**

Air Quality & Noise: During construction, six locations have been proposed for monitoring including depot. The depot, Vidhan Bhawan station, CST Station, Dharavi station, CSIA (Domestic Airport) and MIDC station are proposed during operation. The cost kept for the monitoring will be **Rs. 5.832 million.**

Vibration Monitoring: Ambient Vibration (VdB) & Vibration due to TBM Operation (VdB) shall be carried out at CST, BMC Building, Lady Willingdon Building, Mittal Towers, DN Road and other locations as required during construction phase. Vibration due to Metro Train operation (VdB) shall be monitored at CST, BMC Building, WR Head Quarter, Girgaon station, Lady Willingdon Building, Mittal Towers & DN Road. The cost kept for the monitoring will be **Rs. 9.45 million.**

Ecological Monitoring: The project authority in coordination with the Department of Forest/MCGM shall monitor the status of ecology/trees at regular interval during construction & operation phase.

Environmental Monitoring Division: MMRC shall establish an Environment Division at the initial stage of the project itself. The division should be staffed with an Environmental Engineer/Officer and a Technical Assistant (environment background). The cost of **Rs. 11.40 million** has been kept.

0.10 COST ESTIMATES: The environmental costs towards implementation of environmental management plan and mitigation measures during pre-construction, construction and operation of the proposed project are estimated to be **Rs. 4379.845 million.**

0.11 CONCLUSION: It can be concluded on positive note that after the implementation of Environmental Management Plan and Monitoring Plan, the project will have negligible impact on environment and will also lead to sustainable transport development of the city.

CHAPTER – 1
INTRODUCTION

1.1 INTRODUCTION

Mumbai is the financial capital of India and witnessing phenomenal growth in population and employment. The job opportunities it offers have served as a major attraction for immigration from hinterland of Maharashtra as well as from all parts of the Country. Mumbai Metropolitan Region (MMR) is one of the fast growing metropolitan regions in India. It comprises of 7 municipal corporations, 13 municipal councils and 996 villages and extends over an area of 4,355 sq.km. MMR is projected to have population and employment in the year 2031 as 34.0 million and 15.3 million respectively. The dominant feature of the passenger movements in Mumbai is overwhelming dependence of travel on transport modes and walk. In MMR, public transport systems are overcrowded and the road network is congested as there is a large gap between the demand and supply. To decongest the existing public transport systems and increase mobility across the Region, DMRC in 2004 prepared a Metro Master Plan for Mumbai for a length of 149.97 km of network planned for MMR, to be implemented in three phases, Phase 1: 2005-2011, Phase II: 2011- 2016 and Phase III: 2016-2021.

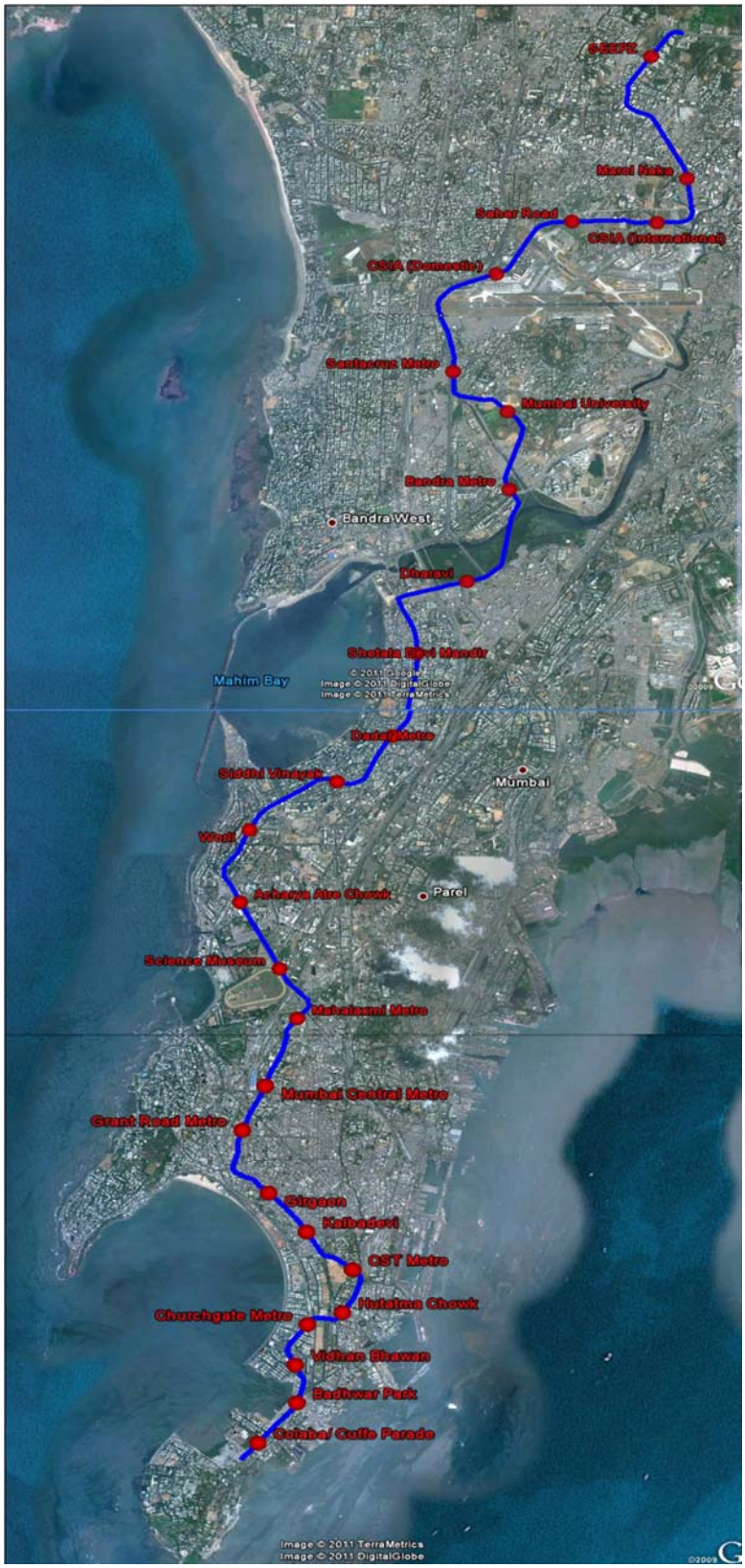
Multimodal access to the airport passengers at CSIA was initially contemplated via line I (Versova – Andheri – Ghatkopar), but the spur line connection was not found feasible. The National Facilitation Committee (NFC), in its meeting held on September 3, 2009, decided that the metro connectivity to the CSIA be expedited and put in the phase 1, rather than in the phase 3 as per Metro Master Plan. This was decided to be achieved by merging Line 6 of Phase 3, named BKC – Kanjur Marg via Airport with the Line 3 of Phase I, i.e. Colaba – Mahim – Bandra and run through services from Colaba till SEEPZ as depicted in **Figure 1.1.**

With this background, MMRDA through MMRC commissioned the services of RITES to update both the studies of DMRC conducted in 2007 for Colaba – Mahim – Bandra Metro Line and Mahim – BKC – Kanjur Marg (2010) and prepare a combined DPR and Environmental Impact Assessment for the running of through services on corridor - Colaba – Bandra – SEEPZ.

1.2 OBJECTIVES AND SCOPE OF STUDY

The objective of the study is to facilitate the Mumbai Metropolitan Region Development Authority (MMRDA) in the preparation EIA report as per requirement of regulatory and funding agency. The scope of EIA includes the impacts resulting from pre-construction, construction and operation phases of Line I Metro corridor, Depot and sub-stations. MMRDA has planned to get fund from Japan International Cooperation Agency (JICA) for the construction of Mumbai Metro Line III.

FIGURE Error! No text of specified style in document.**.1**
PROPOSED COLABA – BANDRA – SEEPZ METRO CORRIDOR



The MoEF, Government of India, Notification of 14th September 2006 and its amendment dated 1st December 2009 enlist projects in Schedule that require environmental clearance. However as per the said notification a metro project does not require environmental clearance from MoEF.

The scope of the study is framed as per JICA guidelines for Environmental and Social considerations. The objectives of the JICA guidelines are to encourage Project proponents to have appropriate consideration for environmental and social impacts, as well as to ensure that JICA's support for examination of environmental and social considerations are conducted accordingly.

1.3 JICA REQUIREMENT

In its confirmation of environmental and social considerations, JICA places importance on dialogue with all involved partners (e.g. the host country, local governments, borrowers and project proponents) regarding environmental and social considerations. Transparent and accountable processes, as well as active participation of key stakeholders (e.g. local residents and local NGOs) in all stages of the project are highly considered. JICA make clear in their "Guidelines for Environmental and Social Considerations" that these are mandatory to receive JBIC's funding. JICA guidelines are formulated based on the World Bank Operational Policy (OP 4.01). The project has been classified according to its impacts on the environment.

BOX 1.1 EIA CATEGORIZATION SYSTEM IN JICA

Category A Projects are likely to have significant adverse impacts on the environment and society. It includes projects in sensitive sectors or with sensitive characteristics and projects located in or near sensitive areas.

Category B Projects are ones with potential adverse impacts on the environment and society less adverse than those of Category A projects.

Category C Projects have minimal or little adverse impacts on the environment and society.

1.4 LEGAL, POLICY AND INSTITUTIONAL FRAME WORK

Since the adoption of The Kyoto Protocol in December 1997 which was entered into force on 16 February 2005, that developing countries are principally responsible for the current high level of GHG emission into the atmosphere due to industrial activities. This protocol

commits the developed countries to reduce 5 percent pollution against 1990 level over the five years period 2008-12.

The need for a well-developed legal mechanism is to conserve resources, protect the environment and ensures the health and well being of the people in India was felt. Keeping the pace with international laws, the Ministry of Environment and Forest enacted Environmental Protection Act in 1986. Over the years, the Government of India has framed several policies and promulgated number of Acts, Rules and Notifications aimed at management and protection of the environment. During last three decades an extensive network of environmental legislation has grown and presently it has a fairly complex body of environmental legislation aimed at ensuring that the development process meets the overall objective of promoting sustainability in the long run. The available legal Acts and Legislation referred during the study are:

- The Water (Prevention and Control of Pollution) Act, 1974 (Amendment 1988).
- The Water (Prevention and Control of Pollution) Cess Act 1977, (Amendment 2003),
- The Water (Prevention and Control of Pollution) Cess Rules, 1978, 1991.
- The Air (Prevention and Control of Pollution) Act 1981 (Amended 1987).
- Noise Pollution (Regulation and Control) Rules, 2000 (Amendment 2002, 2006).
- Municipal Solid Waste Rules, 2000
- The Environment (Protection) Act, 1986, amended 1991.
- The Environment (Protection) Rules, 1986.
- The Indian Forest Act, 1927.
- Forest (Conservation) Act, 1980, amended 1988.
- Forest (Conservation) Rules, 2003.
- The Wild Life (Protection) Act 1972, Amendment, 2002
- The Metro Railway (Amendment) Act 2009
- Metro Railway (Construction of Works) Act, 1978
- Delhi Metro Railway (Operation and Maintenance) Act, 2002
- The Ancient Monuments and Archaeological sites and Remains (Amendment and Validation Act),2010

The EIA is conducted as per “Guidelines for Environmental and Social considerations” of JICA. These guidelines are formulated based on the World Bank Operation Policy (OP – 4.01)

The Environmental Impact Assessment covers the proposed on-site activities as well as the transportation of the generated waste to the waste disposal sites.

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 amended

in 1988. The Water Cess Act, 1977 amended in 1992 and 2003, including Rules 1978 and 1991 provides for levy and collection of Cess on water consumed with a view to generate resources for prevention and control of water pollution. The Act assigns functions and powers to the Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCBs) for prevention and control of water pollution.

The Environment (Protection) Act 1986 amended in 1991 and Rules also lays down specific standards for quality of water effluents to be discharged into different type of water bodies (sewers, surface water bodies). Additionally, the water supplied to users for drinking shall also 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.**

Off late, with rapid depletion of groundwater resources in several areas of the country, efforts have been initiated to regulate the use of groundwater resources. The focus of such acts and rules is to provide for mechanisms that would lead to replenishment of groundwater reserves through techniques like rain water harvesting. The Central Ground Water Board, (CGWB) the statutory authority set up by the Central Government has also restricted the drilling of tube wells and bore wells in certain water scarce areas in the country.

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) as per the Air Act. The Act also lays down National Ambient Air Quality Standards for pollutants like $PM_{2.5}$, PM_{10}, Sulphur dioxide, Oxides of Nitrogen, Carbon monoxide, Lead, Ozone, Ammonia, Benzene and Benzo pyrene with the intent of managing air quality for different category of areas (residential, industrial and sensitive). Ambient Air Quality Standards have been notified by the CPCB vide Gazette Notification dated 16th November 2009, refer **Appendix 1.4.**

The Extended Producer Responsibility (EPR) also specifies source emission standards determined on the basis of the impact of pollutants on human health, vegetation and property for activities, which can pollute the air. The SPCBs, on a case to case basis, can also make the emission standards more stringent on the considerations of the carrying capacity of a specific air shed and the existing pollution levels of ambient air quality.

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 amended in 2002 and 2006 under the EPA. The noise standards for different category of areas are based on the weighted equivalent noise level (L_{eq}). The EPR also lays down equipment noise standards for DG sets, Air conditioners and Construction Equipment, which would be in use for the project. Ambient Noise level standards have been notified by the MoEF vide Gazette Notification dated 26th December 1989 and also in the Schedule III of the Environmental (Protection) Rules 1986. It is based on the 'A' weighted equivalent noise level (L_{eq}). These are presented in **Appendix 1.5.**

1.4.4 Solid Waste Management

Project construction and operation generates solid waste at site. The MMRDA would be responsible for collection and handling of solid waste as per the provisions of the Municipal Solid Waste Rules, 2000. The Hazardous Waste (Management and Handling) Rules, 2000 require facilities to classify wastes into categories, manage them as per the prescribed guidelines and obtain prior authorization from the SPCB for handling, treatment, storage and disposal of Hazardous Wastes.

1.5 INSTITUTIONAL FRAMEWORK

The Ministry of Environment and Forests (MoEF) 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 MoEF 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

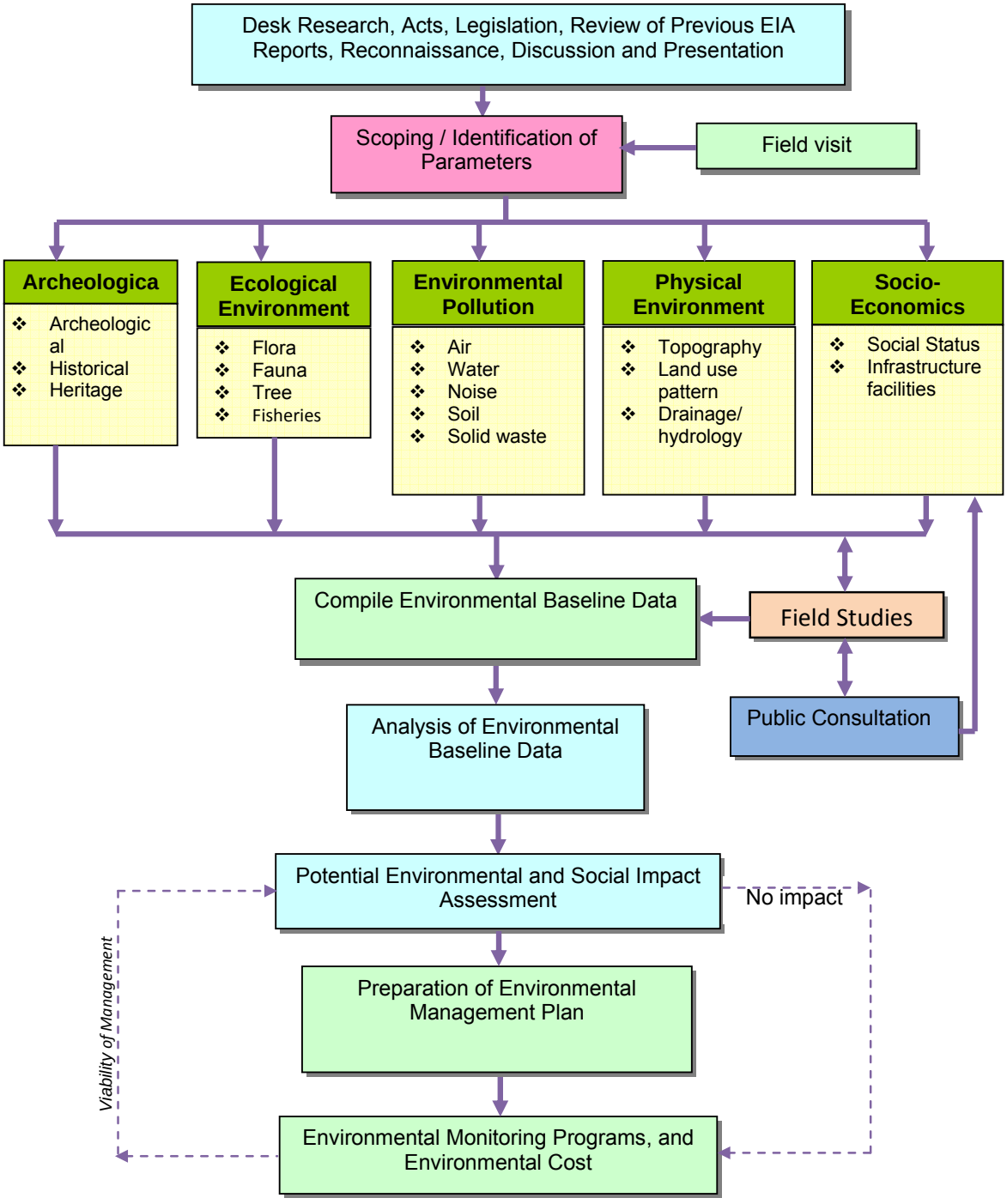
The proposed alignment has been fixed based on Technical Feasibility, Socio-economic acceptability, and Environmental sustainability for Metro Corridors. The environmental study is carried out for the final alignment proposed by MMRDA. The **approach** is to follow the sequence of steps adopted in an EIA study. The basic concept 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 / ecological, environmental and socio-economic etc. have been studied, analyzed and quantified, wherever possible. The identification of parameters for data generation and impact assessment are important. The accurate analysis of assessment depends upon the reliable data generated/ available on environmental attributes. RITES has documented the baseline data for various parameters of physical (physiographic and soils), ecological (forestry, fisheries and wildlife), and environmental pollution (air, water, noise, and solid waste). The impacts are assessed for various phases of project cycle namely:

- Impacts due to project location,
- Impacts due to project design,
- Impacts due to project construction, and
- Impacts due to project operation.

The impacts are categorized as negative and positive. The cost of management and monitoring programs are estimated and budgeted for. The approach for the study is presented in **Figure-1.2.**

FIGURE 1.2

METHODOLOGY FOR THE EIA STUDY



The standard **methodology** for the data collection, impact assessment and formulation of management plans is adopted. The National Acts, Legislation and Laws along with **JICA** and **World Bank** guidelines were consulted with a view to ensure compliance with various requirements. The consultant collected and compiled the environmental baseline data for environmental attributes from primary and secondary sources. The primary sources include site visits, visual inspection, field studies, monitoring and analysis. The secondary sources include the books, reports, maps and documents from various government and non-government organizations on subject matter. The methodology proposed to be adopted for data collection, impact analysis, preparation of environmental management and monitoring plans is highlighted in brief, in the following paragraphs. However, more elaborate methodology is present in the main text in the relevant sections.

1.6.1 Data Collection

The existing **land-use** pattern of the area has been identified mainly as urban human settlements, roads, Trees and water bodies. The **Soils** parameters are studied from the field surveys conducted during this study.

Water Resources in the project were considered in terms of precipitation, surface run off; quantity and quality of water. These will facilitate to decide various uses such as drinking, irrigation etc.

Air and Noise quality is an important consideration during construction and operation phases. Ambient air quality and noise levels were monitored in and around project area to develop present baseline levels in the area. The literature reviews were conducted to establish past air pollution and noise levels in the project area. The future air and noise quality were predicted using mathematical modeling.

Terrestrial **Ecology** was studied. The vegetation types were documented through the visual inspection, past research and field investigations.

1.6.2 Environmental Impact Assessment

The objective of the study is to assess the impacts as a result of construction of the Mumbai metro corridors along with depot and sub-stations. The changes likely to occur in different components of the environment were studied and analyzed. The core area of study is to be 100 m on either side of proposed alignment. Based on project particulars and the existing environmental conditions, potential impacts were identified that are expected to be affected as a result of the proposed project and wherever possible, these are quantified. Both positive and negative impacts are evaluated to have an idea about resultant impacts. These impacts were assessed for various phases of project cycles namely, location, design, construction and operation. The standard methodology was adopted for impact prediction and assessment. Prediction is essentially a process to

forecast the future environmental conditions in the project area that might be expected to occur. The prediction of impacts can be through mathematical modeling, overlays/ super imposition of activity, or comparison of impacts observed. The environmental impact of the project includes changes in land use, soil, erosion, water quality, air quality and noise levels etc. The impact on soils due to disposal of waste water and erosion during storms were predicted. The impact on water quality in the water bodies was evaluated with the help of water quality analysis. The burning issue such as Carbon dioxide emission is also studied. More details on Environmental Impact Assessment are available in **Chapter 4.**

1.6.3 Environmental Management Plan

The project will provide higher living standard, better quality of life, less travel time, better connectivity and transport facilities. The management plans are essential to ensure that stress/ loads on the systems are within carrying capacity. The management plan aims at maintaining the environmental quality of project area. An environmental management strategy/ plans were developed to mitigate the adverse impacts. Efforts are made to enhance the quality of environmental attributes.

1.6.4 Environmental Monitoring

It is necessary to monitor during various phases of project cycles the environmental attributes. Monitoring would indicate any environmental problem, which has come up due to an ongoing activity. This will facilitate to assess the effectiveness of management / mitigation measures. The consultant has designed a post project environmental monitoring program for implementation. The cost estimates for environmental monitoring and management have been included in the project estimates.

1.6.5 Liaison with Authorities

For the preparation of this EIA, the project team and environmental experts have liaised with the MMRDA, and JICA in order to discuss the proposed scope of the EIA, available data in the specific area on environmental attributes and general comments / observations that these authorities may have on the project and its environs. In addition, informal consultations were organized with individuals and nearby people, in order to present the project and collect their views on the perceived positive and negative impacts on the environment on account of this new development.

1.7 FORMAT OF THE REPORT

The main elements of the study are as follows: In **Chapter-2** briefs about the proposed project description & alternatives. **Chapter-3** summarises environmental baseline conditions including physical, biological and socio-economic parameters and pre-project environmental constraint such as air pollution, problems related to public health and traffic

congestion. Potential negative and positive impacts are presented in **Chapters-4 and 5** respectively. These include issues such as loss of land, rehabilitation and resettlement, disposal of soil, loss of trees, noise and vibration, disruption of utilities/ facilities, socio-economic and other problems due to the development of proposed Mumbai Metro Line-III. Based on the anticipated negative impacts, the project may bring about an environmental management strategy, which has been outlined in **Chapter-6.** The detail of Public Consultation for the proposed project has been given in **Chapter-7.**

Chapter-8 includes post project environmental monitoring programmes. This programme aims at signalling any potential environmental problem during construction and operation of the project and it should allow for timely implementation of corrective measures. The costs of the environmental management and monitoring programmes are presented in **Chapter-9.** The conclusion of the EIA study conducted has been presented in **Chapter-10**.

The literature, books, reports referred, is detailed in References. Where applicable, more detailed information on methods used is included in concerning paragraphs. The issue related to rehabilitation and resettlement and rehabilitation plan are available in separate report**.**

Appendix-1.1

DRINKING WATER QUALITY STANDARDS (IS 10500:1991)

S. No.	Substance or Characteristic	Requirement (Desirable Limit)	Undesirable Effect outside the Desirable limit	Permissible limit in the absence of alternate source
Essential Characteristics				
1	Colour, Hazen units, Max	5	Above 5, consumer acceptance decreases	25
2	Odour	Unobjectionable	-	-
3	Taste	Agreeable	-	-
4	Turbidity NTU, max	5	Above 5, consumer acceptance decreases	10
5	pH Value	6.5 to 8.5	Beyond this range the water will affect the mucous membrane and/or water supply system	No relaxation
6	Total Hardness (as $CaCO_3$) mg/l, Max	300	Encrustation in water supply strucute and adverse effects on domestic use	600
7	Iron (as Fe) mg/l, max	0.3	Beyond this limit taste/appearance are affected, has adverse effect on domestic uses and water supply structures and promotes iron bacteria	1.0
8	Chloride (as Cl) mg/l, Max	250	Beyond this limit, test, corrosion and palatability are affected	1000
9	Residual free Chlorine, mg/l, Min	0.2	-	-
10	Fluoride (as F) mg/l, Max	1.0	Fluoride may be kept as low as possible. High fluoride may cause florosis	1.5
11	Dissolved solids mg/l, Max	500	Beyond this palatability decreases and may cause gastro intestinal irritation.	2000
12	Calcium (as Ca) mg/l, Max	75	Encrustation in water supply structure and adverse effects on domestic use	200
13	Magnesium (as Mg) mg/l, Max	30	Encrustation in water supply structure and adverse effects on domestic use	100
14	Copper (as Cu) mg/l, Max	0.05	Astringent taste, discoloration and corrosion of pipes fitting and utensils	1.5
15	Manganese (as Mn) mg/l, Max	0.1	Beyond this limit taste/appearance are affected, has adverse effect on domestic uses and water supply structures	0.3

S. No.	Substance or Characteristic	Requirement (Desirable Limit)	Undesirable Effect outside the Desirable limit	Permissible limit in the absence of alternate source
Essential Characteristics				
16	Sulphate (as SO_4) mg/l, Max	200	Beyond this causes gastro intestinal irritation when magnesium or sodium are present	400
17	Nitrate (as NO_2) mg/l, Max	45	Beyond this methaemoglobinemia takes place	100
18	Phenolic compounds (as C_6H_5OH) mg/l, Max	0.001	Beyond this, it may cause objectionable taste and odour	0.002
19	Mercury (as Hg) mg/l, Max	0.001	Beyond this, the water become toxic	No relaxation
20	Cadmium (as Cd), mg/l, Max	0.01	Beyond this the water become toxic	No relaxation
21	Selenium (as Se), mg/l, Max	0.01	Beyond this the water become toxic	No relaxation
22	Arsenic (as As), mg/l, Max	0.05	Beyond this the water become toxic	No relaxation
23	Cyanide (as CN), mg/l, Max	0.05	Beyond this the water become toxic	No relaxation
24	Lead (as Pb), mg/l, Max	0.05	Beyond this the water become toxic	No relaxation
25	Zinc (as zn), mg/l, Max	5	Beyond this limit it can cause astringent taste and an opalescene in water	15
26	Anionic detergents (as MBAS), mg/l, Max	0.2	Beyond this limit it can cause a light froth in water	1.0
27	Chromium (as Cr^{+6}) mg/l, Max	0.05	May be carcinogenic above this limit	No relaxation
28	Plynuclear aromatic hydrocarbons (as PAH) g/l, Max	-	May be carcinogenic	-
29	Mineral oil mg/l Max	0.01	Beyond this undesirable and odour chlorination place	0.03
30	Pesticides mg/l Max	Absent	Toxic	0.001
31	Radioactive materials a) Alpha emitters Bq/l max b) Beta emitters pci/l, Max	 - -	 - -	 0.1 1
32	Alkalinity mg/l Max	200	Beyond this limit taste becomes unpleasant	600
33	Aluminium (as Al), mg/l Max	0.03	Cumulative effect is reported to cause demntia	0.2
34	Boron, mg/l, mg/l Max	1	-	5

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.	^{o}C	Shall not exceed 5°C above the receiving water temp.
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
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

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^o 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	-	-

Source: *Central Pollution Control Board*

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.

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), $\mu g/m^3$	Annual 24 Hours**	50 80	20 80
Nitrogen Dioxide as NO_2, $\mu g/m^3$	Annual 24 Hours**	40 80	30 80
Particulate Matter (size less than 10µm) or PM_{10} $\mu g/m^3$	Annual 24 Hours**	60 100	60 100
Particulate Matter (size less than 2.5µm) or PM2.5 $\mu g/m^3$	Annual * 24 Hours**	40 60	40 60
Ozone (O_3) $\mu g/m^3$	8 hours** 24 Hours**	100 180	100 180
Lead (Pb) $\mu g/m^3$	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) $\mu g/m^3$	Annual * 24 Hours**	100 400	100 400
Benzene (C_6H_6) $\mu g/m^3$	Annual *	05	05
Benzo (a) pyrene (BaP) particulate phase only ng/m^3	Annual *	01	01
Arsenic (As) ng/m^3	Annual *	06	06
Nickle (Ni) ng/m^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 *	Night
Industrial	75	70
Commercial	65	55
Residential	55	45
Silence Zone **	50	40

Source: Central Pollution Control Board

** Day Time is from 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. Use of vehicle horn, loudspeaker and bursting of crackers is banned in these zones.*

CHAPTER 2
PROJECT DESCRIPTION

2.1 EXISTING SYSTEMS

Mass transport needs of Mumbai Metropolitan Region (MMR) are met by Suburban Trains and Buses. MMR consists of Greater Mumbai, Thane and Raigad districts. The proposed Metro Rail project is in Greater Mumbai where vehicular traffic consists of two wheelers, auto rickshaw, cars, taxis, buses, commercial vehicles and others. Population and growth rate of vehicles in Greater Mumbai for the year 2005 and 2008 are depicted in **Table 2.1.**

TABLE 2.1
GROWTH RATE OF VEHICLE IN GREATER MUMBAI

SL NO.	VEHICLES	NO. OF VEHICLES		GROWTH RATE (%)
		2005	2008	
1	Two Wheelers	647,892	865,466	11%
2	Auto Rickshaw	104,104	108,812	2%
3	Car	409,120	507,408	8%
4	Taxis	58,049	58,813	0.4%
5	Buses	12,290	13,239	3%
6	Commercial Vehicles	56,345	71,329	9%
7	Others	7,140	6,770	-2%
	Total	**1,294,940**	**1,631,837**	**9%**

2.2 PROPOSED METRO SYSTEM IN MUMBAI

There is no existing metro system in Mumbai. Line I from Versova to Ghatkopar is under construction. Line II (Charkop-Bandra-Mankhurd) is finalised and construction will be started as the CRZ clearance will be accorded for Depot. As per the Mumbai Master Plan prepared by DMRC, **Table 2.2** depicts Mumbai Metro Corridors in three phases of execution which is shown in **Figure 2.1**. DPR studies for phase I metro corridors were carried out during the period 2005 -2009 (Line 1: Versova-Andheri-Ghatkopar, Line 2: Charkop–Bandra-Mankhurd and Line 3: Colaba -Bandra). In 2010, MMRDA also carried out the DPRs of four lines of Phase II & III.

TABLE 2.2
MUMBAI METRO MASTER PLAN

LINE NO.	CORRIDOR	LENGTH (KM)	PHASE	IMPLEMENTATION
1	Versova – Andheri – Ghatkopar	15.0	I	2005-2011
2	Charkop – Bandra - Mankhurd	31.87		
3	Colaba - Bandra	20.40		
4	Charkop – Dahisar (East)	7.5	II	2011-2016

5	Ghatkopar – Mulund	12.4		
6	BKC to Kanjurmarg via Airport	19.5	III	2016-2021
7	Andheri (East) – Dahisar (East)	18.0		
8	Hutatma Chowk – Ghatkopar	21.8		
9	Sewri – Prabhadevi	3.5		
		149.97		

Source: DPR, RITES (CTS for MMR, by LASA)

Phase wise length of metro corridor as per Master Plan and as per amendment is depicted in **Table 2.3.**

TABLE 2.3
LENGTH OF MUMBAI METRO PHASES

S.No.	Phase	Length (km) as Master Plan	Length(Km) as per amendment
1	Phase I	67.27	79.36
2	Phase II	19.90	19.90
3	Phase III	62.8	43.3
	Total	**149.97**	**142.56**

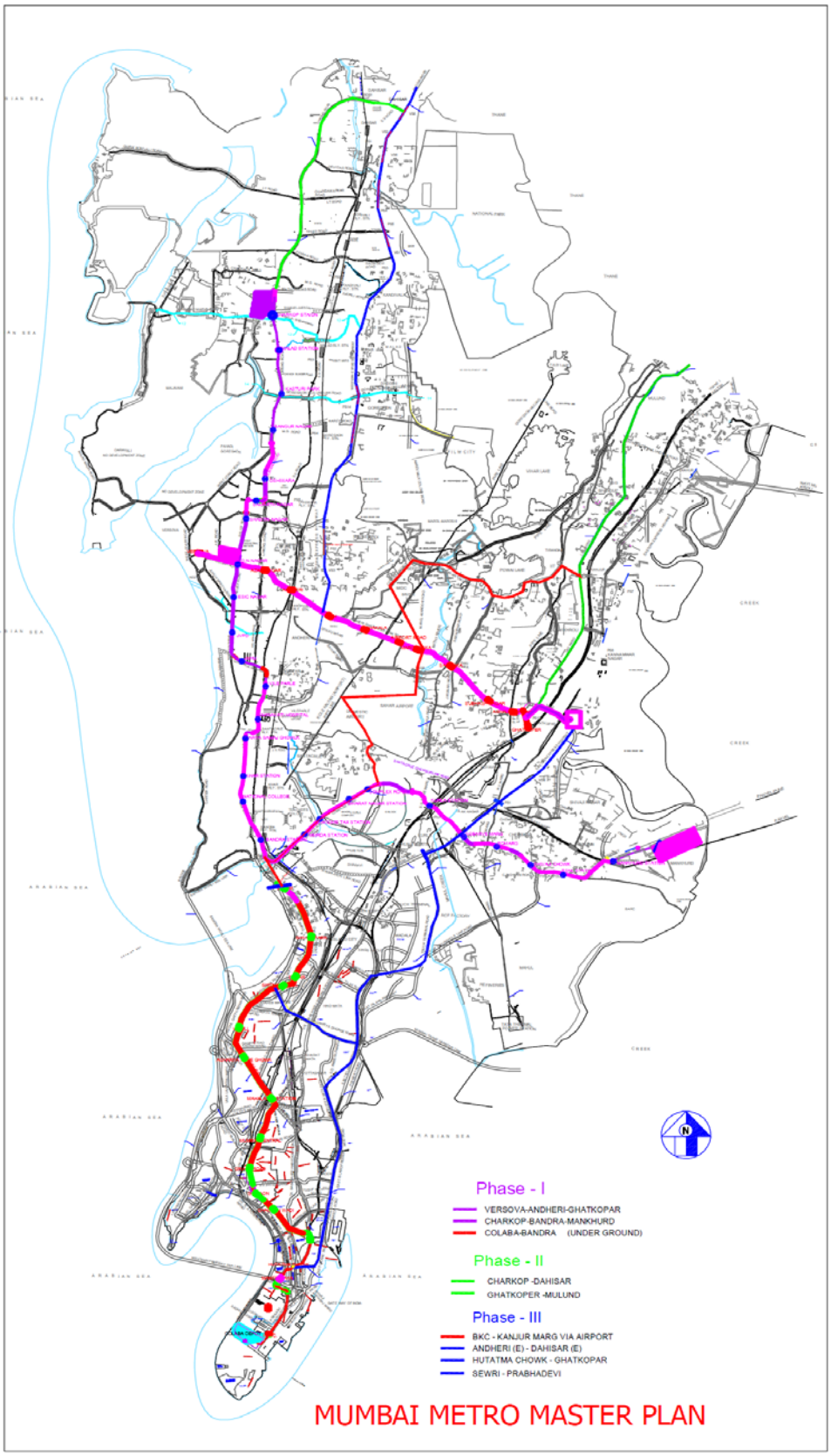
2.3 ANALYSIS OF ALTERNATIVES

2.3.1 Alignment Planning

Selection of an optional alignment is a multi-disciplinary decision, with objectives which may conflict with one another. The selection of approach for resolving the problem is the multi-criteria analysis for the alternative to be analyzed. The principal objectives which were considered while selecting the metro-alignment are minimization of the impact on the environment & social, minimum land acquisition, optimization of the functionality of the alignment, minimization of construction time, minimization of construction and operational cost and maximization of the results of the economic investment. Minimization of construction time and construction and operational cost are amongst the criteria with the highest weighting factors in selecting the optimal alignment. While selecting the alignment of Mumbai Metro Rail corridors spread over in three phases and having total length of 149.87 km. Following parameters are taken into consideration:

- Catchment area,
- Integration with other mass transit corridors,
- Construction feasibility, and
- Environment and social aspects.

FIGURE 2.1
MUMBAI METRO MASTER PLAN



Detailed Project Report from Colaba to Bandra falling in Phase I was prepared by Delhi Metro Rail Corporation Ltd in 2007 and BKC to Kanjur Marg via Airport (Line VI) in Phase III was prepared by RITES Limited in 2011.

The present proposed alignment from Colaba to SEEPZ via BKC has been finalized by combining Line III and Line VI. Line III had been proposed underground from Colaba to Mahim and elevated from Mahim to Bandra. Line VI was underground from Mahim to ITO and elevated from ITO to Kanjur marg. Another alternative in this alignment was elevated from Mahim to ITO. Considering the environmental, social, traffic and land availability aspects, it was decided to keep the proposed alignment underground.

The National Facilitation Committee (NFC), in its meeting held on September 3, 2009, decided that the metro connectivity to the CSIA be expedited and put in the phase 1, rather than in the phase 3 as per Metro Master Plan. This was decided to be achieved by merging Line 6 of phase3, named BKC-Kanjur Marg via Airport with the Line 3 of phase I, i.e Colaba-Mahim-Bandra and run through services from Colaba till SEEPZ.

2.3.2 Proposed Alignment

The proposed alignment as mentioned in 2.4.1 was studied by RITES Ltd. During the study, RITES Ltd examined the proposed alignment to finalize it. Two alternatives were taken between Cuffe Parade Road and Vidhan Bhawan for analysis. These two alternatives were studied and their benefits and drawbacks were examined, which are depicted in subsequent para.

Alternative-I

From Cuffe Parade Road (fisherman colony), alignment takes left turn to cross the sea and follows the Jamnala Bajaj Road and passes in front of Vidhan Bhawan. The major disadvantage of the alignment is that the 600 m alignment was passing under sea.

Alternative-II

From Cuffe Parade Road, alignment follows Foreshore Road (Captain Prashant Pethe Marg) and takes left turn near Fire station and passes through State Govt. Barracks and between Vidhan Bhawan/SBI building. The merit of this alignment is that it is close to Mantralaya as well as Vidhan Bhawan. The major advantage is to serve the important catchment areas of Colaba localities. Also by selecting this alignment the route passing under sea in Alternative is avoided.

Hence, MMRDA has decided to adopt Alternative II to serve additional catchment areas and avoid the sea route. The two alternatives are shown in **Figure 2.2**.

FIGURE 2.2
ALTERNATIVE ROUTES

2.4 Depot Planning

The proposed corridor would require a dedicated depot for the maintenance of the rakes. The inspection, overhauling and all maintenance facilities for P Way, S & T, OHE etc will also be provided at the depot cum maintenance workshop. As per the preliminary assessment, train operation on Colaba-Bandra-SEEPZ corridor will require about 45 rakes of 4 cars to meet the traffic projection in the horizon year 2031. Depot cum workshop shall have necessary facilities viz stabling lines, schedule inspection lines, workshop for overhaul, unscheduled maintenance including major repairs, wheel profiling, and heavy interior/under frame/roof cleaning etc.

In addition, the Depot will also house for operation control centre (OCC), administrative building, maintenance facilities for civil-track, water supply; electrical-traction, E&M; signalling & telecomm; etc.

2.4.1 Car Depot Site Requirement

The pre requisites of coach maintenance depot site are as under-

- A plot size of adequate area- about 30 Ha,
- Proximity to alignment: Site must be located as close to the alignment as possible.
- Ease to movement: There should not be any obstruction to movement of rakes in either direction

2.4.2 Proposed Alternative sites for Depot

Following sites had been selected for the depot having requisite size along the alignment.

- Mahalaxmi Race Course
- Kalina University land
- Aarey milk colony land

Alternative I: Mahalaxmi Race Course

The land requirement of 19.2 Ha is available and it is well close to alignment. The rakes are easily placed & retrieved from depot from Science Museum station. However, the land requirement for depot is in possession of Rayal Western India Turf Club and the grandstand of the course is a designated heritage structure which requires additional clearance.

Alternative II: Kalina University land

Kalina University is located at the western edge of BKC with a total vacant area available of 20 Ha and it is well close to the alignment i.e less than 1 km. The rakes are easily placed & retrieved from depot in either direction. However, it would be difficult to acquire land as the land is in possession of Kalina University and is meant for educational purposes. Also the part of the land is falls in CRZ-II, hence additional clearance will be required.

Alternative III : Aarey Milk Colony

Aarey Milk Colony land is adequate in size for metro car depot located along JVLR opposite to SEEPZ. The proposed depot land is very close to the alignment. The depot can be constructed at-grade level. No major complications are involved in shifting of public utilities. Also rakes can be easily placed & retrieved from depot. Furthermore future expansion would be possible as adequate land is available in the vicinity. However, only the corridor needs to be expanded for about 1 km for the depot accessibility.

In view of the above, depot cum workshop is found to be more suitable at Aarey milk colony land. The area is also available for future expansion and the proper landscaping can be retained or enhanced the beauty of the area. The alignment is shown in the **Figure 2.3**.

2.5 MAJOR SECTION OF PROPOSED METRO CORRIDOR (LINE III)

The proposed Metro corridor will facilitate the commuters to travel from South Mumbai to Airport via Mahim-BKC. It will also provide direct access to the economic hubs such as BKC, MIDC Industrial Estate, SEEPZ and famous landmarks such as Kalina University, Mahalaxmi etc. The proposed 33.51 km metro corridor has been divided into six sections as depicted in **Table 2.4.**

TABLE 2.4
MAJOR SECTIONS OF METRO CORRIDOR (PHASE III)

S.NO.	MAJOR SECTIONS	LENGTH IN KM
1	Colaba/WTC/Cuffe Parade to CST	4.475
2	CST to Science Museum	7.000
3	Science Museum to Mahim	7.000
4	Mahim to Airport	7.000
5	Airport Region	5.000
6	Airport to SEEPZ	3.033
	Total	**33.508**

FIGURE 2.3
ALTERNATIVE DEPOT LOCATIONS

2.6 RIDERSHIP ON PROPOSED METRO CORRIDOR

The ridership has been estimated by MMRDA based on the results of CTS Transport Demand Model considering the following points.

1. P3E3 land use scenario is considered in which growth to MCGM and RoR is allocated in equal proportion.
2. CTS proposed Road and Rail network is considered for horizon years 2016, 2021 and 2031.
3. Metro Fare is considered as 1.5 times the ordinary bus fare.
4. Speed of the metro is taken as 35 kmph.
5. Frequency of metro service is considered as 4 minutes for 2016 and 3 minutes for 2025 and 2.5 minutes for 2031 horizon years.

Based on the above consideration, the proposed Metro Corridor is expected to have a daily ridership of 16.99 Lakh and Maximum PHPDT of 42000 by 2031. These are shown in **Table 2.5**

TABLE 2.5
MAXIMUM PHPDT AND DAILY RIDERSHIP

YEAR	MAXIMUM PHPDT	DIAILY RIDERSHIP (IN LAKH)
2016	25700	10.06
2021	39000	13.87
2031	42000	16.99

The proposed corridor has two distinct sections in terms of passenger loading (i) Colaba- Bandra with higher peak section loads, and (ii) Bandra – SEEPZ with comparatively lower section loads. Hence a mid terminal facility is proposed at Bandra Metro station to enable differential train frequencies in these two sections. The broad PHPDT for the two sections are depicted in **Table 2.6.** These will be considered to work out the train operation plan, rake requirement etc.

TABLE 2.6
PHPDT FOR COLABA – BANDRA AND BANDRA - SEEPZ

SECTION/YEAR	2016	2021	2031
Colaba-Bandra	25000	36000	40000
Bandra-SEEPZ	16000	18000	21000

2.7 ROLLING STOCK, TRACTION AND SIGNALLING

The salient features of proposed Metro Corridor (underground) in respect of rolling stock, power supply, traction system and signalling are summarised in DPR and reproduced below:

- A short train consisting of 4 cars with high frequency service which can be increased to 6-cars and 8-car for increasing the Passenger Carrying Capacity of Trains with the consideration of matching the growing traffic demand.

- The rolling stock shall be Standard 1435 mm track gauge Section having maximum width of 3.20 m, Axle load of 17 tonnes and capacity of 4 coach unit as 1178 passengers. Seating arrangement will be longitudinal and AC class accommodation will be provided.

- 25 KV AC 50 Hz Traction system is proposed to fulfil the power demand of 65 – 48 MVA in 2016. Three receiving stations have been proposed at Colaba (Cuffe Parade), Race Course and Dharavi.

- The system, under normal operating conditions, will be an automatically operated system utilizing Automatic Train Control and Automatic Train Protection (ATP) under the overall control of a train driver and OCC operators.

- Computer Based Interlocking (CBI) signalling and continuous automatic train control with Automatic Train Protection (ATP) is prposed., while telecommunication system is integrated with Optical Fiber Cable, LED/LCD based boards, Mobile Radio, Mobile system etc.

- Fare collection system is provided with automation in association with Contactless Smart Card and Retractable Flap Type Control Gates, Ticket Office Machine, TR, PTD etc.

2.8 PASSENGER CARRYING CAPACITY

In order to maximise the passenger carrying capacity, longitudinal seating arrangement shall be adopted. Criteria for the calculation of standing passengers are 3 persons per square metre of floor area in normal state, 6 persons in crush state of peak hour and 8 persons in dense crush state of peak hour. Therefore, Driving Trailer with 21.84 m car body length, 3.2 m car body width and longitudinal seat arrangement conceptually have the capacity of 43 seated, 239 standing, thus a total of 282 passengers while a Motor car with 21.74 m car body length, 3.2 m car body width and longitudinal seat arrangement conceptually have the capacity of 50 seated, 257 standing, thus a total of 307 passengers for a car is envisaged considering a standee area of 6 persons per square metre. These are shown in **Table 2.7**.

TABLE 2.7
CARRYING CAPACITY A CAR

DESCRIPTION	DRIVING TRAILER CAR		TRAILER CAR/ MOTOR CAR		4 CAR TRAIN	6 CAR TRAIN	8 CAR TRAIN
	Normal	Crush	Normal	Crush	Crush	Crush	Crush
Seated	43	43	50	50	186	286	386
Standing	120	239	129	257	992	1506	2020
Total	**163**	**282**	**179**	**307**	**1178**	**1792**	**2406**

2.9 MAINTENANCE DEPOTS

The maintenance depot along with full workshop facilities have been proposed at Arey Milk Colony for the proposed metro corridor. The facilities include for the maintenance of the Rakes, Track, Electrical – Traction (OHE), E & M, Signalling & Telecom, Automatic Fare Collection etc. It will house Operation Control Centre (OCC) and Administrative Building. All the systems at depot have been designed to cater for 55 rakes of 8 Car composition to take care of requirement beyond the horizon year 2031. In 2031, rake requirement is 55 with 6 coaches.

2.10 POWER REQUIREMENTS

Power supply is required for the operation of Metro system for running of trains, station services, workshop, depot and other maintenance works within the premises of metro system. The power requirement is for peak hour demand for traction and auxiliary application. The power requirement is estimated on the basis of 8 car train operation at 150 second headway for Colaba-Bandra section and 300 second headway for Bandra-SEEPZ section considering requirement beyond the horizon year 2031. Some of assumptions to estimate the power supply are

- Specific energy consumption of rolling stock : 70 KWh per 1000 GTKM
- Train operation design :150 seconds headway on Colaba-Bandra and 300 seconds headway on Bandra-SEEPZ section
- Underground station : Design Load 3000 kW
- Depot auxiliary : Design load 3000 kW
- Power factor of load : 0.9 and Transmission losses @ 5%

Keeping in view the above norms, designed load and power requirement projected are depicted in **Table 2.8**

TABLE 2.8
POWER DEMAND IN MVA

PARTICULARS/YEAR	2016	2021	2031	TOTAL
Traction	24.13	32.49	37.71	55.88
Auxiliary	65.33	73.50	81.67	98.00
Total	89.46	105.99	119.38	153.88

2.11 SUB STATIONS

As per power supply network of Mumbai city, the city has 220 KV, 100 kV, 33/22 kV and 11 kV network to cater to various types of demand in the vicinity of proposed corridor. Out of these, 33 kV and 100 kV networks are highly reliable and stable to meet the power requirement of 33 kV and 25 kV for the proposed corridor as per the discussion with Tata Power Company Limited. Keeping in view the reliability requirements and considering the complete corridor of 33.508 m length with all underground stations, three receiving Sub-stations are proposed to avail power supply for traction as well as auxulliary services from three grid sub-stations at 100 kV voltage through cable feeders for Colaba-Bandra-SEEPZ Corridor. Sources of Power Supply are depicted as in **Table 2.9**

TABLE 2.9
SOURCES OF POWER SUPPLY

S NO.	GRID SUB-STATION	RECEIVING SUB-STATION	CABLES
1	Badhwar Park (100 kV)	Colaba (100/33/25 kV)	2 km 100 kV double circuit cables
2	Mahalaxmi (100 kV)	Race Course (100/33/25 kV)	1 km 100 kV double circuit cables
3	Dharavi (100 kV)	Dharavi (100/33/25 kV)	1 km 100 kV double circuit cables

2.12 CONSTRUCTION METHODOLOGY

Construction of the underground section shall be done by Cut and Cover, NATM and Tunnel Boring Machine (TBM). Station will be constructed either by Cut and Cover or NATM method depending upon the availability of space.

2.12.1 Construction Strategy

Design and build contacts will be adopted for proposed corridor. There will be three major contracts 1. Civil Works, 2. System Contract and 3 Depot Contract. Under civil contact, Architectural finishes, fire fighting and general electrification will be included along with the civil construction works. System contract will be on the basis of design, construct and installation which will include Traction and Power Supply, Signal and Telecommunication, Lifts, Escalators, Fare collection, Rolling Stock, Track and Signages. Layout, design and construction and general electrification comes under the Depot contract.

2.12.2 Construction Period

It is proposed to complete the project in a time period of 60 months.

2.13 COST ESTIMATES

The completion cost of the project with all taxes, escalation & private land comes to Rs 243400.00 millions.

CHAPTER–3
ENVIRONMENTAL BASELINE DATA

3.1 ENVIRONMENTAL SCOPING

This chapter 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. Data on land environment has been collected and compiled from various published sources and field focused surveys. Attributes of the physical environment like air, water, soil, and noise quality in the surrounding area were assessed, primarily through field studies, and by undertaking monitoring and analysis of samples collected from field. Information about geology, hydrology, prevailing natural hazards like earthquakes, etc have been collected from literature reviews and authenticated information made available by government departments. Climatological data was collected from Indian Meteorological Department. The methodology adopted for data collection is highlighted wherever necessary. A scoping matrix along with the frequency adopted for data collection for environmental attributes is summarized in **Table 3.1**.

TABLE 3.1
ENVIRONMENTAL ATTRIBUTES AND FREQUENCY OF MONITORING

S. NO	ATTRIBUTE	PARAMETER	FREQUENCY	SOURCE
LAND ENVIRONMENT				
1	Soil	Soil Characteristics	Once	Field studies and Detailed project report
2	Geology	Geological Status	---	Literature review
3	Seismology	Seismic Hazard	---	Literature review
WATER ENVIRONMENT				
4	Water Quality	Physical, Chemical and Biological parameters	One Season	Field studies/literature review
AIR, NOISE AND METEOROLOGY				
5	Ambient Air Quality	PM2.5 , PM10, SO_2,,NO_x, CO, HC	Two Season	Field Studies/literature review
6	Meteorology	Temperature, Relative humidity, Rainfall, wind direction and speed	Data	India Meteorological Department/literature review
7	Noise	Noise levels in dB (A)	One Season	Field monitoring
8	Vibration	Vibrations in VdB	--	Field monitoring & modeling
SCIO-ECONOMIC				
9	Socio-economic aspects	Socio-economic characteristics	Once	Field Studies, Literature review.
Ecology				
10	Trees	Number/species	Once	Filed Studies

3.2 LAND ENVIRONMENT

The Project area is situated in Mumbai, the commercial capital of India. The average elevation of Mumbai plains is 14 m above the sea level (a-MSL). Mumbai is located along western Arabian cost of India from 18^0 53' north to 19^0 16 'north latitude and from 72^0 East to 72^0 59' longitude. Parameters involved in land environment are, physiography, geology and soils, and seismicity. These are discussed in the following paragraphs.

3.2.1 Physiography

The physiographic feature of the Mumbai district is broad and flat terrain flanked by north – south trending hill ranges. The hill ranges from almost parallel ridges in the eastern and western part of the area. The Powai – Kanheri hill ranges are the other hill extending in the eastern and central part running NNE – SSW. The maximum elevation of the area is 450 m above mean sea level (amsl) at some of the peaks of hill ranges. Trombay Island has north – south running hills with maximum elevation of 300 m above mean sea level (amsl). Malbar, Colaba, Worli and Pali hills are the isolated small ridges trending north – south in the western part of the district. The Powai – Kanheri hills form the largest hilly terrain in the central part of the Salsette Island and are the feeder zone for the three lakes viz., Powai, Vihar and Tulsi. There are a number of creeks, dissecting the area. Among them, Thane is the longest creek. Other major creeks are Manori, Malad and Mahim which protrudes in the main land and give rise to mud flangs and swamps. The area is drained by Mahim, Mithi, Dahisar and Polsar rivers. These small rivers near the coast, form small rivulets which intermingle with each other resulting in swamps and mud flats in the low lying areas

3.2.2 Geology and Soils

The entire Greater Mumbai area is occupied by Deccan basalt flows and the associated pyroclastics and the plutonic rocks of upper cretaceous to palaeogene age. The Deccan basalt of Mumbai Island is considered to be the youngest basalt of Eocene age. Overall the geology around Mumbai indicates presence of ultrabasic, basic and acid differentiates with intertrappean beds, agglomerates and tuffs. The ultrabasic differentiates are of limited occurance. Acid rocks include rhyolite and quartz trachyte. The agglomerate and tuff include reworked material as indicated by current bedding and graded bedding. The basalt flows of the area have been grouped into compound flows (i.e pahoehoe type), simple flows and flows which do not fall in the above categories and hence termed as unclassified flows. The basaltic flows are typically of quartz and hypersthenes normative with minor amount of olivine theolites. The lava of Mumbai is intern intruded by columnar jointed medium grained doleritic dykes.

The Deccan Trap basalt has been classified as Sahyadri Group which has been divided into three formations viz. the lower most Upper Ratangarh Formation followed by Elephanta Formation and topmost Borivali Formation. The Upper Ratangarh Formation is restricted to two patches, one from Kurla to Mulund and the other at SE of Kurla. The middle formation i.e Elephanta Formation comprising of simple and compound flows occur as small isolated patches in the SE corner of the city near Thane creek and covers very negligible area. The rest of the area is covered by rocks of Borivali Formation where it is not occupied by alluvium. Normally, alluvium is restricted to the western half of the

area. Laterite occurs as small isolated patches in the area north and east of Mulund. Bauxite occurs within the Laterite in a irregular shape and is not of any economic importance. The Geological features of the Mumbai are shown in the **Figure 3.1**.

The predominant soil cover in Mumbai city is sandy whereas in the suburban district, the soil cover is alluvial and loamy. In order to ascertain the quality and nature of soil within the vicinity of the project site, six soil samples were collected. The location of soil samples is shown in the **Figure 3.2**. These samples were collected about 60 cm depth. The samples were tested for physical and chemical properties. The results of soil analysis are presented in **Table 3.2**. As per the test results it is observed that soil is tending to become alkaline. Soil has medium content of nitrogen, phosphors and potassium. At all places the soil texture is sandy silt.

TABLE 3.2
SOIL TEST RESULTS

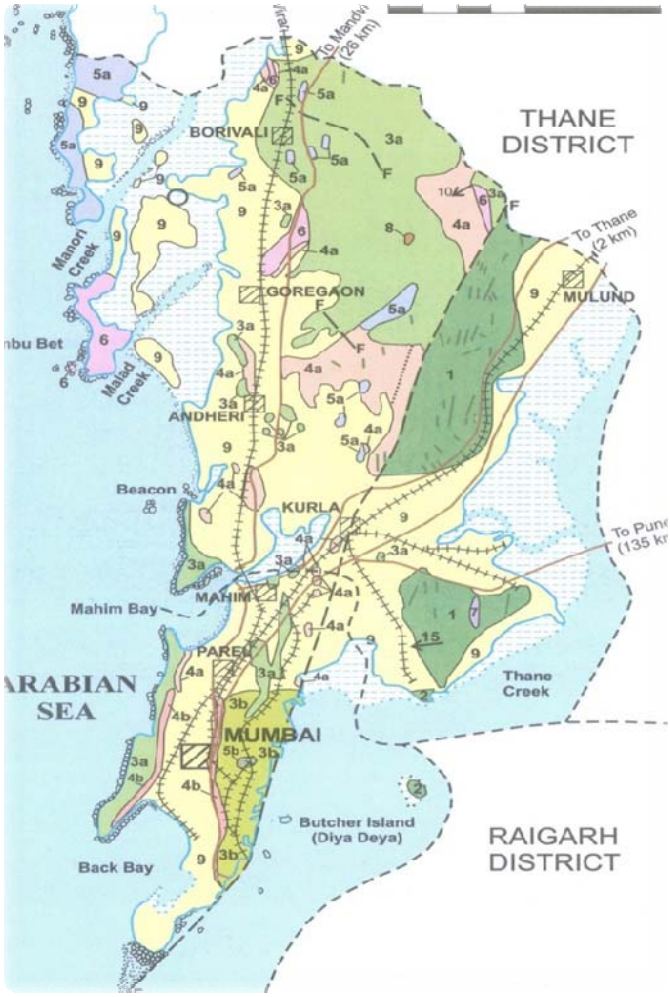
S. NO	PARAMETER	LOCATION					
		Caffe Parade	Jacob Circle	Worli	International Airport	SEEPZ	Aarey Colony
1.	pH	7.10	7.60	7.87	7.19	6.80	6.28
2.	Conductivity (mS/cm)	0.80	0.85	0.53	1.46	0.19	0.18
3.	Sodium (As Na, mg/100gm)	22.61	21.02	35.59	18.34	7.62	3.45
4.	Organic Matter (% By Mass)	1.80	1.48	1.37	0.90	1.15	1.53
5.	Nitrogen (N, Kg/hectare)	121.99	33.77	28.81	40.09	32.72	41.57
6.	Calcium (As Ca, mg/100gm)	329.94	648.09	710.94	487.05	263.16	141.40
7.	Chloride (As Cl, mg/100gm)	450.63	404.54	289.29	262.86	299.22	208.55
8.	Magnesium (As Mg, mg/100gm)	85.80	81.03	126.32	162.07	135.85	102.48
9.	Sand (% By Mass)	46.20	42.30	40.20	39.50	39.30	64.12
10.	Silt (% By Mass)	35.10	32.10	30.10	28.10	28.10	25.83
11.	Clay (% By Mass)	11.10	10.20	10.10	11.40	11.20	10.10
12.	Potassium (As K, mg/100gm)	179.98	366.80	232.06	130.59	51.95	94.43
13.	Phosphate (As Po4, kg/hectare)	23.68	16.24	24.27	14.87	30.80	13.01

3.2.3 Seismicity

The country has been classified into different zones indicating the intensity of damage or frequency of earthquake occurrences. These zoning maps indicate broadly the seismic coefficient that could generally be adopted for design of buildings in different parts of the country.

Mumbai lies in the Bureau of Indian Standards (BIS) in Seismic Zone III, which means the city is at moderate risk. The last time Mumbai witnessed seismic activity was in 2005. Three consecutive tremors of 4-5 magnitude were witnessed. Mumbai lies over more than 10 seismic fault lines. Major fault lines lie along the Thane creek, Ulhas river, the Manori and Malad creeks and the lakes. To the west, a fault line stretches from Colaba to Vasai, touching Malabar hill. The seismic zoning map of India showing Mumbai region is given in the **Figure 3.3**.

FIGURE 3.1
GEOLOGICAL MAP OF MUMBAI



LITHOLOGY	STRATIGRAPHIC STATUS		AGE	NATURE AND CHARACTERISTICS
9 Alluvium			QUATERNARY	Occur as black coloured muddy coastal sandy, marshy land along coastal plains, creeks
8 Laterite			CAINOZOIC	Occur as small isolated pockets near boundary as lensoid bodies
Basic Dykes				Occur as weathered, fresh dark coloured, fine grained, compact and hard rock
7 Pyroxene megacryst rock				Occur as dark, compact ground mass with big phenocrysts in fine grained ground mass
6 Trachyte				Occur as dark, fine grained, leucocratic outcrops
5a 5b Rhyolite, hybridised acid Lava and silicified tuff	Borivali Formation	SAHYADRI GROUP (DECCAN TRAP)	CRETACEOUS TO PALAEOGENE	As sandy shale, dense, dark, fine grained with crude stratification and with number of depositional features, brown ground mass
4a 4b Agglomerates and tuff/ Intetrappean				As red to brown coloured, stratified, greenish, ill developed graded bedding, coarse to fine grained with current bedding leucocratic rock
3a 3b Unclassified/'aa' flows				As sparsely to nonporphyritic, amygdular, glassy looking at places, fine grained Showing both 'aa' and pahoehoe characters
2 5 nos of flows of compound and simple type (220 mtrs.)	Elephanta Formation			As sparsely to nonporphyritic, amygdular flows, highly vesicular aphenaric flows Colourless to pale yellowish, fine grained ground mass
1 Mainly compound flows	Upper Ratangarh Formation			Occur as two patches as dense, dark grey, fine grained and nonporphyritic, compact, hard rock.

MINERAL INDEX	GENERAL INDEX		STRUCTURAL INDEX
Bauxite	State boundary	Drainage	Fault
	District boundary	Mud	Fracture/shear zone
	Road	Rock	Gradient/Dip of flow
	Railway line	Shoal	
	Settlement		

FIGURE 3.2
ENVIRONMENTAL MONITORING LOCATIONS

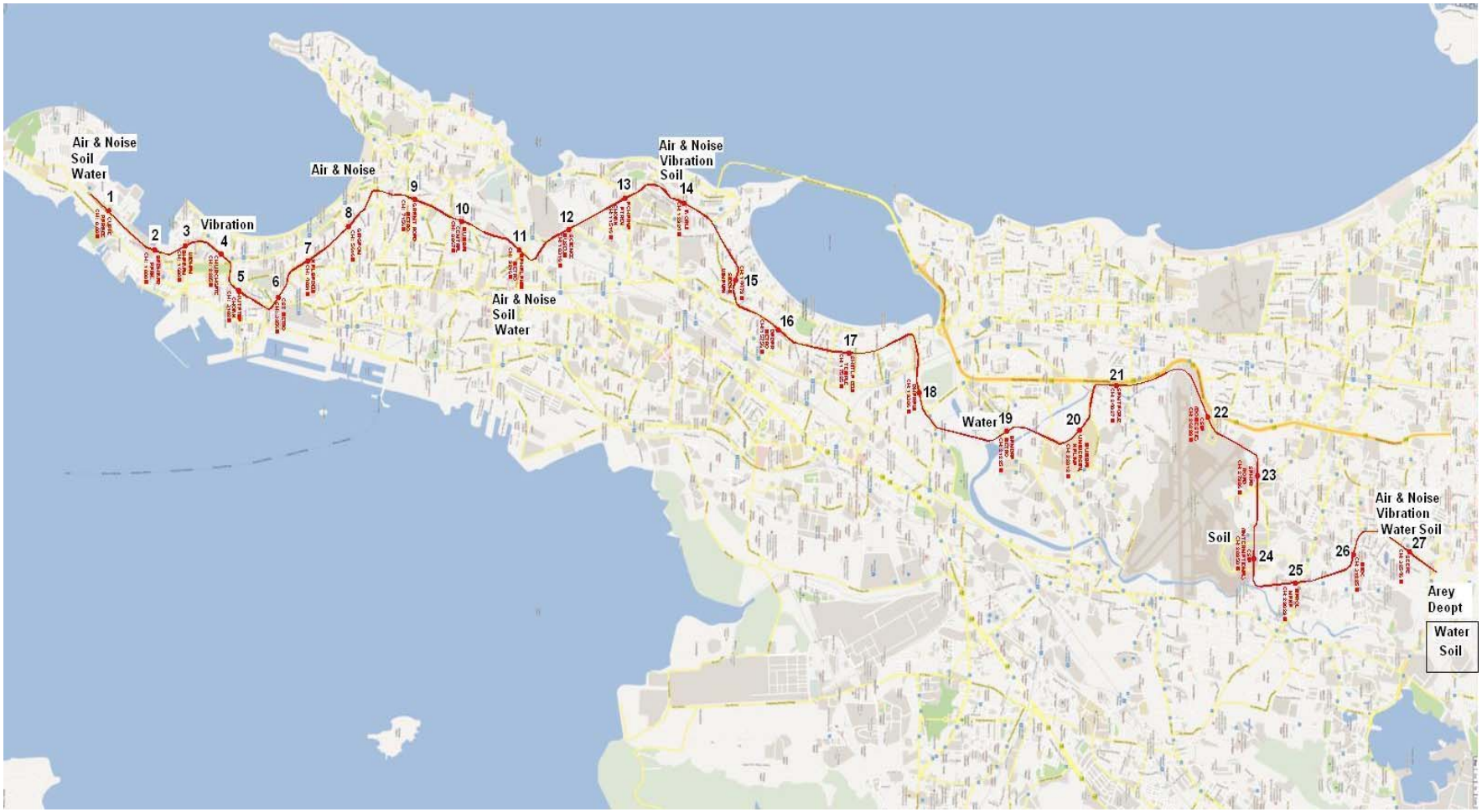
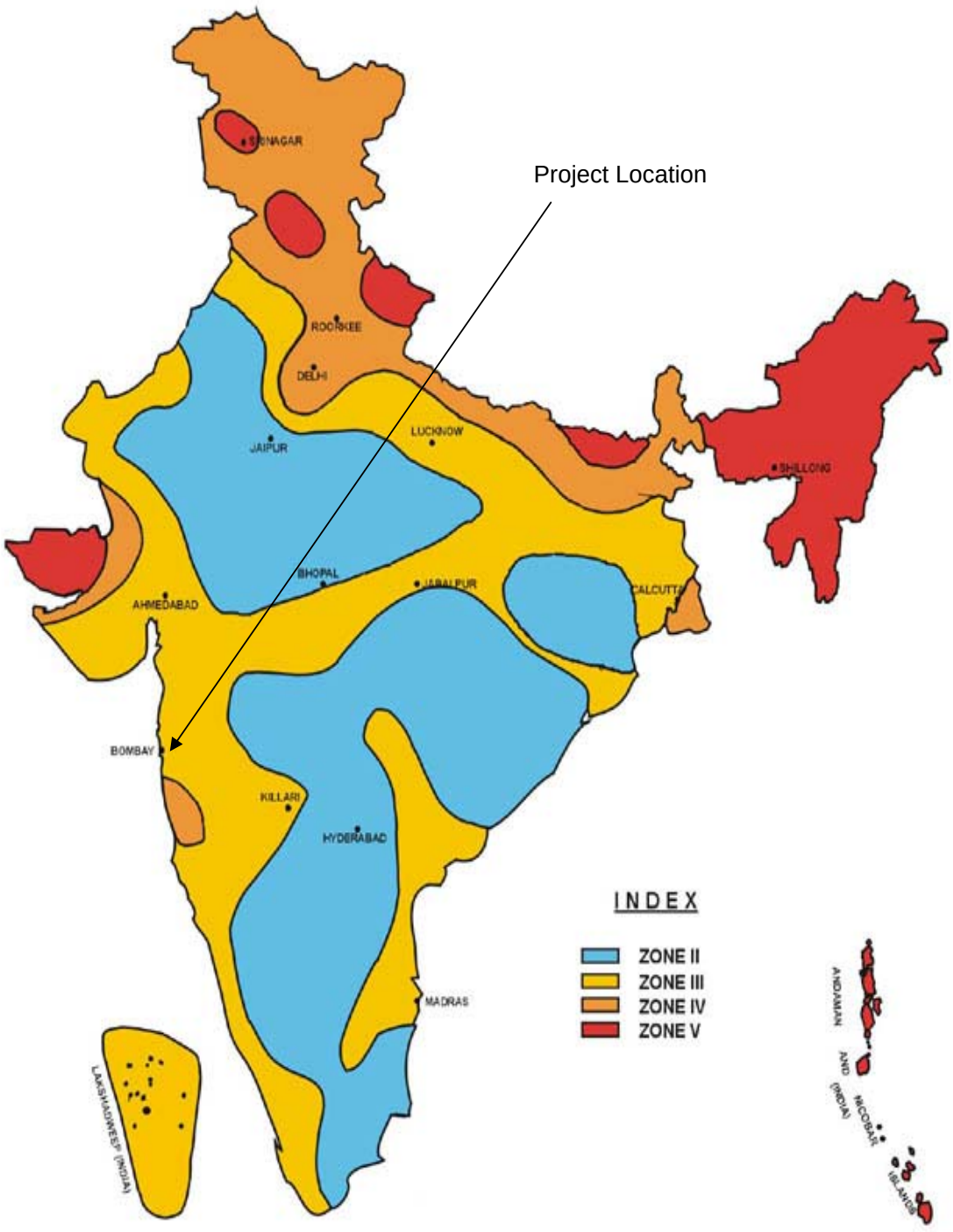


FIGURE 3.3
SEISMIC ZONING MAP OF INDIA



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 the project in its various stages of the project cycle and also to assess the impact of the project on water environment. Anticipated impacts of the proposed project on water environment have also been addressed.

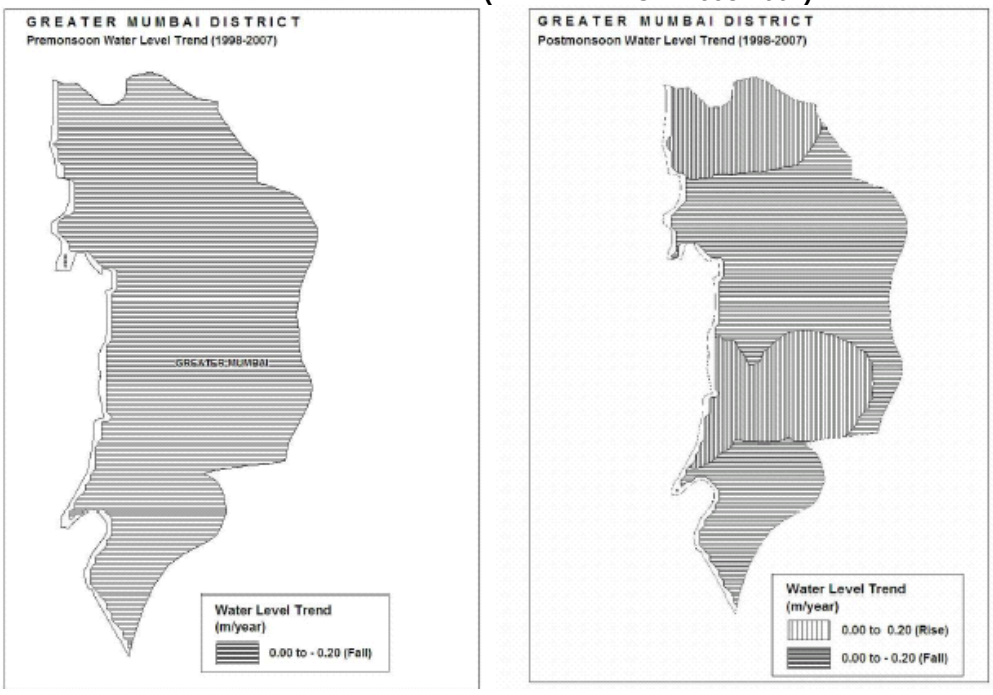
3.3.1 Water Resources

Water supply to Mumbai district are from various sources viz. Tulsi Lake (18 MLD), Vihar (110 MLD), Tansa (477 MLD), Vaitarna (1070 MLD) and Bhatsa (1475 MLD). The Central Ground Water Board, Ministry of Water Resources, Government of India monitored ground water depth in May 2007 which is reported in subsequent section.

3.3.2 Ground Water

The data of Central Ground Water Board (CGWB) from the year 1998 to 2007 shows decline in ground water levels in major parts of the district. The pre-monsoon and post monsoon trend maps were also prepared by CGWB are presented in **Figure-3.4**. During pre-monsoon period entire district shows fall in water level trend of up to 20 cm/year, whereas during post-monsoon period rise in water level trend of up to 20 cm/year is observed in extreme northern part and central southern parts of the district.

FIGURE-3.4
WATER LEVEL TREND (MAY AND NOV. 1998-2007)



The depth to water levels during pre-monsoon has been depicted in **Figure-3.5**. The shallow water levels between 2 and 5 m bgl are observed in southern part, whereas moderate water levels in the range of 5 to 10m bgl are observed in northern part of the area.

Spatial variation in post-monsoon depth to water level is shown in **Figure-3.6**. The water levels in major part of the district range between 2 and 5 m bgl. Shallow water levels of < 2 m bgl are observed in small area in southern part, whereas water levels of 5 to 10 m bgl are observed in north central part of the district.

FIGURE-3.5
DEPTH TO WATER LEVEL (PRE-MONSOON)

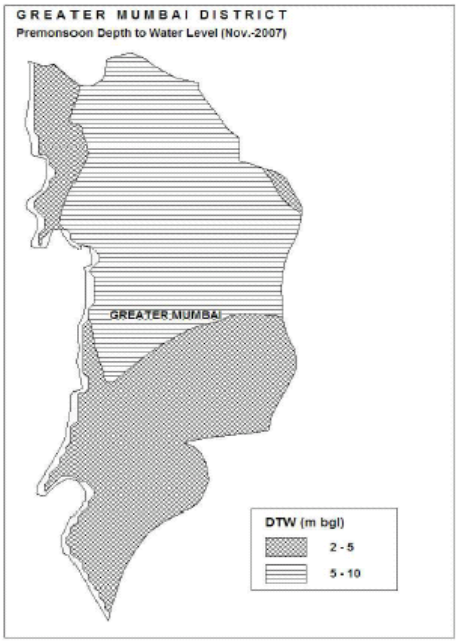
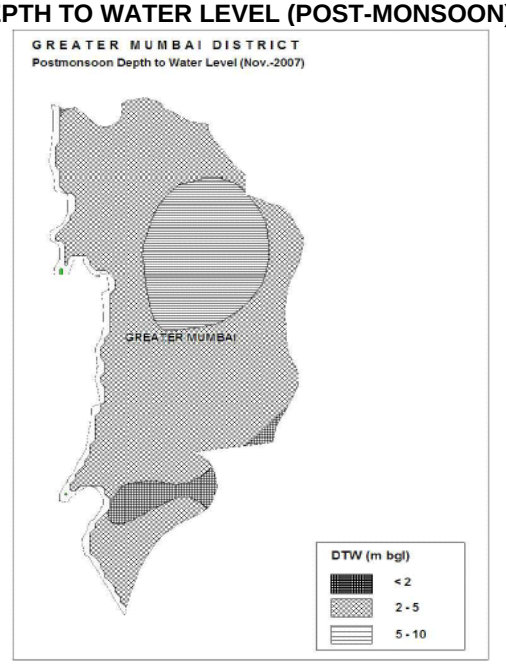


FIGURE-3.6
DEPTH TO WATER LEVEL (POST-MONSOON)



3.3.3 Water Quality

Water quality is the physical, chemical and biological characteristics of water. It is most frequently used with reference to a set of standards against which compliance can be assessed. 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.

Central Ground Water Board in the year 2007 has monitored the ground water quality of the district through analysis of water samples collected by keeping objective to understand an overall picture of ground water quality of the district. The result of chemical analysis shows that the ground water in the district is alkaline in nature. The suitability of ground water for drinking were checked with the standards proposed by the Bureau of Indian Standards (BIS) (IS-10500-91, Revised 2003). The concentrations of all the parameters in all the samples tested were within the Maximum Permissible Limit (MPL). Therefore, it can be concluded that the ground water quality in majority of the area were good for drinking purpose.

In order to collect baseline data on the existing water quality, water samples were collected from 5 different locations along the alignment in the project study area and analyzed as per the procedure specified in standard methods for examination of water and wastewater published by American Public Health Association and the Bureau of Indian Standards (APHA/BIS). The results of the physio-chemical analysis are summarized in the **Table 3.3**.

The test results when compared with the prescribed limits of various parameters as per IS 10500:1991 indicated that at some locations certain parameters are more than desirable limit. These values are shown in bold italics in the table. Most of the parameters tested for Mahim Creek (Location 3) are more than permissible limit. At rest of the locations, the parameters are within limit.

TABLE 3.3
WATER QUALITY AT PROJECT SITE

PARAMETER	LOCATION							
	1	2	3	4	5	6	7	8
pH	7.20	7.21	6.89	7.10	7.02	6.98	7.41	7.72
Total Hardness as CaCo3(mg/l)	48.0	60.00	3500	140.00	44.00	444.72	126.48	379.44
Calcium (As Ca, mg/l)	8.02	11.22	480.96	38.48	9.62	107.93	31.07	55.60
Alkalinity (As CaCO3, mg/l)	51.08	52.39	2060.19	143.91	80.15	466.44	102.29	249.2
Chloride (As Cl, mg/l)	13.80	9.86	5518.86	25.62	11.83	181.99	58.71	68.49
Magnesium (As Mg, mg/l)	6.80	7.78	558.90	10.69	4.86	42.63	11.90	***58.49***
Total Dissolved Solid (mg/l)	123	155	15387.0	278.00	181.0	949.0	261.00	***567.0***
Sulphate (As So_4 , mg/l)	3.13	4.17	615.13	10.71	4.17	11.49	4.90	36.79
Fluoride (As F, mg/l)	0.11	0.21	3.11	0.36	0.27	0.47	0.15	0.41
Nitrate (NO_3, mg/l)	0.11	0.42	0.34	0.02	0.46	0.34	0.29	0.19
Iron (As Fe, mg/l)	0.05	0.08	0.32	0.08	0.06	0.13	0.07	0.07
Aluminium (As Al, mg/l)	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Phenolic Compounds (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc (As Zn, mg/l)	<0.10	<0.10	0.17	<0.10	<0.10	<0.10	<0.10	<0.10
Chromium (As Cr, mg/l)	<0.01	<0.01	0.01	<0.01	<0.001	<0.01	<0.01	<0.01
Copper (As Cu, mg/l)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese (As Mn, Mg/l)	<0.10	<0.10	0.10	<10.0	<0.10	<0.10	<0.10	<0.10
Cadmium (as Cd, mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead (As Pb, mg/l)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Arsenic (As As, mg/l)	0.00	0.00	0.00	0.00	0.00	<0.05	<0.05	<0.05
Mercury (as Hg, mg/l)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Sodium (As Na, mg/l)	16.00	50.00	3475.00	58.00	48.30	110.00	12.00	48.0
Potassium (As K, mg/l)	0.20	2.00	120.00	14.00	0.30	104.00	2.00	15.0
Phosphate (as PO4, mg/l)	<0.02	<0.02	1.39	0.01	<0.02	<0.02	0.02	0.07
Total Suspended Solids (mg/l)	<5.0	<5.0	187.00	8.40	<5.0	21.00	27.00	<5.0
Biochemical Oxygen Demand at 20^oC for 3 Days	<1.0	<1.0	144.00	<1.0	<1.0	14.40	15.60	<1.0
Chemical Oxygen Demand, (mg/l)	<5.0	<5.0	380.00	<5.0	<5.0	54.76	39.82	<5.0
Oil & Grease (mg)	<0.40	<0.40	0.60	<0.40	<0.40	<0.40	0.40	<0.20
Dissolved Oxygen (mg/l)	5.08	5.17	4.08	5.27	5.07	4.88	3.51	5.56
Nickel (as Ni, mg/l)	<0.20	<0.20	<0.20	<0.2	<0.20	<0.20	<0.20	<0.20
Total Coliform (MPN/100 ml)	<2.0	<2.0	78.00	<2.0	<2.0	39.00	500.0	<2.0

Source: Sampling as per IS: 10500, 1991 – Drinking Water Specifications.
Sampling Locations: 1. Caffe Parade (Ground water), 2. Jacob Circle (Tap Water), 3.Mahim Creek (Surface water), 4. Aarey Colony (Ground Water), 5. SEEPZ (Tap Water), 6. Andheri East,(Handpump) 7. Mithi River (Surface water), 8.Parsi Well, Charchgate(Well water).

3.4 METEOROLOGY AND AIR ENVIRONMENT

Meteorology is an important parameter in an environmental impact assessment study. All air pollutants emitted by point and non-point sources are transported, dispersed or concentrated by meteorological and topographical conditions. The main parameters are: temperature, humidity, rainfall, winds and cloud cover. The meteorological data of Mumbai is collected from Regional Meteorological Centre (RMC) of India Meteorological Department (IMD) for the year 2009 to year 2011. The data has been collected at Colaba and Santacruz station. The meteorology and air environment of the area are discussed in subsequent sections.

3.4.1 Meteorology

Mumbai experiences tropical savanna climate. The climatic conditions in project area are experienced four distinct seasons mansoon (June-September), post monsoon (October-December), winter (December-February) and summer (March-May).

The normal annual rainfall over the district varies from 1800 mm to about 2400 mm. It is minimum in the central part of the district around Kurla (1804.9 mm). It gradually increases towards north and reaches a maximum around Santacruz (2382.0 mm). The relative humidity at Mumbai ranges between 54.5 % to 85.5%. Records of monthly total rainfall, mean maximum and mean minimum relative humidity of Mumbai obtained from Regional Meteorological Department (RMC), Colaba and Santacruz has been presented in **Table 3.4** to **Table 3.6**.

The mean minimum temperature is 16.3°C and the mean maximum temperature is 32.2°C at Santacruze. Records of mean maximum and mean minimum temperatures are given in **Table 3.7** and **Table 3.8** respectively.

The predominant wind direction is south/south-west in monsoon and north/north-east in winter. The windrose diagrams are prepared showing wind speed and direction at 8:30 and 17:30 hrs and placed at **Figure 3.7**.

TABLE 3.4
MONTHLY TOTAL RAINFALL AT STATION: COLABA

PARAMETERS	YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
MONTHLY TOTAL RAINFALL (MM)	2009	0.000	0.000	trace	0.000	002.3	265.9	771.3	204.5	519.1	158.3	120.2	trace
	2010	trace	trace	000.0	000.3	000.0	947.4	1099.0	849.8	272.9	122.4	053.7	000.0
	2011	000.0	000.1	000.0	000.0	000.7	461.2						

TABLE 3.5
MONTHLY TOTAL RAINFALL AT STATION: SANTACRUZ

PARAMETERS	YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
MONTHLY TOTAL RAINFALL (MM)	2009	000.0	000.0	000.0	000.0	000.3	216.4	1142.2	290.3	322.2	223.3	77.5	trace
	2010	000.0	trace	000.0	000.7	000.0	712.1	1250.4	1036.5	328.9	064.0	047.2	000.0
	2011	000.0	000.0	000.0	000.0	trace	661.7	--	--	--	--	--	--

TABLE 3.6
MONTHLY MEAN RELATIVE HUMIDITY AT STATION: COLABA

PARAMETERS	YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
MONTHLY MEAN RELATIVE HUMIDITY AT 08:30 HRS (%)	2009	81	86	79	79	79	85	93	91	92	86	85	84
	2010	80	85	88	83	84	92	96	96	90	85	86	78
	2011	80	85	81	83	77	92	--	--	--	--	--	--
MONTHLY MEAN RELATIVE HUMIDITY AT 17:30 HRS (%)	2009	61	64	63	67	67	75	88	81	83	76	72	64
	2010	63	62	70	74	72	84	91	90	82	72	73	59
	2011	63	62	58	74	68	84	--	--	--	--	--	--

TABLE 3.7
MONTHLY MEAN RELATIVE HUMIDITY AT STATION: SANTACRUZ

PARAMETERS	YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
MONTHLY MEAN RELATIVE HUMIDITY AT 08:30 HRS (%)	2009	78	77	73	70	69	74	88	84	87	79	77	75
	2010	65	76	79	69	71	83	91	90	86	84	79	77
	2011	77	77	72	77	71	78	--	--	--	--	--	--
MONTHLY MEAN RELATIVE HUMIDITY AT 17:30 HRS (%)	2009	49	44	49	56	63	68	84	77	77	64	61	55
	2010	47	52	54	61	66	75	84	83	75	68	69	57
	2011	45	46	45	65	65	79	--	--	--	--	--	--

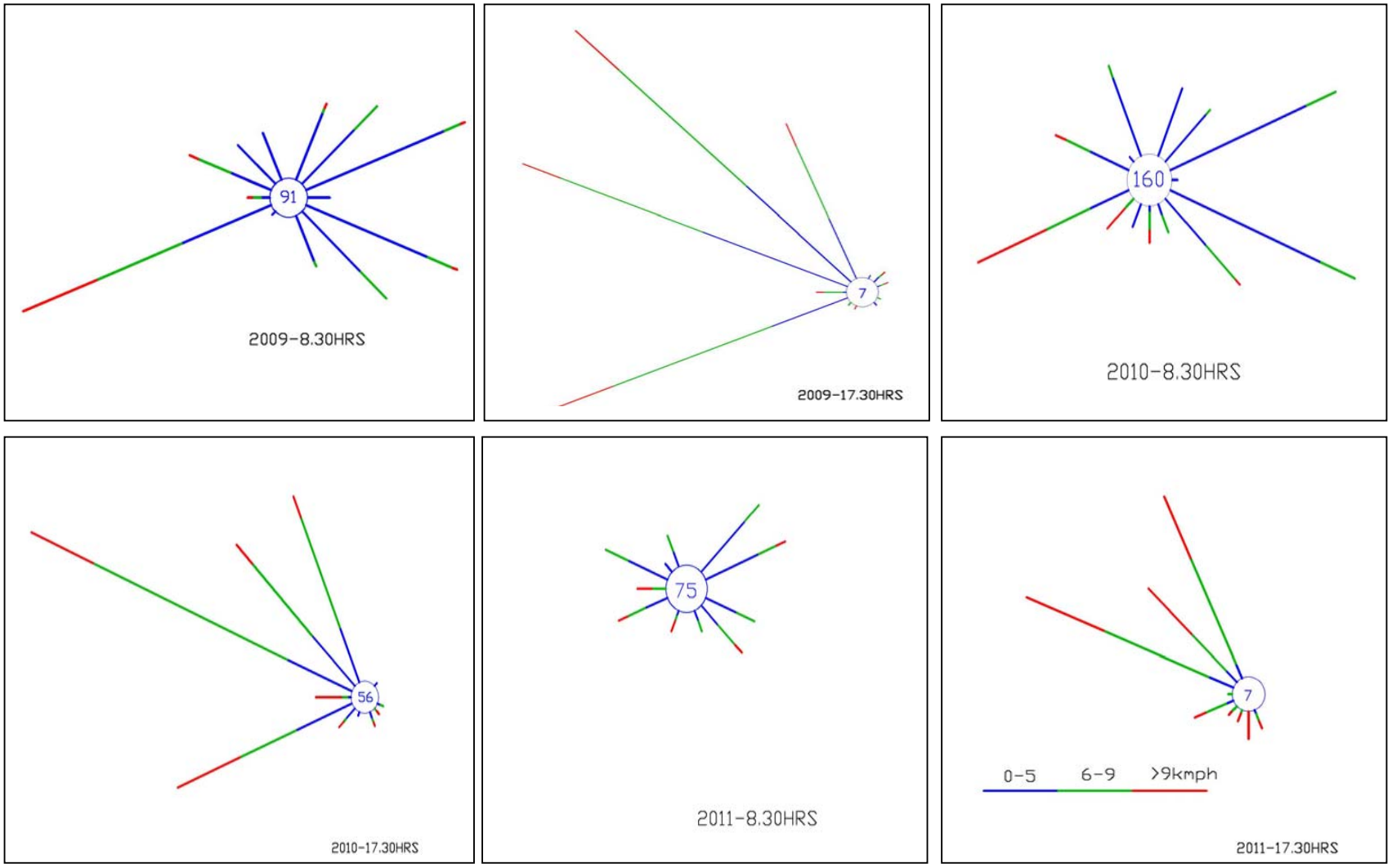
TABLE 3.8
MONTHLY MEAN MAXIMUM AND MINIMUM TEMPERATURE AT STATION: COLABA

PARAMETERS	YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
MONTHLY MEAN MAXIMUM TEMPERATURE (deg C)	2009	32.0	30.7	32.6	34.2	34.7	33.8	29.5	31.2	31.1	32.7	32.8	32.2
	2010	32.0	30.4	32.1	34.3	35.3	32.4	29.9	29.9	31.7	33.0	33.3	30.9
	2011	30.7	31.2	33.6	33.2	34.2	31.8	--	--	--	--	--	--
MONTHLY MEAN MINIMUM TEMPERATURE (deg C)	2009	19.4	19.5	22.5	24.6	26.7	27.7	25.6	26.2	25.8	24.6	23.8	22.3
	2010	21.3	21.8	24.2	26.5	28.5	26.6	25.3	25.6	25.9	25.9	24.9	20.6
	2011	18.6	20.8	23.4	25.3	27.6	26.7	--	--	--	--	--	--

TABLE 3.9
MONTHLY MEAN MAXIMUM AND MINIMUM TEMPERATURE AT STATION: SANTACRUZ

PARAMETERS	YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
MONTHLY MEAN MAXIMUM TEMPERATURE (deg C)	2009	32.9	32.6	34.3	35.4	33.9	33.6	29.8	31.1	31.2	33.3	32.9	32.1
	2010	32.5	31.6	33.6	34.6	34.7	33.0	30.3	29.8	31.5	33.0	33.6	30.8
	2011	31.6	32.1	35.3	33.2	33.5	32.0	--	--	--	--	--	--
MONTHLY MEAN MINIMUM TEMPERATURE (deg C)	2009	17.9	18.1	21.8	25.1	27.3	27.8	25.4	26.1	25.4	23.1	22.1	19.2
	2010	18.8	19.0	22.2	24.8	27.8	26.1	24.9	25.1	25.2	24.7	23.4	17.4
	2011	14.9	17.2	20.1	23.8	26.8	26.2	--	--	--	--	--	--

FIGURE 3.7
WINDROSE DIAGRAME



3.4.2 Air Quality

The atmospheric concentrations of air pollutants were monitored at 5 locations during January 2012 by setting up ambient air quality monitoring stations. The monitoring stations were selected to generate the representative samples for air quality covering residential, institutional and industrial area along the corridor. Locations of air monitoring stations are shown in **Figure 3.2.** Air Monitoring was carried out for parameters $PM_{2.5}$, PM_{10}, NOx, SO_2, CO, and HC. Results of the air quality monitoring are presented in **Table 3.10.** The results show that the concentration of PM_{10} and $PM_{2.5}$ exceeds the standards at all locations whereas other parameters are within permissible limits at all the locations.

TABLE 3.10
AMBIENT AIR QUALITY RESULTS

Location	Date	Timing	PM $_{10}$ µg/m^3	PM $_{2.5}$ µg/m^3	NO_x µg/m^3	SO_2 µg/m$_3$	(HC) (ppm)	CO (mg/m^3)
Limits As per CPCB (MoEF)			100	60	80	80	--	2
Mahim	10/01/2012 To 11/01/2012	01:30 PM To 09:30 PM	247	151	40.1	12.3	3.4	1.35
		09:30 PM To 05:30 AM	143	85	20.0	< 5.0	2.5	1.13
		05:30 AM To 01:30 PM	211	124	32.2	8.4	3.1	1.22
BKC	11/01/2012 To 12/01/2012	03:00PM To 11:00 PM	235	140	31.2	6.2	3.0	1.28
		11:00 PM To 07:00 AM	138	81	26.5	< 5.0	2.4	1.11
		07:00 AM To 03:00 PM	304	135	37.1	9.4	4.1	1.43
SEEPZ	12/01/2012 To 13/01/2012	03:00PM To 11:00 PM	185	109	19.2	< 5.0	2.3	1.10
		11:00 PM To 07:00 AM	112	60	15.0	< 5.0	2.3	1.00
		07:00 AM To 03:00 PM	230	140	24.1	6.5	2.9	1.24
Colaba	13/01/2012 To 14/01/2012	04:00 PM To 12:00 AM	325	213	37.1	7.4	3.8	1.34
		12:00 PM To 08:00 AM	189	98	22.4	< 5.0	2.7	1.18
		08:00 AM To 04:00 PM	387	250	39.8	8.2	4.0	1.42
Airport	14/01/2012 To 15/01/2012	05:00PM To 01:00 AM	311	185	35.6	9.5	4.5	1.45
		01:00 AM To 09:00 AM	241	142	28.1	6.5	2.9	1.23
		09:00 AM To 05:00 PM	388	236	41.0	11.3	4.2	1.42

An ambient air quality data for pre monsoon (i.e months of February & March) and post monsoon (i.e months of September & October) for the year 2011 at Worli, Khar and Andheri has been collected from Air Quality Monitoring and Research Laboratory, Khar and Maharashtra Pollution Control Board, Mumbai. The air quality data namely SPM, SO_2, NO_2 and NH_3 has been graphically presented in **Figure 3.8** to **Figure 3.27**.

FIGURE 3.8 : AIR QUALITY AT WORLI: FEBRUARY 2011

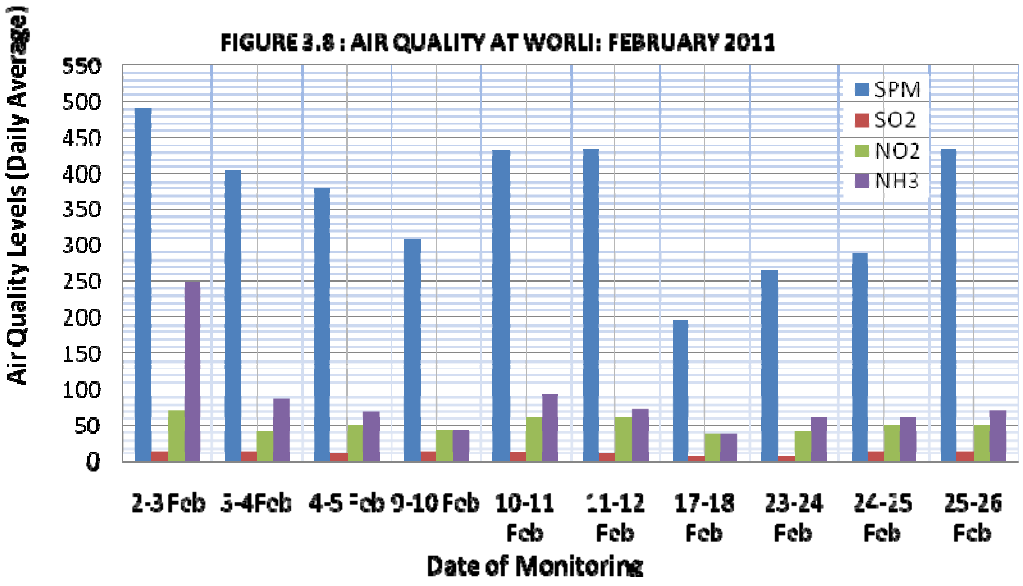


FIGURE 3.9: AIR QUALITY AT KHAR: FEBRUARY 2011

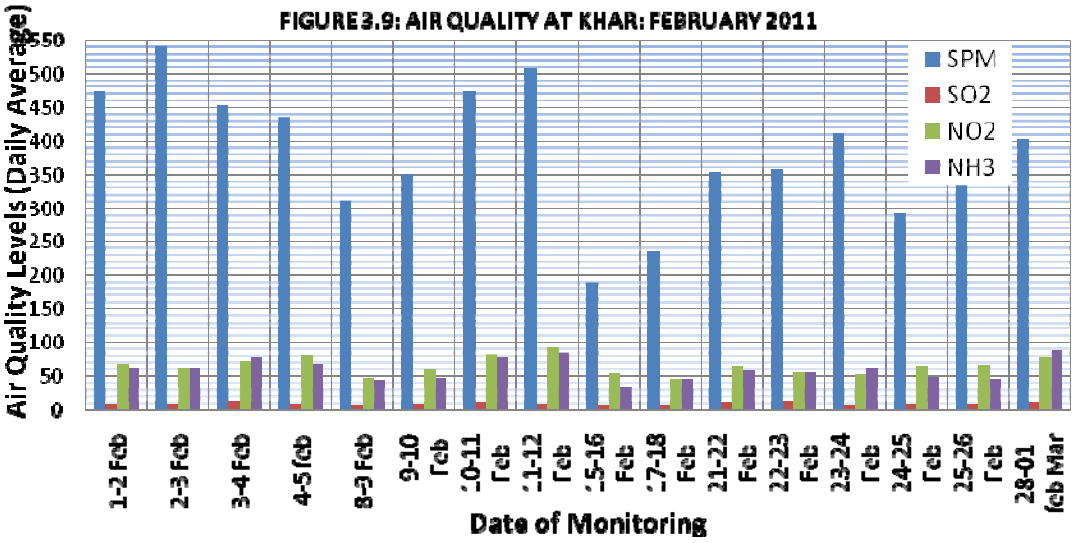


FIGURE 3.10: AIR QUALITY AT ANDHERI: FEBRUARY 2011

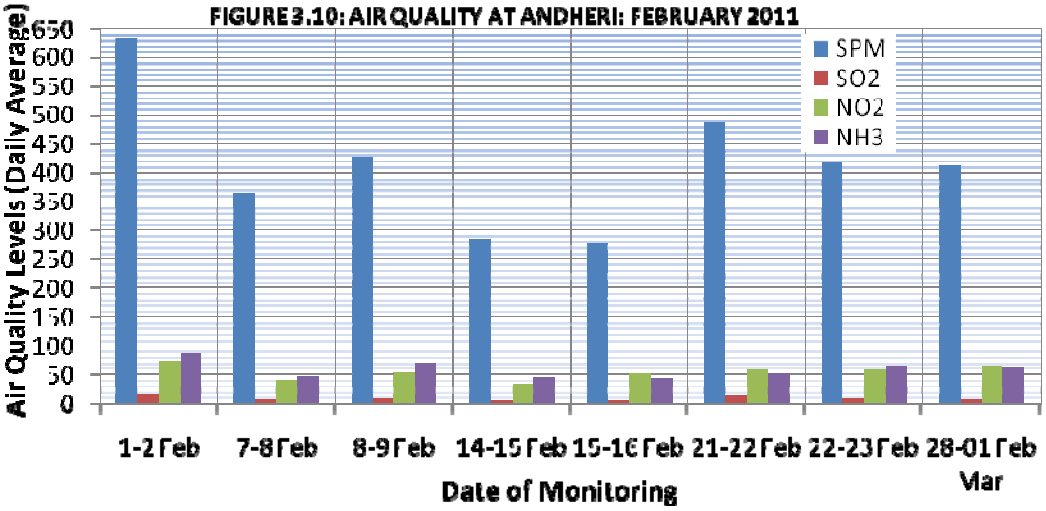


FIGURE 3.11: AIR QUALITY AT BANDRA: FEBRUARY 2011

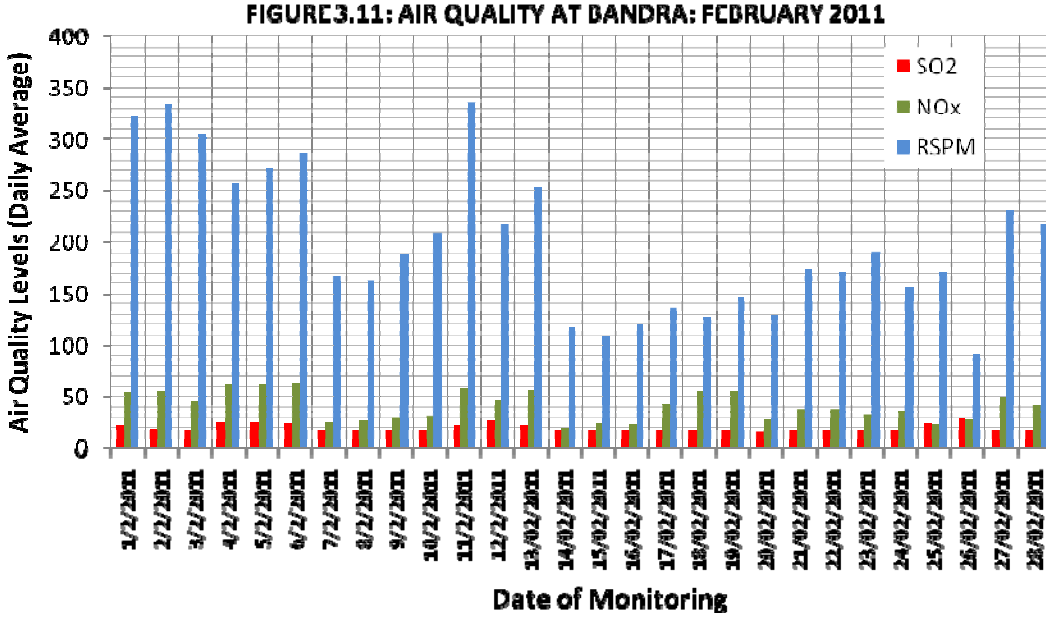


FIGURE 3.12: AIR QUALITY AT KALBADEVI: FEBRUARY 2011

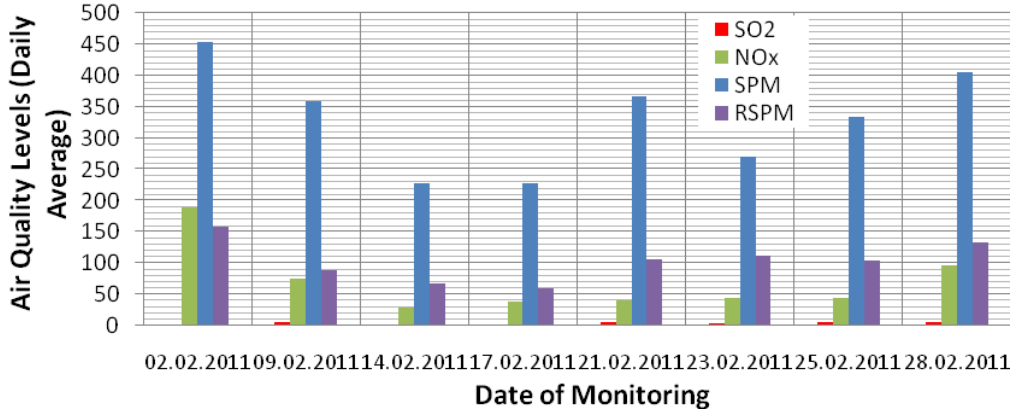


FIGURE 3.13: AIR QUALITY AT WORLI: MARCH 2011

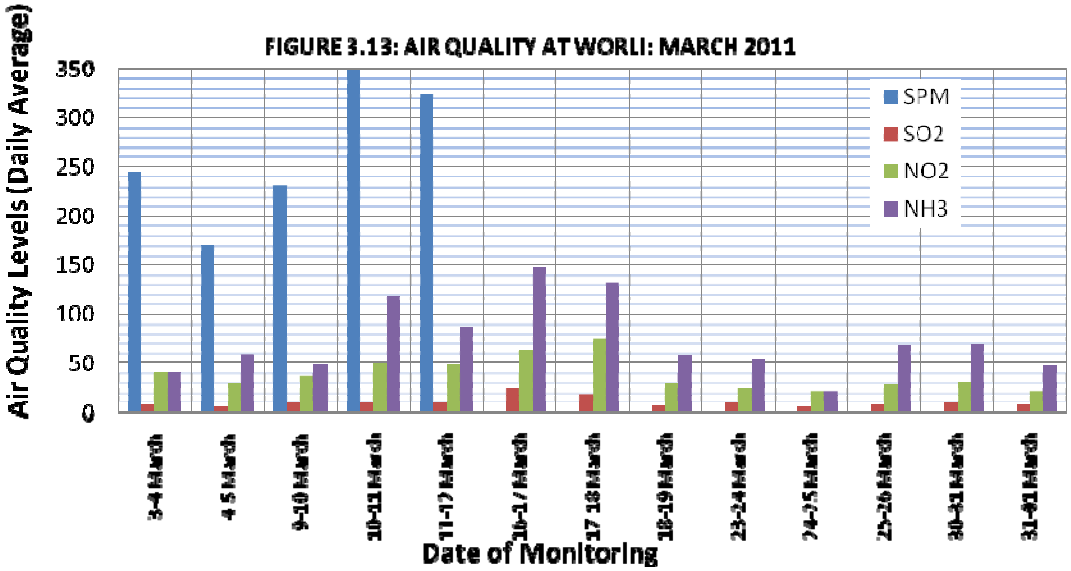


FIGURE 3.14: AIR QUALITY AT KHAR: MARCH 2011

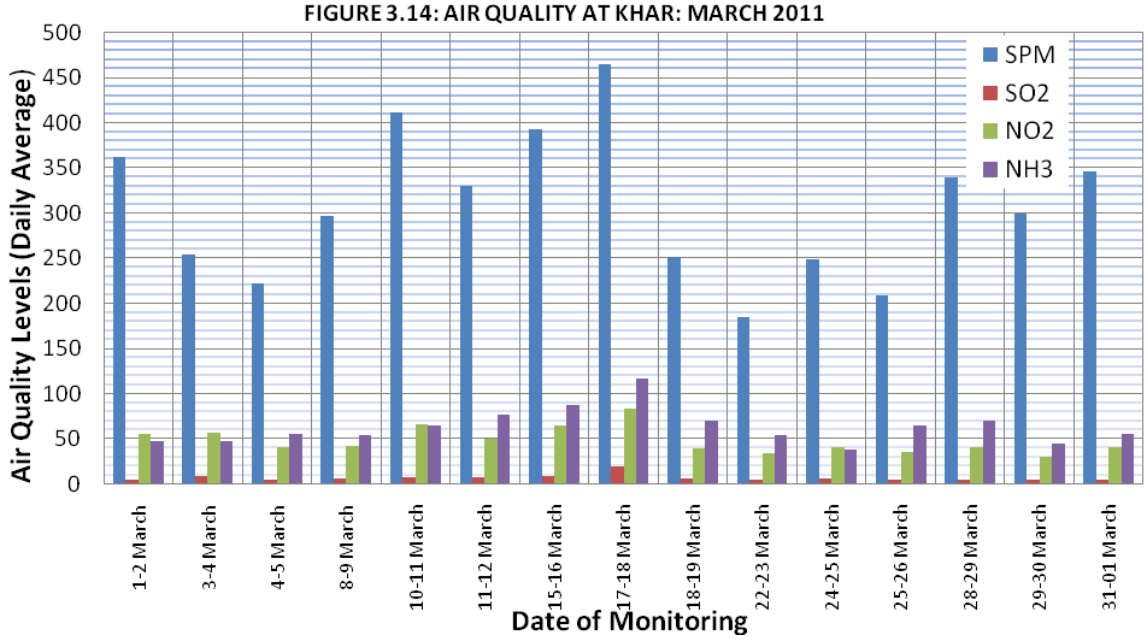


FIGURE 3.15: AIR QUALITY AT ANDHERI: MARCH 2011

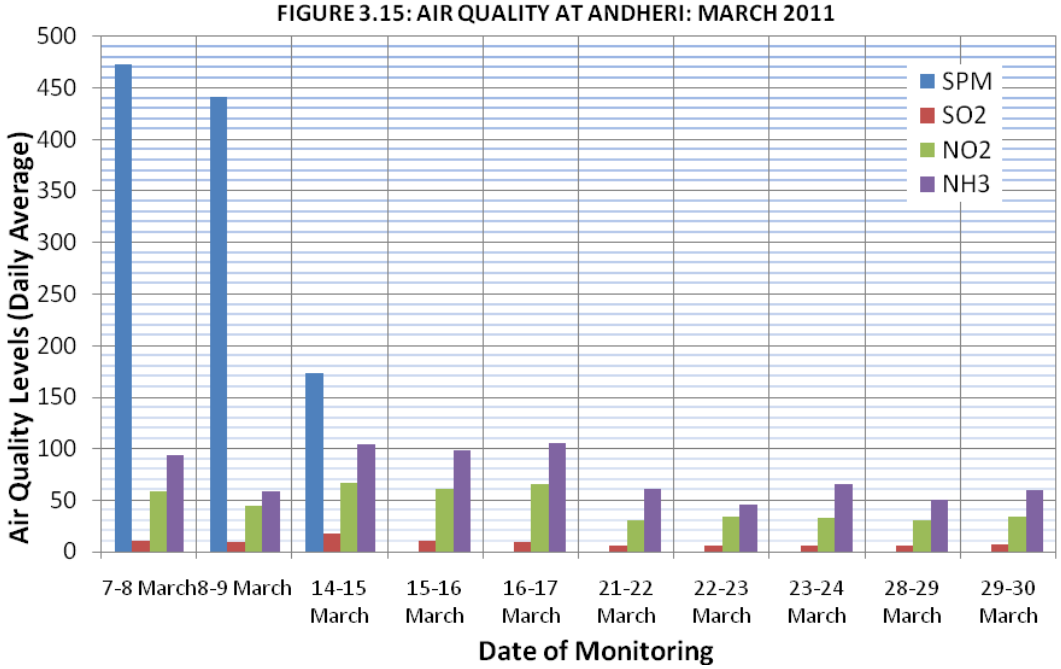


FIGURE 3.16: AIR QUALITY AT BANDRA: MARCH 2011

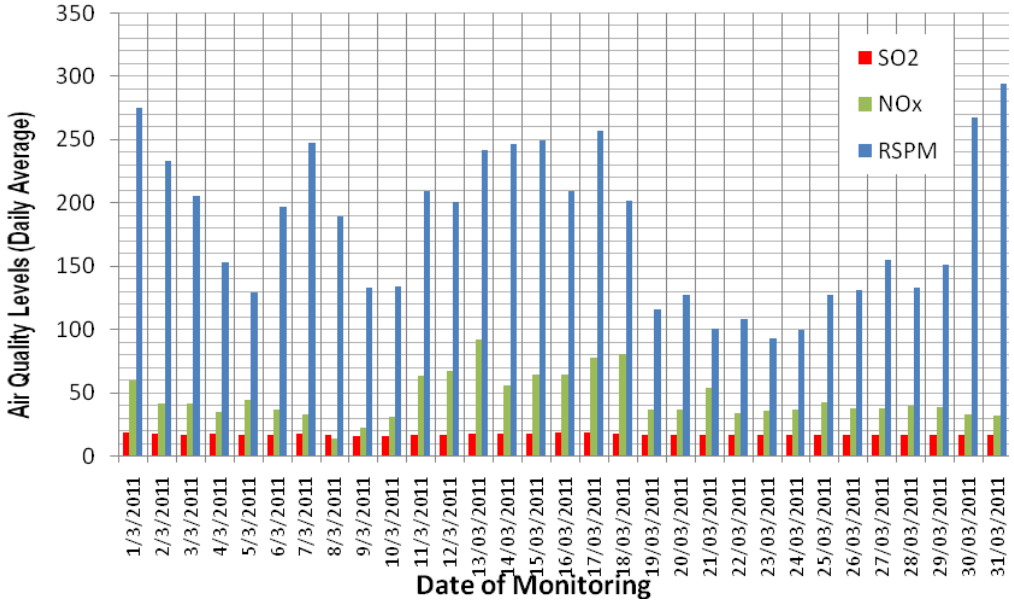


FIGURE 3.17: AIR QUALITY AT KALBADEVI: MARCH 2011

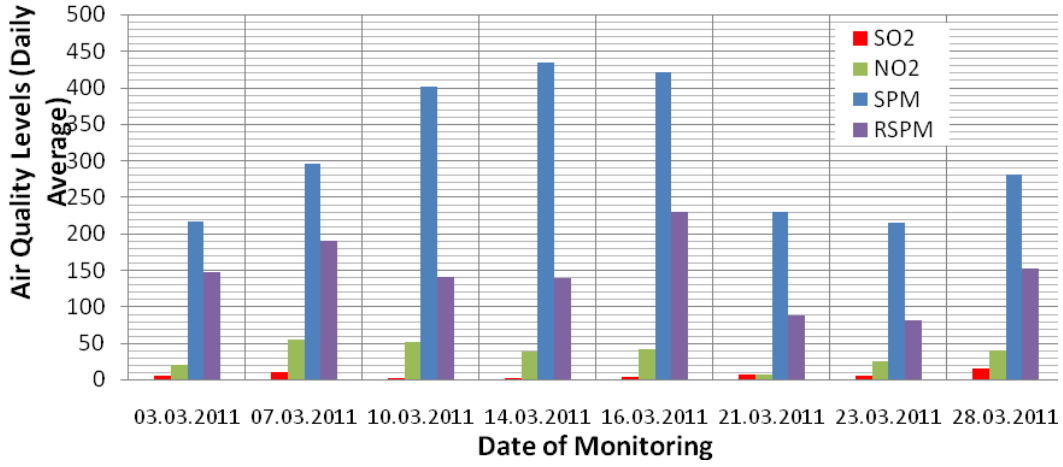


FIGURE 3.18: AIR QUALITY AT WORLI: SEPTEMBER 2011

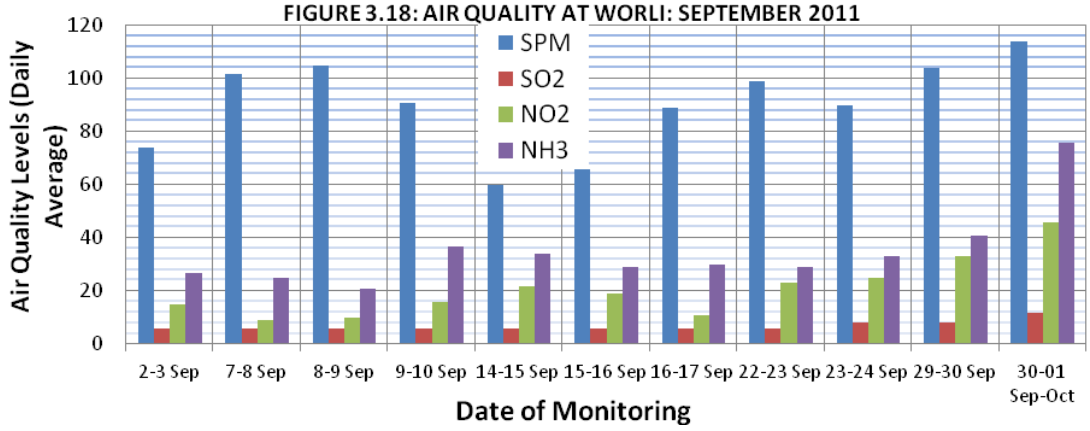


FIGURE 3.19: AIR QUALITY AT KHAR: SEPTEMBER 2011

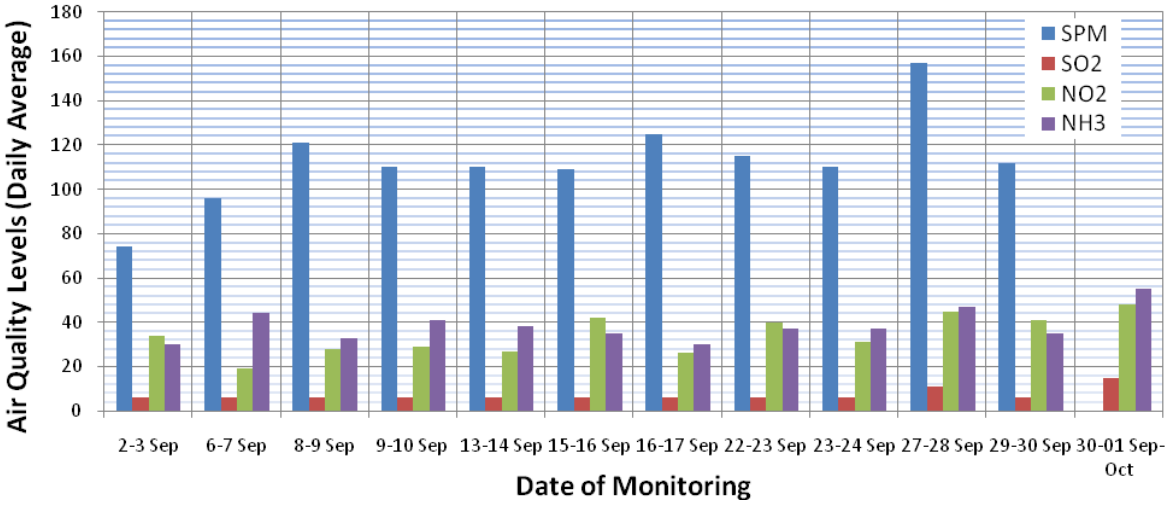


FIGURE 3.20: AIR QUALITY AT ANDHERI: SEPTEMBER 2011

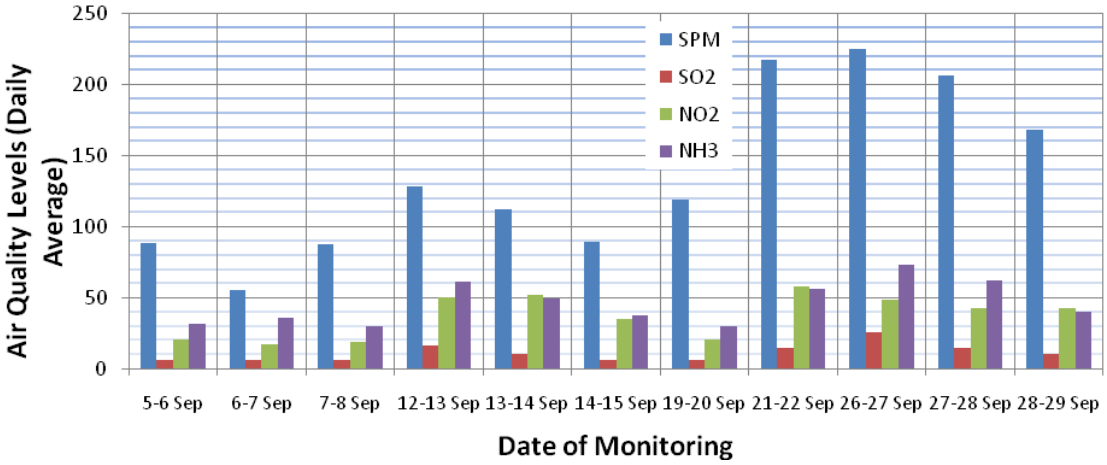


FIGURE 3.21: AIR QUALITY AT BANDRA: SEPTEMBER 2011

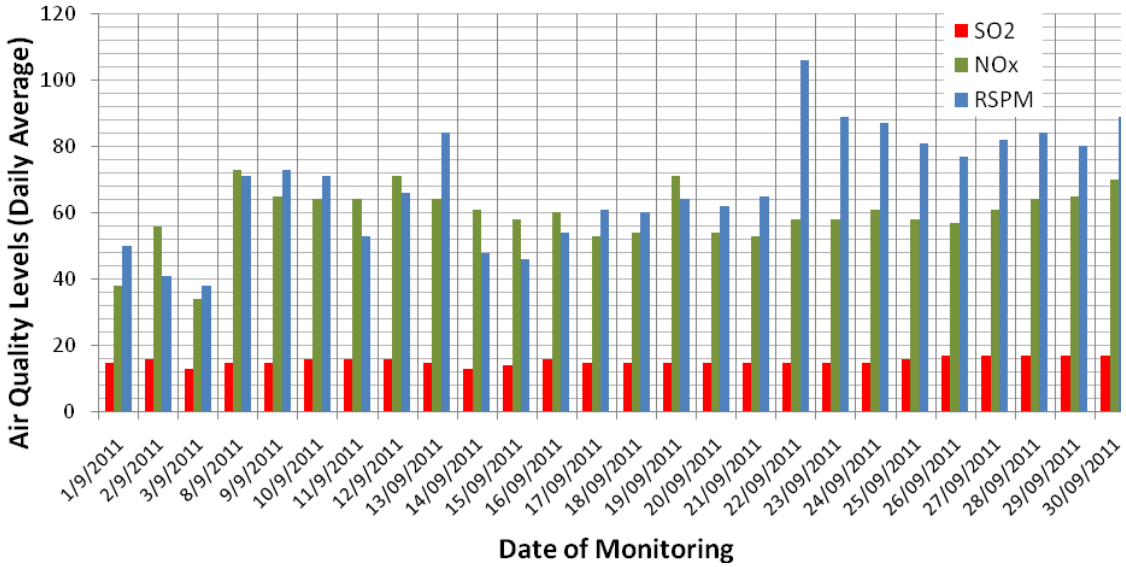


FIGURE 3.22: AIR QUALITY AT KALBADEVI: SEPTEMBER 2011

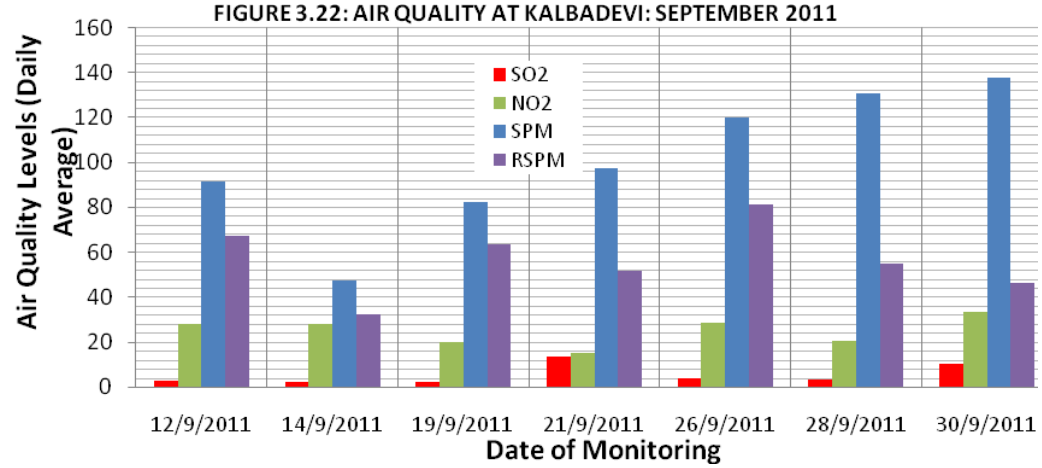


FIGURE 3.23: AIR QUALITY AT WORLI: OCTOBER 2011

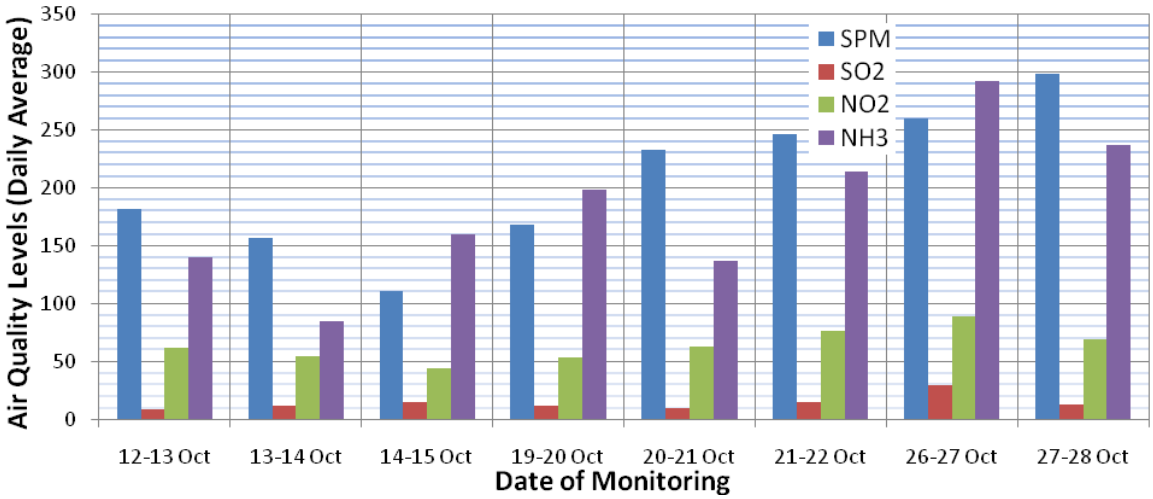


FIGURE 3.24: AIR QUALITY AT KHAR: OCTOBER 2011

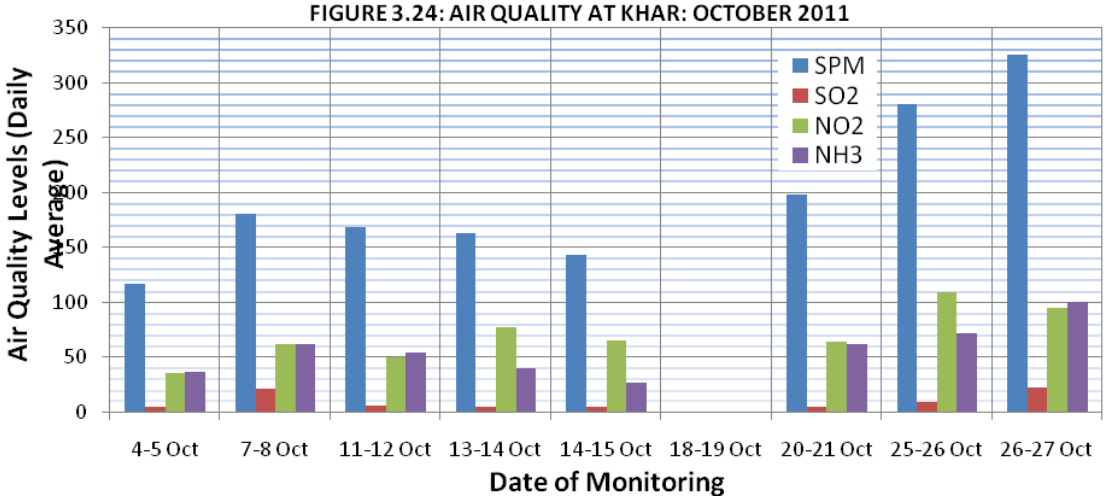


FIGURE 3.25: AIR QUALITY AT ANDHERI: OCTOBER 2011

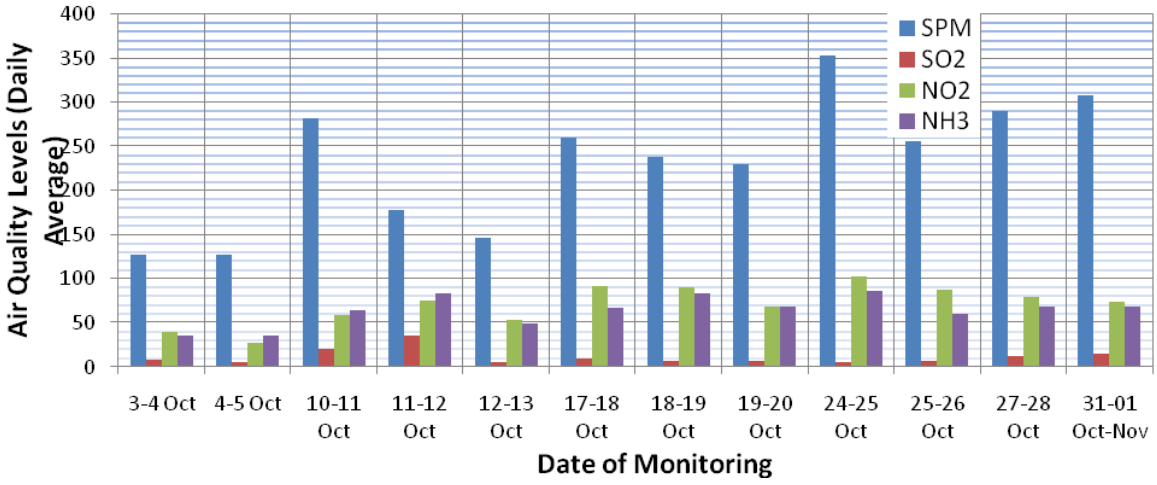


FIGURE 3.26: AIR QUALITY AT BANDRA: OCTOBER 2011

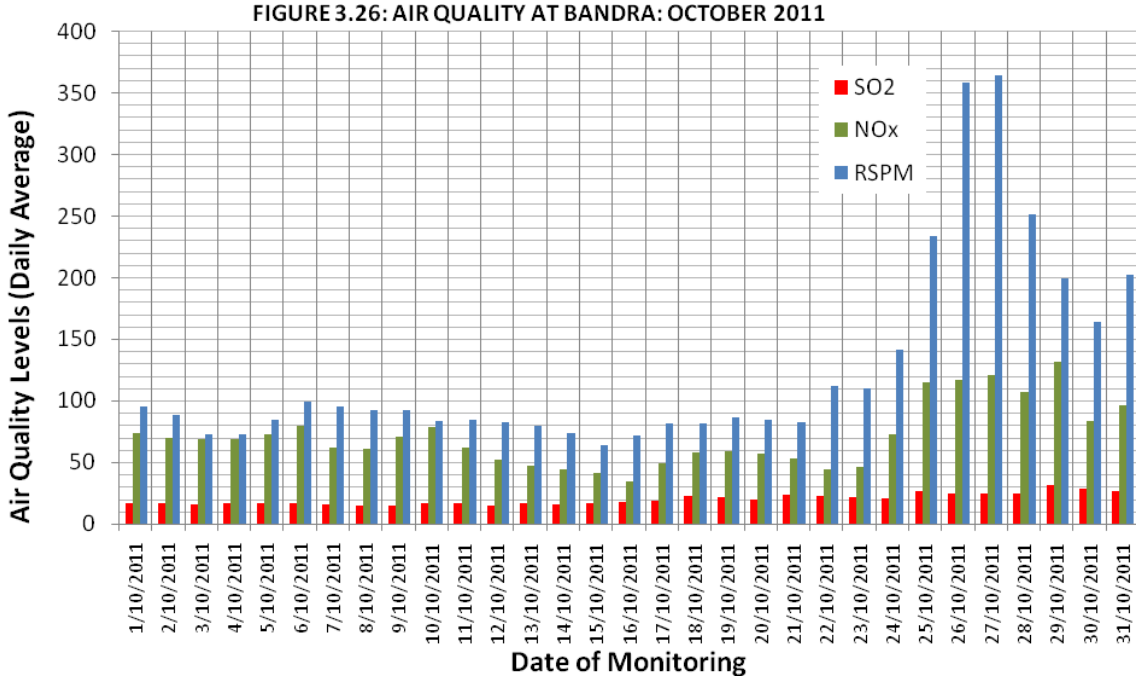
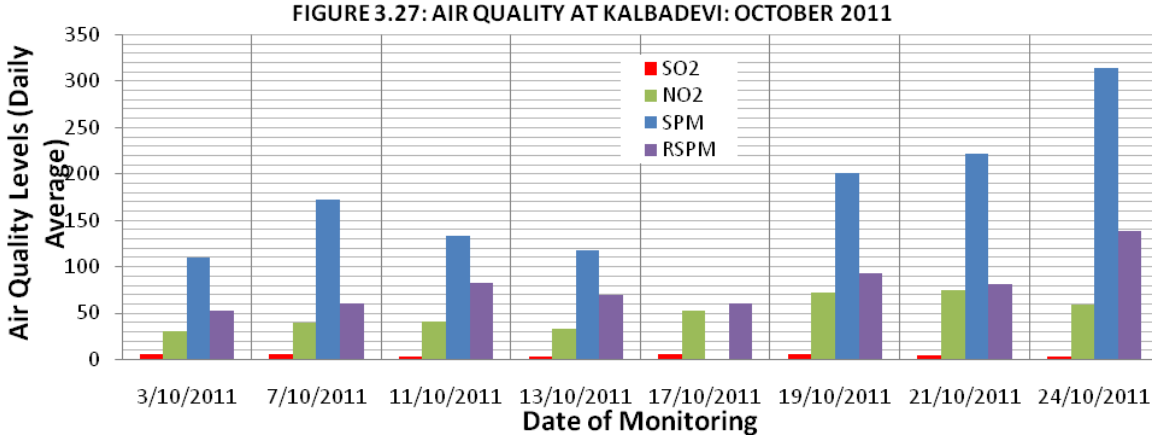


FIGURE 3.27: AIR QUALITY AT KALBADEVI: OCTOBER 2011



3.5 NOISE ENVIRONMENT

Noise pollution is caused by an unwanted sound that is produced by various natural or man-made sources such as oceans, construction, industrial, transportation etc. Noise can have any adverse affects such as hearing impairment; sleep disturbance, interference with speech communication, reduced performance, annoyance and harming physiological functions.

Noise pollution is regarded as a public nuisance under Sections 268, 290 and 291 of the Indian Penal Code. There are several other legislations relating to noise pollution such as The Factories Act, 1948 (under which 'noise induced hearing loss' is notified as a disease); Motor Vehicles Act, 1988 (which specifies rules for horns and silencers); Law of Torts (civil suits can be filed for claiming damages); The Air (Prevention and Control of Pollution) Act, 1981 (ambient noise standards have been given), The Environment (Protection) Act, 1986; Noise Pollution (Regulation and Control) Rules, 2000 and regulations in respect of Loudspeakers/Public Address System. Further, there are standards and guidelines for ambient noise quality, automobiles, domestic appliances and construction equipment, generator sets, and firecrackers as notified under the Environment (Protection) Act, 1986. In general, continued exposure to noise levels above 85 dB would cause hearing loss over time. However, noise above 140 dB could cause aural damage after just one exposure. As a safeguard against harmful noise level, the CPCB has specified standards (National Ambient Noise Standards) for various categories of areas as given below in Table.

Noise level survey was conducted along the alignment with an objective to establish the baseline noise levels and assess the impacts of total noise expected due to the proposed metro. Noise levels has been measured at five locations as shown in Figure 3.2. Hourly Noise levels were recorded at 2 m away from source as per standard practice. Sampling duration were taken on hourly basis in the time bracket of 08-10,12-14,16-18,20-22 & 24-02 hours in order to have an assessment of the Day and Night time noise levels. The results of the noise quality has been reported as L_{eq}, L_{10}, L_{50}, L_{90}, L_{max}, L_{min}, $L_{day,}$ $L_{night.,}$ $L_{DN.}$ The noise levels so obtained are summarised in **Table 3.11.** The results of observations indicate that the equivalent noise levels at all the five sites are more than the limit prescribed for residential areas.

TABLE 3.11
NOISE LEVELS

Date: 10/01/2012 to 11/01/2012
Location: Mahim

Time	Hourly Leq dB (A)	Result dB (A)	
MIDNIGHT	52.8	Leq(24hrs.)	67.0
1:00 AM	50.2	L10	72.7
2	49.5	L50	69.5
3	52.9	L90	67.5
4	49.3	Lday	68.3
5	55.9	Lnight	60.9
6	59.7	Ldn	69.4
7	63.3	Lmax	74.1
8	65.1	Lmin	49.3
9	66.4		
10	68.2		
11	69.4		
12 NOON	73.2		
13	74.1		
14	68.3		
15	67.4		
16	69.2		
17	68.7		
18	65.3		
19	64.2		
20	63.4		
21	68.2		
22	63.7		
23	58.2		

Date: 11/01/2012 to 12/01/2012
Location: BKC

Time	Hourly Leq dB (A)	Result dB (A)	
MIDNIGHT	51.2	Leq(24hrs.)	68.6
1:00 AM	49.4	L10	73.4
2	48.3	L50	71.4
3	47.1	L90	69.2
4	49.6	Lday	70.3
5	52.4	Lnight	53.0
6	58.9	Ldn	68.9
7	61.3	Lmax	74.3
8	65.3	Lmin	47.1
9	68.2		
10	72.4		
11	69.7		
12 NOON	74.3		
13	72.6		
14	73.1		
15	68.3		
16	72.8		
17	71.4		
18	70.1		
19	69.9		
20	68.6		
21	59.3		
22	52.7		
23	50.8		

Date: 12/01/2012 to 13/01/2012
Location: SEEPZ

Time	Hourly Leq dB (A)	Result dB (A)	
MIDNIGHT	45.3	Leq(24hrs.)	65.9
1:00 AM	43.9	L10	72.9
2	44.8	L50	68.9
3	45.7	L90	66.5
4	46.9	Lday	67.7
5	49.3	Lnight	46.5
6	52.7	Ldn	66.1
7	53.9	Lmax	73.9
8	55.6	Lmin	43.9
9	59.8		
10	62.5		
11	64.3		
12 NOON	65.9		
13	68.7		
14	66.5		
15	70.2		
16	71.7		
17	73.9		
18	72.7		
19	64.3		
20	50.9		
21	49.4		
22	47.9		
23	45.1		

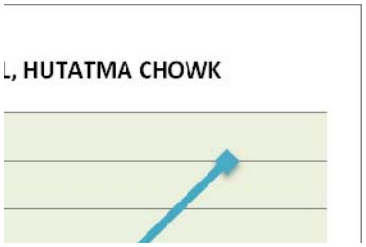
Date: 13/01/2012 to 14/01/2012
Location: Colaba

Time	Hourly Leq dB (A)	Result dB (A)	
MIDNIGHT	49.3	Leq(24hrs.)	68.2
1:00 AM	48.4	L10	74.3
2	46.5	L50	71.1
3	43.8	L90	68.8
4	49.3	Lday	69.9
5	55.6	Lnight	50.5
6	57.4	Ldn	68.4
7	59.3	Lmax	74.9
8	63.5	Lmin	43.8
9	61.9		
10	65.9		
11	68.2		
12 NOON	70.8		
13	72.9		
14	74.3		
15	73.7		
16	68.0		
17	74.9		
18	73.0		
19	62.3		
20	58.2		
21	56.8		
22	52.1		
23	48.4		

Date: 14/01/2012 to 15/01/2012

Location: Airport

Time	Hourly Leq dB (A)	Result dB (A)	
MIDNIGHT	52.3	Leq(24hrs.)	68.6
1:00 AM	55.1	L10	74.5
2	68.4	L50	71.3
3	70.2	L90	69.1
4	64.1	Lday	68.6
5	75.6	Lnight	68.5
6	73.2	Ldn	74.6
7	69.2	Lmax	75.6
8	62.0	Lmin	49.6
9	71.8		
10	69.3		
11	63.2		
12 NOON	70.2		
13	65.2		
14	59.8		
15	63.4		
16	74.5		
17	70.1		
18	63.8		
19	59.2		
20	55.7		
21	52.1		
22	50.0		
	49.6		



NATIONAL AMBIENT NOISE STANDARDS

TEGORY OF ZONES	Leq IN dB (A)	
	DAY *	NIGHT
Industrial	75	70
Commercial	65	55
Residential	55	45
Silence Zone **	50	40

Source: *Central Pollution Control Board,*
** **Daytime** is from 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. Use of vehicle horn, loudspeaker and bursting of crackers is banned in these zones.*

3.6 Vibration

The source of the vibration and noise during construction of tunnel is due to operation of Tunnel Boring Machine (TBM) and due to metro train during operation phase. The vibration during operation is mainly due to the rolling stock, track and the interaction between them. Continuous effect of vibration on the buildings can cause damage to buildings. Building subjected to the vibration effect with more than 50 mm/s (154 VdB) would receive structural damage. Historic buildings are more susceptible to vibration effect due to type of building material and design. The vibration induced by the operation of train first causes the vibration of track structure as well as tunnel structure, and then, propagate through the strata to the surrounding environment.

Human response to vibration is subjective and will be different for different people. When the vibrations reach the floors and walls it may result in perceptible vibration depending on the amplitude and frequency of the vibrations. People may be more annoyed if they are exposed to both noise and vibration compared to when only vibration is felt. According to the U.S. Department of Transportation, (1998) the perception threshold of humans for peak particle velocity is about 0.04 mm/s (65VdB with reference 1e-6 inch/sec).

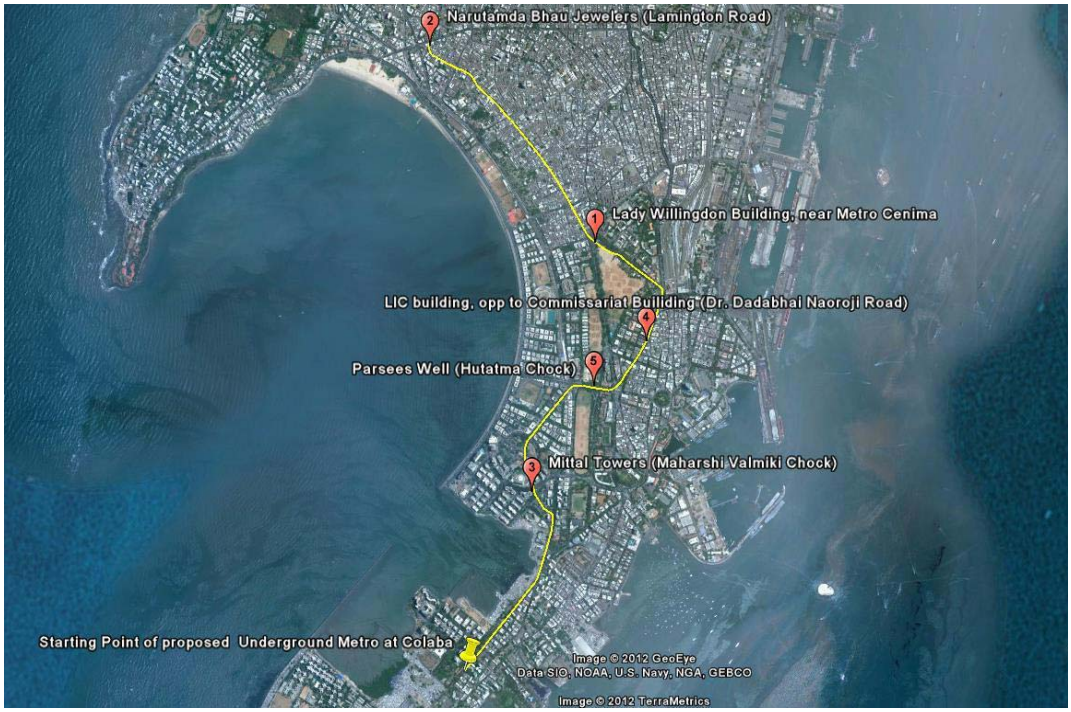
To know the impact of vibration due to TBM operation on the existing structures along the alignment and due to metro train operation has been studied at six locations by selecting the most sensitive area falling on the proposed metro line alignment. The monitoring is

carried out using the Nomis Seismographer equipment which can measure the radial, transverse and vertical vibration of ground borne vibration. The detail of location where vibration monitoring has been carried out is given in **Table 3.12 and** shown in Google map as **Figure 3.28**. The hard rock structure will be considered while predicting the vibration impact as the proposed metro is 18 to 20 m below the ground level.

TABLE 3.12
VIBRATION MONITORING LOCATION

SI	LOCATION	LATITUDE	LONGITUDE
1	Lady Willingdon Building, Dhobi Talao, near Metro Cenima. Mahapalika Road.	18° 56' 34.64" N	72° 49' 46.57" E
2	Narutamdas Bhau Jewelers, K.Gajanan Vertak Chowk, Lamington Road.	18° 57' 24.59" N	72° 48' 59.58" E
3	Mittal Towers, Maharshi Valmiki Chowk. Press Journal Marg.	18° 55' 30.94" N	72° 49' 30.37" E
4	Central Assurance Building, opp to Commissariat Building, Dr. Dadabhai Naoroji Road.	18° 56' 9.74" N	72° 50' 1.24" E
5	Bhikha, Behram, Parsees Well, Hutatma Chowk.	18° 55' 58.24" N	72° 49' 46.95" E
6	Chhatrapati Shivaji Terminus (CST), Mumbai. DN Road.	18° 56' 23.30" N	72° 50' 06.01" E

FIGURE 3.28
LOCATION OF VIBRATION MONITORING



The vibration study has been conducted to know the existing vibration cause due to the road traffic. The study has been conducted during the busy traffic hours at morning and evening time. The detail description of field monitoring vibration at each monitoring location is given in the subsequent section.

3.6.1 Vibration Monitoring at Location 1: Lady Willingdon Building, Dhobi Talao

The Lady Willingdon Building at Dhobi Talao, Mumbai was constructed in 1934; the building won an award from the Heritage Society in 1993 for being in good shape even though it was more than 60 years old at the time. The vibration monitoring has been carried out in front of the building for about 8 hr on 23/01/2012. The location of the monitoring point is shown in **Figure 3.29**. The monitoring location falls at chainage no. 4400.00 of proposed metro alignment. As per the field observation about 3400 vehicles per hour pass by this chowk, that includes all type of vehicles including two, three and four wheelers.

FIGURE 3.29
VIBRATION MONITORING AT LOCATION LADY WILLINGDON BUILDING, DHOBI TALAO

The graph has been plotted for the radial, transverse and vertical vibration and shown in **Figure 3.30**, **Figure 3.31** & **Figure 3.32** respectively. The monitoring result shows that, the average radial vibration is 85 VdB which are quite normal vibration due to road traffic. At one point, we have observed peak radial vibration of 119 VdB, this may be due to some passage of heavy vehicle. The average transverse vibration is found to be between 87.5 VdB and the peak transverse vibration is 118 VdB. The average vertical vibration is 88 VdB and the peak vertical vibration is found to be **113.9 VdB** and.

FIGURE 3.30
RADIAL VIBRATION AT LADY WILLINGDON BUILDING, DHOBI TALAO

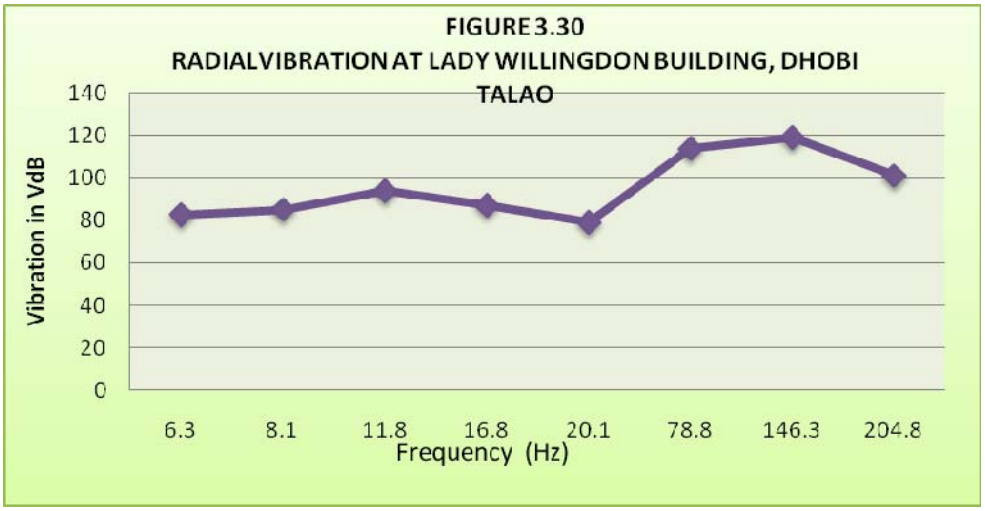


FIGURE 3.31
TRANSVERSE VIBRATION AT LADY WILLINGDON BUILDING, DHOBI TALAO

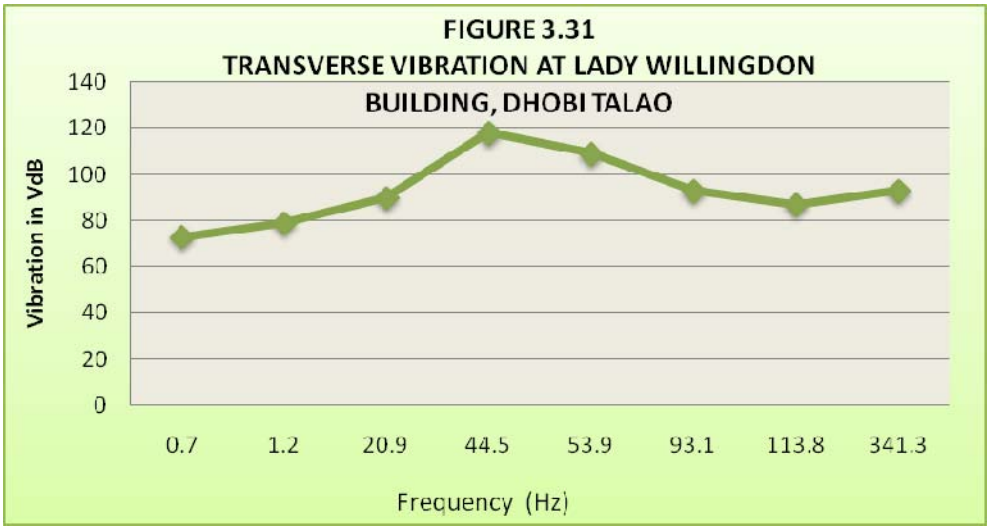
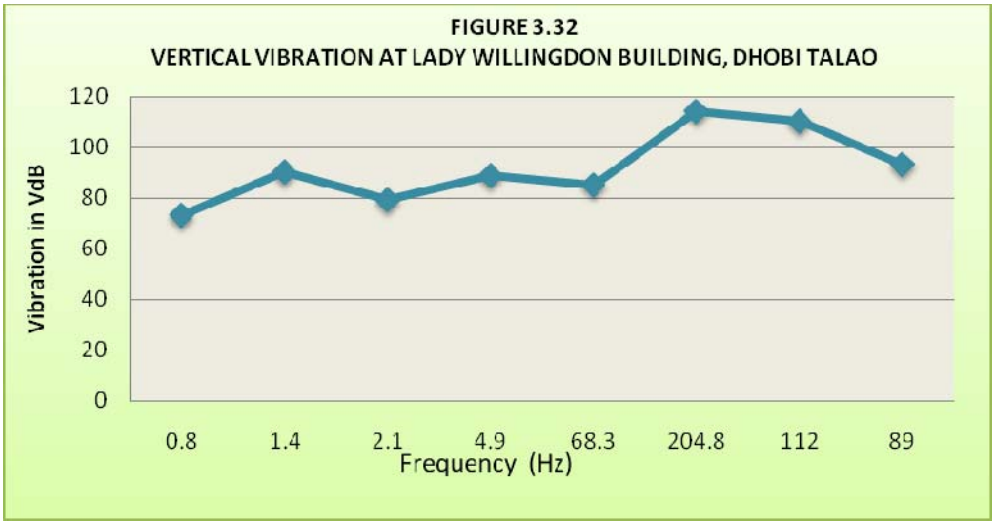


FIGURE 3.32
VERTICAL VIBRATION AT LADY WILLINGDON BUILDING, DHOBI TALAO



3.6.2 Vibration Monitoring at Location 2: Narutamdas Bhau Jewelers, K.Gajanan Vertak Chowk, Lamington Road

Narutamdas Bhau Jewelers building is more than 100 year old located at the K. Gajanan Vertak Chowk. There are many old structures that are closely located at this chowk. The monitoring location falls at chainage no. 6500.00 of proposed metro alignment. As per the field observation about 3000 vehicles per hour pass by this chowk that includes all type of vehicles including two, three and four wheelers. The location of the monitoring is shown in **Figure 3.33**.

FIGURE 3.33
VIBRATION MONITORING AT LOCATION LAMINGTON ROAD

The graph of the radial vibration, transverse and vertical vibration has been plotted and shown in **Figure 3.34**, **Figure 3.35** & **Figure 3.36** respectively. The result of the monitoring shows the average radial vibration is 90 VdB, which is because of variation in traffic flow as well as the source is closely located with the point of monitoring. The peak radial vibration is around 101 VdB. The average transverse vibration is found to be 87.5 VdB and the peak transverse vibration is 105 VdB. The average vertical vibration is 105 VdB. The peak vertical vibration is found to be **123.5 VdB** this may be due to passing of heavy vehicle.

FIGURE 3.34
RADIAL VIBRATION AT NAROTAMDAS BAHU JEWELLERS, LAMINGTON ROAD

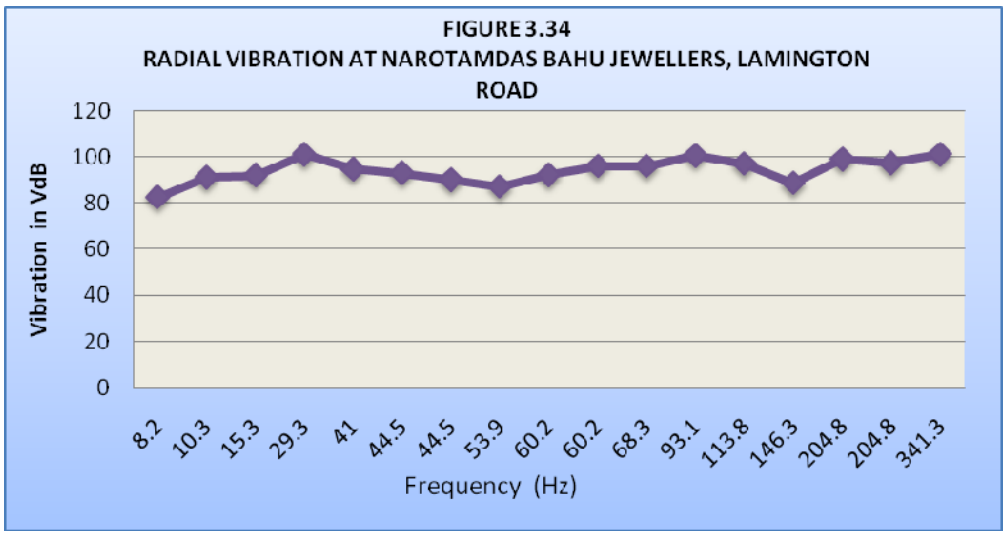


FIGURE 3.35
TRANSVERSE VIBRATION AT NAROTAMDAS BAHU JEWELLERS, LAMINGTON ROAD

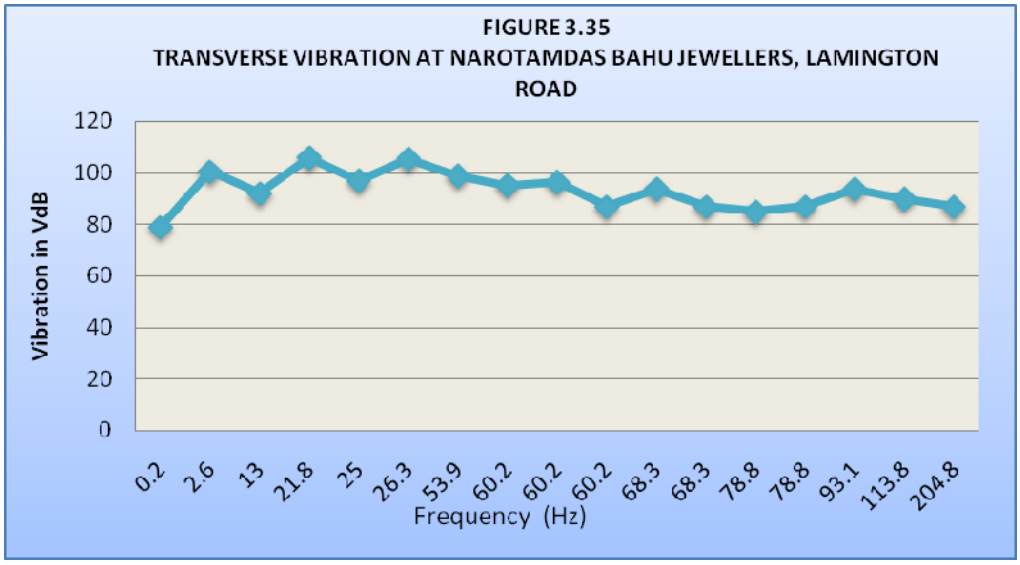
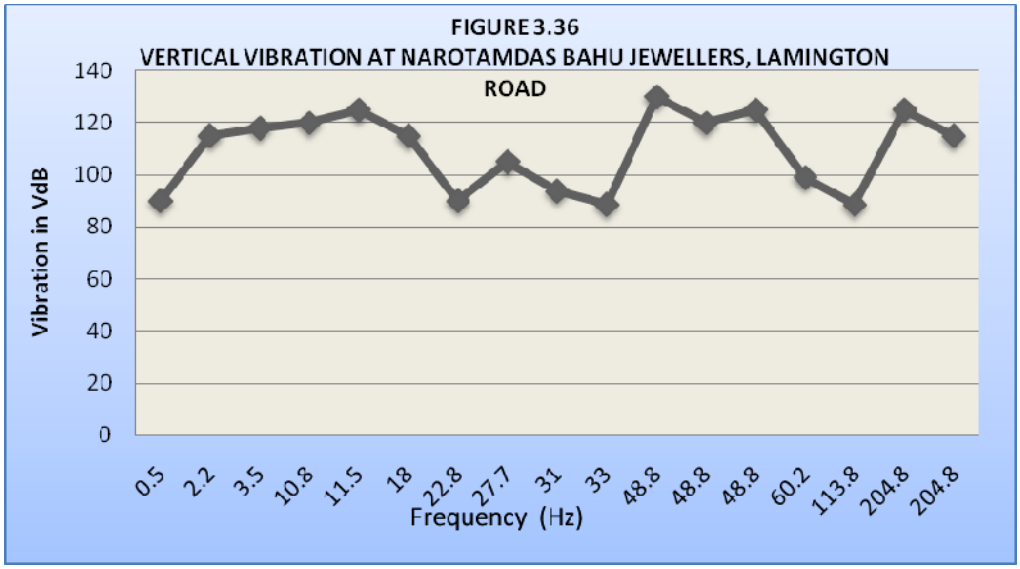


FIGURE 3.36
VERTICAL VIBRATION AT NAROTAMDAS BAHU JEWELLERS, LAMINGTON ROAD



3.6.3 Vibration Monitoring at Location 3: Mittal Towers, Maharshi Valmiki Chowk.

The proposed metro line is passing through the Sh. Maharshi Valmiki chowk near to SBI building and opposite to Mittal towers. Here metro line is passing through the road in between Vidhan Sabha and State Bank of India building. The location of the monitoring is shown in **Figure 3.37**. The monitoring location falls at chainage no.1600.00 of proposed metro rail alignment. As per the field observation about 1500 vehicles per hour pass by this chowk that includes two, three and four wheelers.

FIGURE 3.37
VIBRATION MONITORING AT LOCATION AT MITTAL TOWERS

The graph has been plotted for radial vibration, transverse and vertical vibration and shown in **Figure 3.38**, **Figure 3.39** & **Figure 3.40** respectively. The result of the monitoring shows that, the average radial vibration is between 82 to 85 VdB and the peak radial vibration is around 102 VdB. The average transverse vibration is found to be between 83.5 VdB and the peak transverse vibration is 105 VdB. the average vertical vibration is 104 VdB and the peak vertical vibration of the study location is found to be **126 VdB.**

FIGURE 3.38
RADIAL VIBRATION AT MITTAL TOWERS, SH. MAHARSHI VALMIKI CHOWK

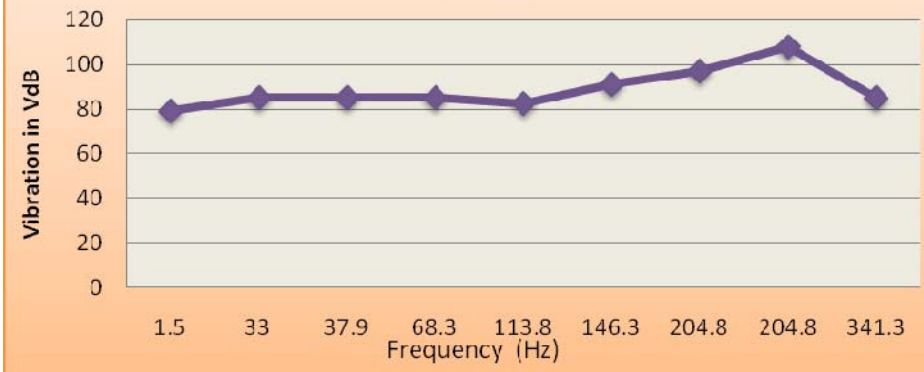


FIGURE 3.39
TRANSVERSE VIBRATION AT MITTAL TOWERS, SH. MAHARSHI VALMIKI CHOWK

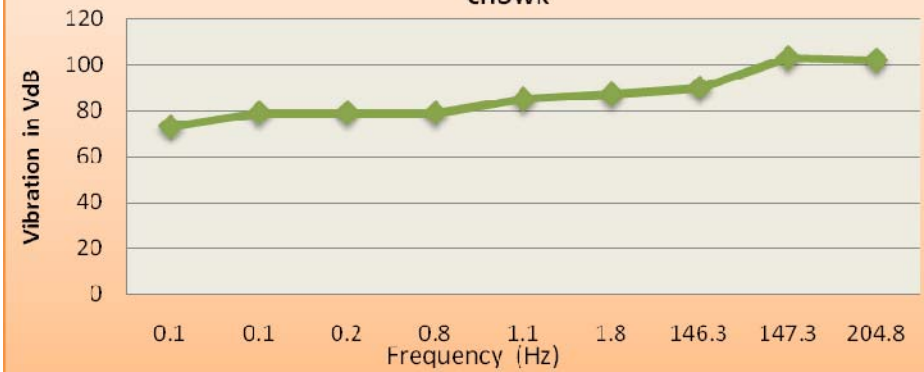
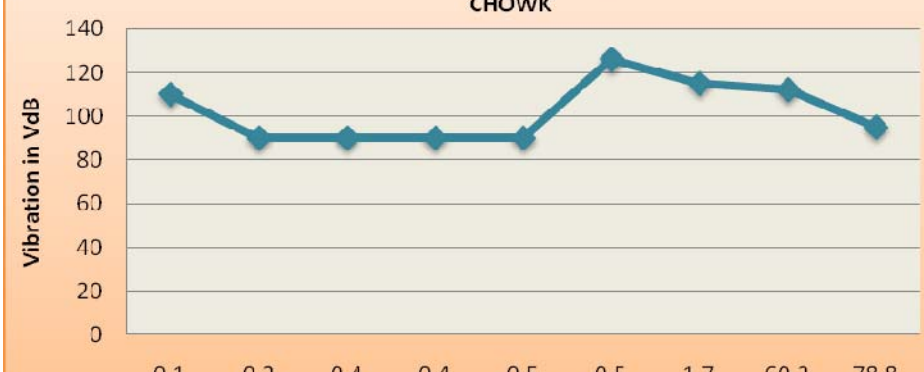


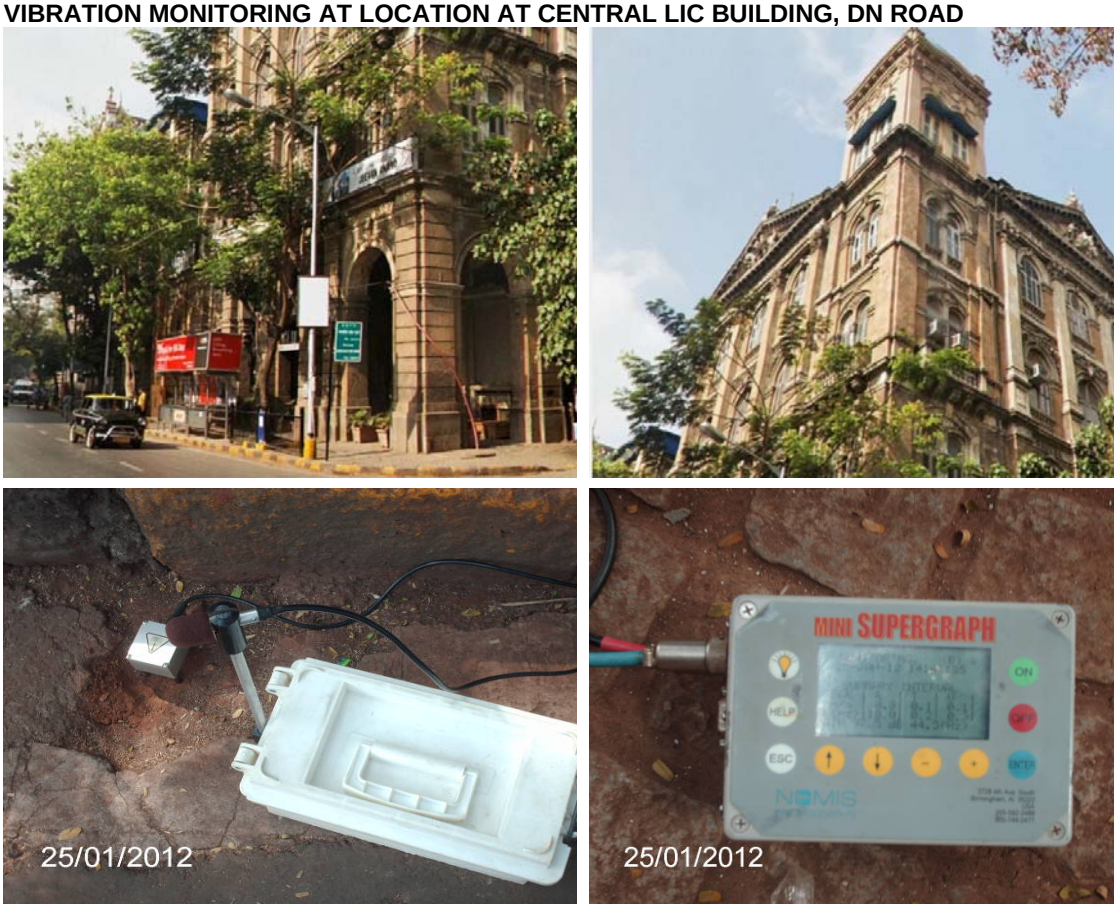
FIGURE 3.40
VERTICAL VIBRATION AT MITTAL TOWERS, SH. MAHARSHI VALMIKI CHOWK



3.6.4 Vibration Monitoring at Location 4: Central Assurance Building, opp to Commissariat Building, Dr. Dadabhai Naoroji Road

The Central Assurance Building is one of the oldest building and is also in the list of Heritage structures. The vibration monitoring was carried out in front of the building. The location of the monitoring is shown in **Figure 3.41**. The monitoring location falls at chainage no. 3280.00 of proposed metro alignment. As per the field observation about 4500 vehicles per hour pass by this road which includes two and four wheelers.

FIGURE 3.41
VIBRATION MONITORING AT LOCATION AT CENTRAL LIC BUILDING, DN ROAD



The graph has been plotted for radial, transverse and vertical vibration and shown in **Figure 3.42**, **Figure 3.43** & **Figure 3.44** respectively. The result of the monitoring shows that, the average radial vibration is 85 VdB which is quite normal vibration due to road traffic and the peak radial vibration is 93 VdB. The average transverse vibration is found to be between 86 VdB and the peak transverse vibration is 94 VdB. The average vertical vibration is 112 VdB and the peak vertical vibration of the study location is found to be **124 VdB.**

FIGURE 3.42
RADIAL VIBRATION AT LIC BUILDING, DR. DADABHAI NAOROJI ROAD

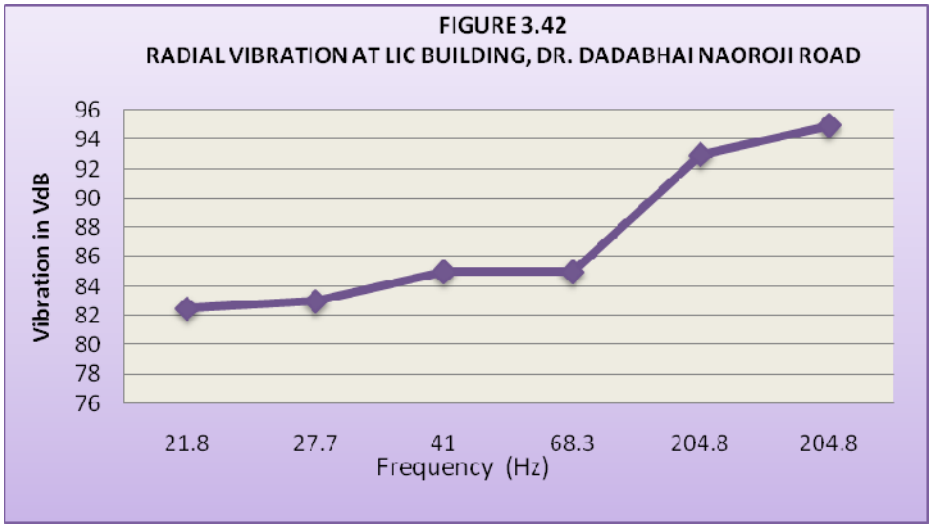


FIGURE 3.43
TANSVERSE VIBRATION AT LIC BUILDING, DR. DADABHAI NAOROJI ROAD

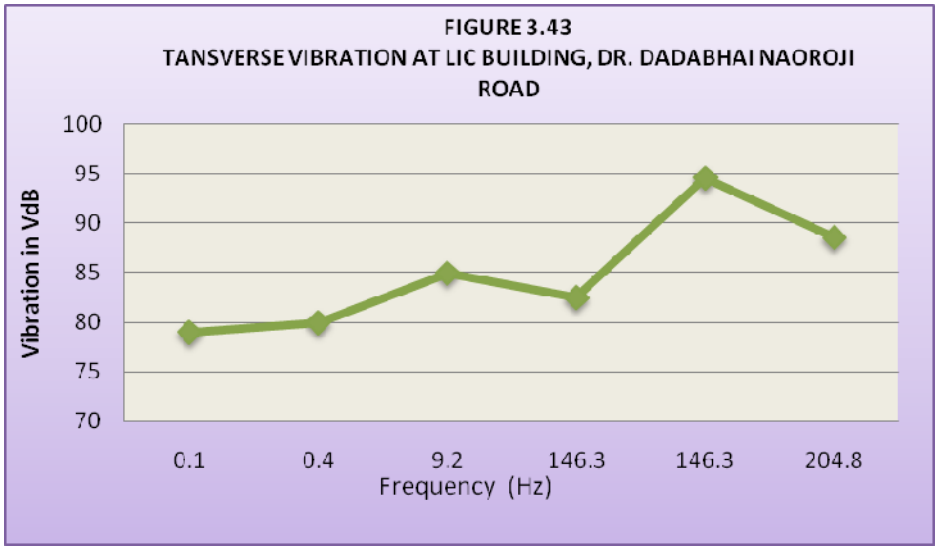
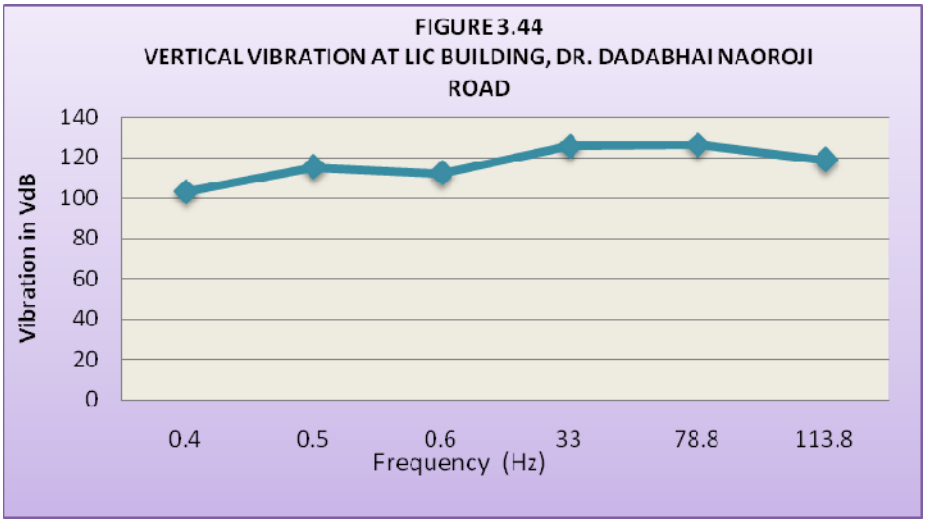


FIGURE 3.44
VERTICAL VIBRATION AT LIC BUILDING, DR. DADABHAI NAOROJI ROAD



3.6.5 Vibration Monitoring at Location 5: Bhikha, Behram, Parsees Well, Hutatma Chowk.

Bhika Behram Well is a freshwater well dug in 1725 by a Parsi named Bhikaji who had come from Bharuch to Mumbai. The well has a perennial source of sweet water, which is remarkable as most of the water in the area is brackish owing to the proximity to the Arabian Sea. The vibration monitoring was carried out in front of Parsees well. The location of the monitoring is shown in **Figure 3.45**. The monitoring location falls at chainage no. 2700.00 of proposed metro alignment. As per the field observation about 4700 vehicles per hour pass by this chowk.

FIGURE 3.45
VIBRATION MONITORING AT LOCATION AT PARSEES WELL, HUTATMA CHOWK

The graph has been plotted for radial, transverse and vertical vibration and shown in **Figure 3.46**, **Figure 3.47** & **Figure 3.48** respectively. The result of the monitoring shows that, the average radial vibration is about 86 VdB and the peak radial vibration is 88 VdB. The average transverse vibration is found to be 81 VdB and the peak transverse vibration is 83 VdB. The average vertical vibration is 107 VdB and the peak vertical vibration is found to be **113.9 VdB**.

FIGURE 3.46
RADIAL VIBRATION AT PARSEES WELL, HUTATMA CHOWK

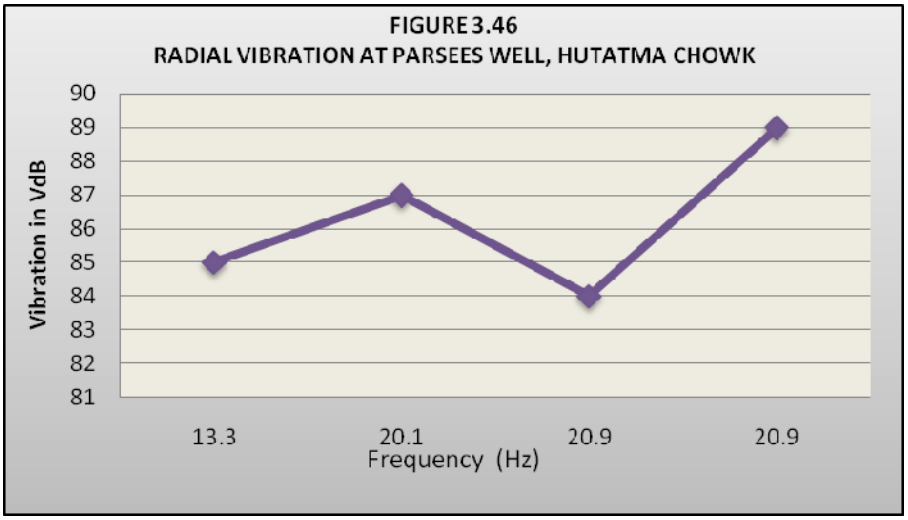


FIGURE 3.47
TRANSVERSE VIBRATION AT PARSEES WELL, HUTATMA CHOWK

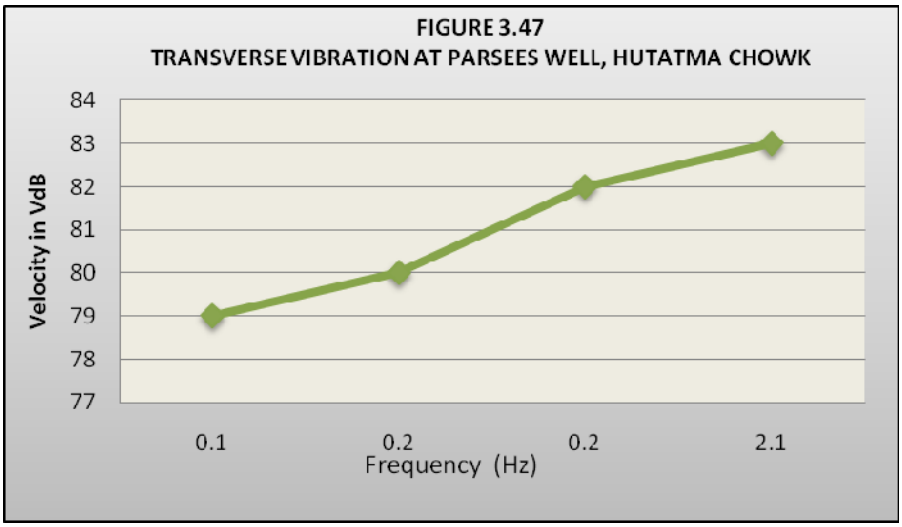
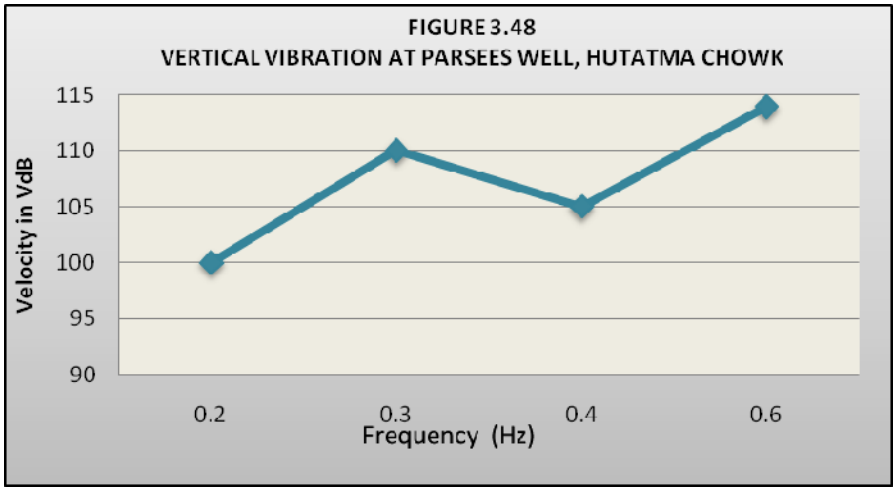


FIGURE 3.48
VERTICAL VIBRATION AT PARSEES WELL, HUTATMA CHOWK



3.6.6 Vibration Impact Assessment at Location 6: Chhatrapati Shivaji Terminus, Mumbai.

Chhatrapati Shivaji Terminus (Victoria Terminal) is one of the very renowned World Heritage structure in India which serves as the headquarters of the Central Railway. Chatrapati Shivaji Terminus building is more than 125 year old located at the heart of South Mumbai. Based on the measured vibration at 5 locations along the corridor, the verticle vibration level for this location would be in the range of 110-126 VdB. The photograph of CST is given in the **Figure 3.49**. Ambient vibration at this location will be measured prior to the start of construction work, as per the vibration monitoring program given in Table 8.6.

FIGURE 3.49
PHOTOGRAPHS SHOWING CHHATRAPATI SHIVAJI TERMINUS BUILDING

The impact of vibration due to TBM operation and train traffic has been predicted using GIS software on the satellite image of study location and using the Pipe-in-Pipe (PiP) model. The vibration analysis is presented in Chapter-4.

3.7 ECOLOGY

An ecological study is essential to understand the impact due to project development activities on flora and fauna of the area. The project site is located in city area and no wildlife is envisaged. To have a general understanding of the ecology within project area, brief information about flora and fauna of Mumbai is given below.

3.7.1 Forests/Flora

The forests cover in Mumbai city is 0.45 sq.km and Mumbai Suburban district 33.0 sq. km. which are entirely under the management of the Forest Department. The important species found in the Mumbai forests are Teak, Khair (Acacia Catechu), Sisav (Dalbergia latifolia), Hed (Adina or Nauclea Cordifolid), Kalamb (Stephegyne or Nauclea arvifolia) and Bamboo.

Trees survey has been conducted along the proposed alignment, at station locations and at depot area. The type of species observed is Gulmohar, Peepal, Coconut Palms, Sirus,

Pilkhan and Neem. Approximately 589 trees have been observed along the project alignment at proposed station locations which are depicted in **Appendix-3.1**. About 1652 trees are observed at depot location at Aarey Milk Colony, which is given in **Appendix-3.2.** Tree species are Gulmohar, Mango, Ber etc. No rare or endangered species of trees have been noticed during field studies.

The proposed alignment is passing underground at a depth of about 20 m below ground level, hence no mangrove area are getting affected and no issue of CRZ are anticipated for the project.

3.7.2 Fauna

Mumbai is now so populous and overcrowded that it is no more a congenial home for wild animals. Greater Mumbai at present comprises mainly of residential and industrial areas. At present there is no forest in the true sense except the national Park at Borivli, extending over an area of about 19.18 sq. km. Hence, wild life as such is almost extinct from Mumbai. The fauna mainly consists of the common varieties of domesticated animals, such as, cows, oxen, buffaloes, sheeps, goats, pigs, donkeys, and mules. Wild life is now seen only within the National Park. The Tulsi and Vihar lakes are reported to provide a habitat to crocodiles and alligators. The varieties of birds occur in Mumbai city and suburbs and particularly in the National Park are listed in **Appendix 3.3**. Mumbai is known as a fishing centre from the earliest days and fishing was one of the chief industries during the pre-British epoch. The Kolis (Fisherman) are fishing as their hereditary occupation and operating from Colaba, Chaupati, Mazagaon, Worli, Sion, Mahim, Bandra, Trombay, Madh, Danda, Vesava, etc. The common species of fishes are Bombil (Harpodon nehereus), Mandeli (Coilia dussumieri), Kolambi (Penacus sp. Actes sp), Rawas (Eleutheronema) etc.

Biodiversity, Flora and Fauna of Sanjay Gandhi National Park

Sanjay Gandhi National Park is the house of 40 species of mammals, 251 of birds, land and water birds, 38 species of reptiles, 9 species of amphibians besides a large variety of fishes. The spectacular flowering of Butea monosperma (Flame of Forests) is a real feast to eye in the dry month of February to May. The national Park is a bird watcher paradise having Tickell's flower pecker (small bird in India), sun bird (humming birds), majestic white bellied sea eagle, the elusive Trogon and many species of Kingfishers, Woodpeckers, and Drongos. The varieties of insects found in the park are Silk cotton bugs, Beetles and Mantis.

Sanjay Gandhi National Park, Borivalli is coming within the 10 km radius and at a distance of 1.65 km from centre of proposed depot having higher contour level than depot area. No wildlife has been observed at the project site. The location of Depot is shown in **Figure 3.50**.

The depot has been planned at Aarey Milk Colony covering an area of 26.407 Ha. A landuse map has been prepared for study area of 10 km radius keeping depot site at centre is given in **Figure 3.51**.

FIGURE 3.50
LOCATION OF NATIONAL PARK

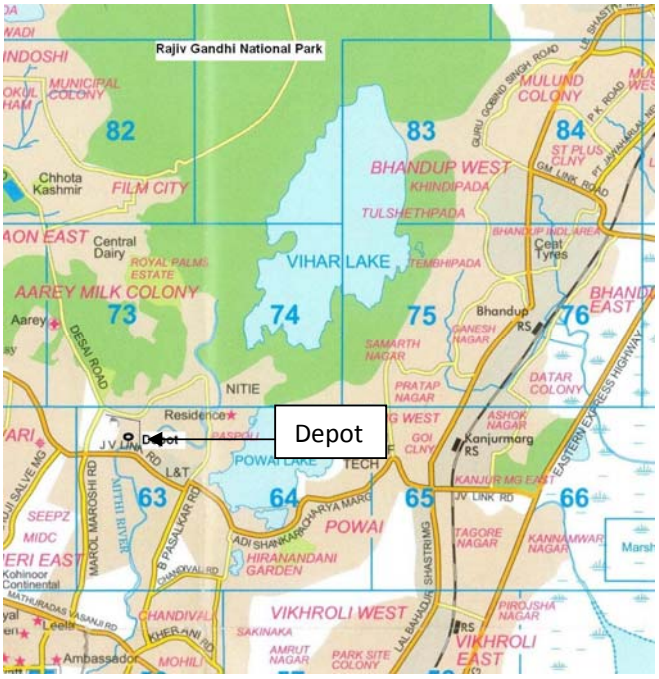
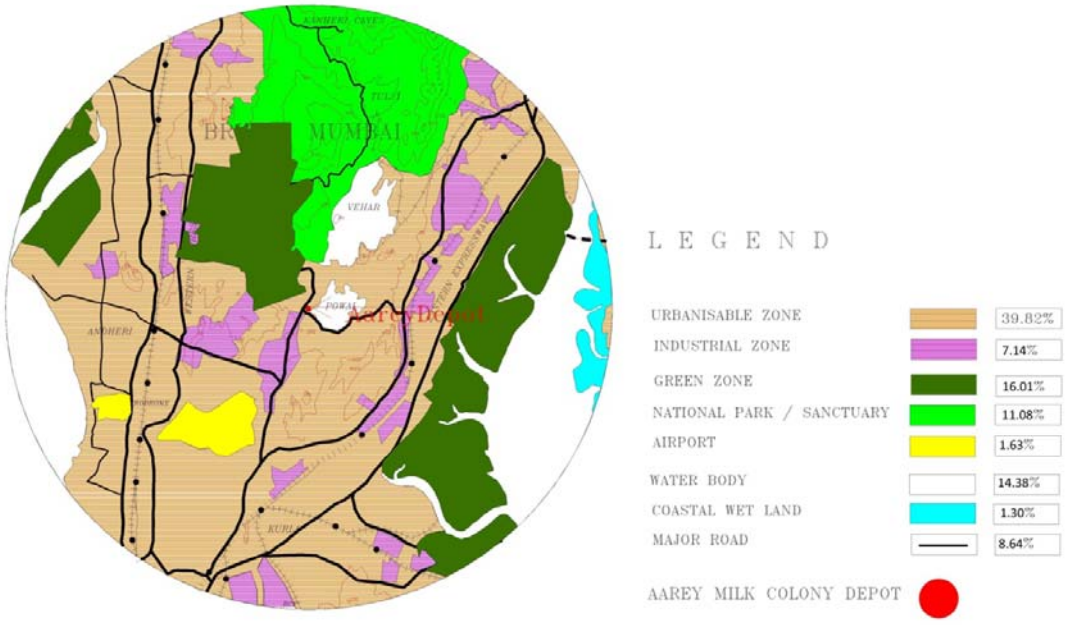
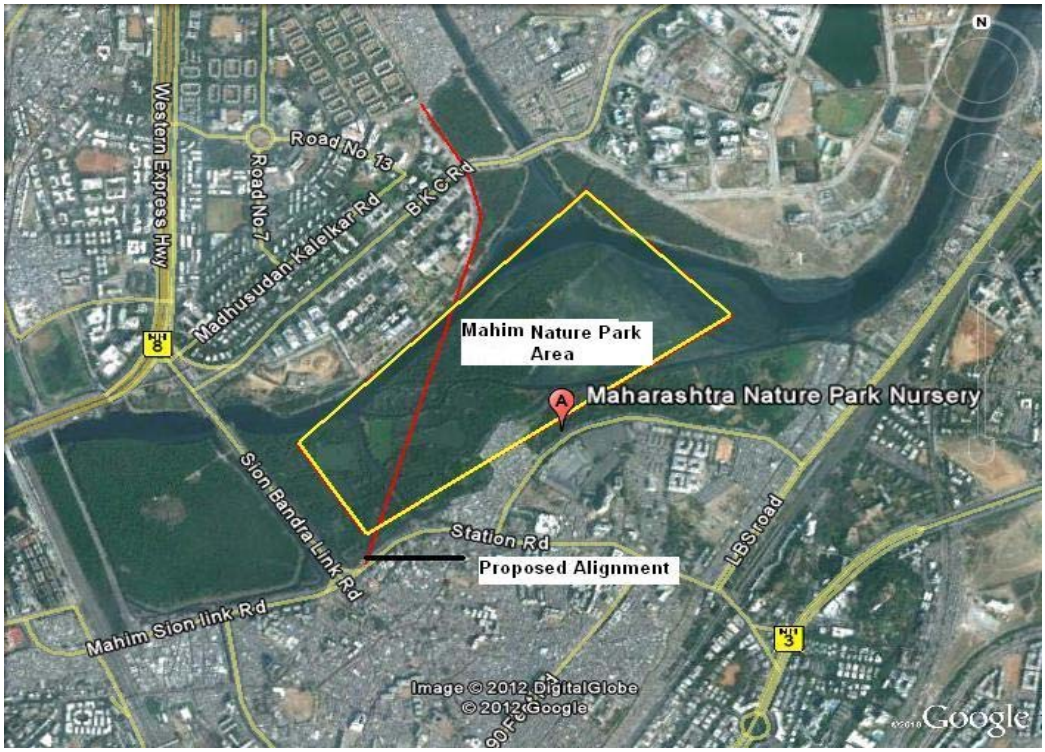


FIGURE 3.51
LANDUSE PATTERN OF DEPOT



Mahim Nature Park: Located on the southern bank of Mithi River, and at Bandra-Sion Link Road close to Mahim Nature Park at Mahim. Here the proposed Metro alignment is passing underground. Earlier being the garbage dump, the place was conceived by WWF-India to be a nature park in 1976. MMRDA undertook the project to restore and develop the place as sophisticated nature park. The nature park is having the rich greenery. The location of Mahim Nature Park and the alignment of proposed metro are shown in the Google map as **Figure 3.52**.

FIGURE 3.52
LOCATION OF MAHIM NATURE PARK



3.8 SOCIO- ECONOMIC CONDITIONS

Development of proposed Mumbai Metro (Coloba-Bandra-SEEPZ) involves acquisition of land for stations, running sections, TSS, Depot and for other facilities. For different components of this corridor, out of total 45.81 hectare requirement of land, 4.72 hectare private land and 41.08 hectare government land shall be acquired. The detailed socio-economic assessment and resettlement action plan for the proposed project is being presented in separate report i.e., Social Impact Assessment for Mumbai Metro Corridor (Coloba-Bandra-SEEPZ).

3.9 HISTORICAL SITES

In 1972, the General Conference of UNESCO adopted a resolution with overwhelming enthusiasm creating thereby a 'Convention concerning the protection of the World Cultural and Natural Heritage'. The main objectives were to define the World Heritage in both cultural and natural aspects; to enlist Sites and Monuments from the member

countries which are of exceptional interest and universal value, the protection of which is the concern of all mankind; and to promote co-operation among all Nations and people to contribute for the protection of these universal treasures intact for future generations.

The proposed alignment is passing closer to three historical monuments and given in the **Table 3.13**. Chhatrapati Shivaji Terminus (formerly Victoria Terminus) is the World Heritage Cultural Properties located at 40 m from the centre of the proposed metro alignment. Brihanmumbai Municipal Corporation Building located on Mahapalika Marg is declared as Historical Monuments and is 22 meter from the centre of the proposed metro alignment. The location of historical monuments and its distance from the centre of proposed alignment are shown in Google map as **Figure 3.53, Figure 3.54** and **Figure 3.55** respectively.

TABLE 3.13
HISTORICAL MONUMENTS WITHIN VICINITY OF ALIGNMENT

SI	HISTORICAL MONUMENTS	DISTANCE FROM CENTRE OF METRO ALIGNMENT
1	CST Railway Station	40 metre
2	BMC Building	22 metre
3	Western Railway Head Quarter	45 metre

FIGURE 3.53
CST RAILWAY STATION & BMC BUILDING AT DN ROAD

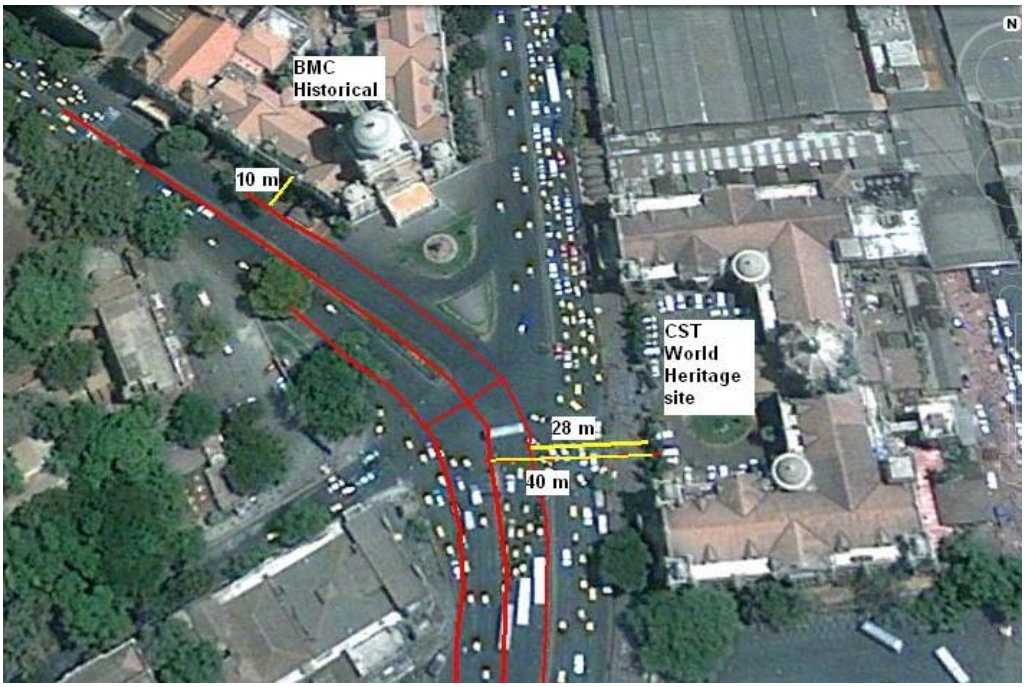
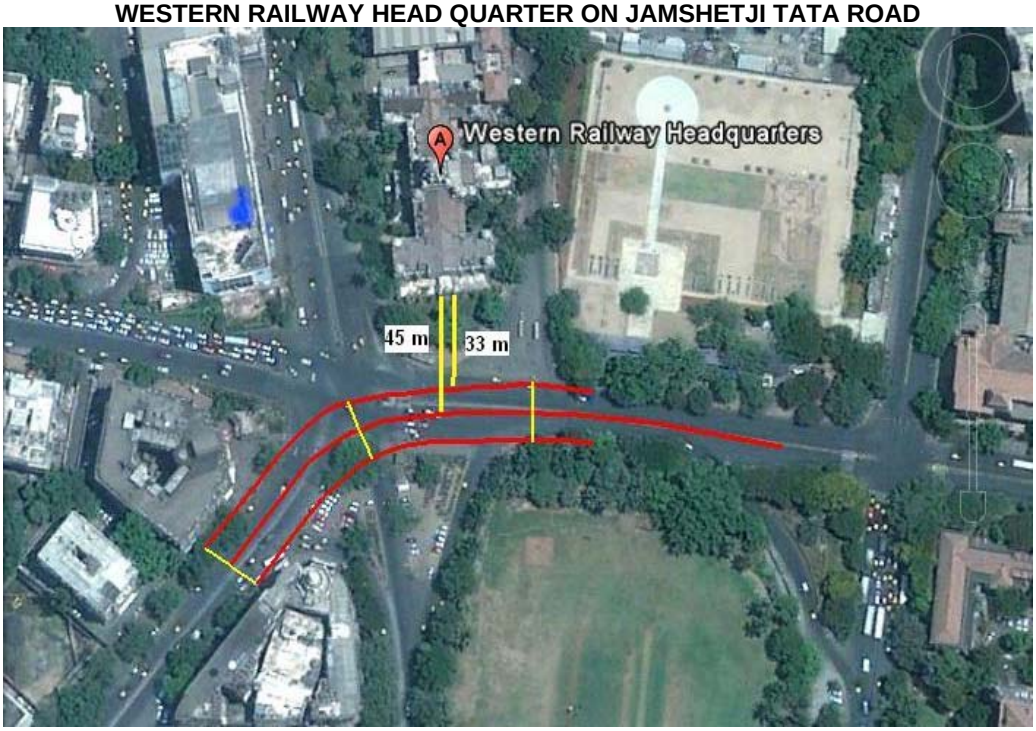


FIGURE 3.54
WESTERN RAILWAY HEAD QUARTER ON JAMSHETJI TATA ROAD



3.10 SENSITIVE RECEPTOR

A drawing showing sensitive receptor like school, colleges, hospitals, place of worship, monuments/Statue structures etc. within 100 m on either side of metro is prepared and enclosed at last of the report in plastic pouch. The list of sensitive receptor is tabulated in **Table 3.14.**

TABLE 3.14
LIST OF SENSITIVE RECEPTORS

Sl	Description	Within 100 m on Either side
1	School	13
2	Hospital	22
3	Temple	21
4	Mosque	05
5	Church	06
6	Monuments/Statue	08
7	Nature Park	01
	Total	**76**

Appendix 3.1

TREES OBSERVED AT STATION LOCATIONS

Sl No	Station	Component	Species	Ht m	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
1	Caffe parade	ST 1H	Gulmohar	15						1															
		ST 1G	Peepal	10				3																	
			Gulmohar	15								1													
			peepal	15								1													
		ST 1E	Gulmohar	15					4																
			Gulmohar	15							1														
		ST 1I	Ashoka	10			1																		
		TSS-1	Sirus	10						1															
			Sirus	10					2																
			Peepal	10					1																
			Gulmohar	15									1												
			Gulmohar	8					1																
			Gulmohar	10								1													
			Sirus	10		1																			
			Sirus	10			1																		
			Sirus	10				2																	
			Sirus	10					1																
			Gulmohar	10			1																		
			Gulmohar	10				1																	
			Gulmohar	10					2																
			Gulmohar	10				2																	

Sl No	Station	Component	Species	Ht m	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
			Badam	12				1																	
			Badam	10			1																		
			Others	8	1																				
		ST-1A	Others	25								1													
			Others	8	2																				
			Others	15							1														
			Others	10		2																			
			Others	3	2																				
			Others	12				1																	
			Others	11			1																		
			Others	10						1															
			Others	8		1																			
			Others	5	1																				
			Others	7		1																			
			Others	10			1																		
			Others	10					1																
		CD-1	Gulmohar	5		1																			
			Gulmohar	5			1																		
			Gulmohar	5					1																
			Peepal	5	1																				
			Peepal	8				1																	
			Others	8				1																	
		CD-2	Ber	3	1																				
			Ber	5		1																			

Sl No	Station	Component	Species	Htm	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
			Gulmohar	5	1																				
		Platform	Gulmohar	8			1																		
			Pilkhan	15		1																			
			Gulmohar	8		1																			
			Gulmohar	8								1													
			Gulmohar	5		2																			
			Gulmohar	8			1																		
			Gulmohar	10					2																
			Others	4		1																			
			Gulmohar	4		1																			
			Others	3		1																			
			Gulmohar	8			1																		
			Gulmohar	8						1															
			Gulmohar	8	2																				
			Gulmohar	8			2																		
			peepal	8			1																		
			Pilkhan	8	3																				
			Pilkhan	8		1																			
			Pilkhan	10	1																				
			Pilkhan	10				1																	
			Gulmohar	8											1										
			Ashoka	8				2																	
			Gulmohar	6					1																
			Gulmohar	8											1										

Sl No	Station	Component	Species	Htm	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
			Peepal	10							1														
			Pilkhan	8	1																				
			Gulmohar	5	1																				
			Gulmohar	8					1																
			Poplar	4		1																			
			Peepal	8			1																		
			Gulmohar	8							1														
			Ashoka	5	1																				
			Gulmohar	5		1																			
			Gulmohar	15				1																	
			Ashoka	5	2																				
			Gulmohar	10				1																	
			Ashoka	5				1																	
			Ashoka	8																		1			
			Ashoka	8			2																		
			Ashoka	8			1																		
			Gulmohar	4		1																			
			Gulmohar	5			1																		
			Gulmohar	10					2																
			Gulmohar	8						1															
			Gulmohar	10						1															
			Karanj	8			1																		
			Pilkhan	15						1															
			Gulmohar	3	1																				

Sl No	Station	Component	Species	Ht m	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
			Gulmohar	8				1																	
			Ashoka	5	1																				
			Neem	5	1																				
			Badam	5	2																				
			Badam	5			1																		
			Mango	5	1																				
			Coconut	1.5				1																	
			Gulmohar	5	3																				
			Pilkhan	8				1																	
			Zial	10		1																			
			Gulmohar	5			1																		
			Gulmohar	10			1																		
			Gulmohar	5	1																				
			Gulmohar	8							1														
			Gulmohar	5						1															
			Gulmohar	7						1															
			Gulmohar	5				1																	
			Gulmohar	5					1																
			Gulmohar	6			1																		
			Gulmohar	8					1																
			Gulmohar	8							1														
			Gulmohar	5					3																
			Gulmohar	12									7												

Sl No	Station	Component	Species	Htm	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
2	Bhadwar Park	ST 2D	Badam	5		1																			
		ST 2C	Gulmohar	10				1																	
		ST 2H	Others	10		1																			
		ST 2I	Coconut	10			1																		
			Gulmohar	8	1																				
		ST-2F	Coconut	10			19																		
			Karanj	12					1																
			Karanj	8					2																
			Garden Tree	5						1															
			Karanj	10					1																
			Garden Tree	5						1															
			Garden Tree	5					1																
			Gulmohar	8			2																		
			Garden Tree	10		1																			
			Garden Tree	15								1													
			Garden Tree	10			1																		
			Garden Tree	10				1																	
			Pilkhan	20								1													
		Platform	Coconut	10		25																			

Sl No	Station	Component	Species	Htm	Tree Girth in Centimetres																				
					20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-120	120-140	140-160	160-180	180-200	200-220	220-240	240-260	260-280	280-300	300-350	450	500
			Bottle Brush	5			1																		
			Coconut	12		1																			
			Gulmohar	8					1																
			Bottle Brush	10				1																	
			Coconut	10		1																			
			Garden Tree	3			1																		
			Bottle Brush	8		1																			
			Bottle Brush	6	1																				
			Bottle Brush	8					1																
			Badam	5			1																		
			Coconut	15			1																		
			Mango	8			1																		
			Gulmohar	10					1																
			Gulmohar	10				1																	
			Gulmohar	10											1										
			Badam	12											1										
			Coconut	10			1																		
			Gulmohar	8					1																
			Gial	10			2																		

Sl No	Station	Component	Species	Ht m	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
3	Vidhan Bhawan	ST 3E	Peepal	20		1																			
			Gulmohar	20									1												
		ST 3H	Coconut	15				1																	
			Coconut	10				1																	
			Gulmohar	10	1																				
			Peepal	15																		1			
			Other	10				1																	
		ST 3G	Gulmohar	10				2																	
		ST 3B	Peepal	20		1																			
		ST 3C	Gulmohar	15				7																	
4	Church Gate	ST 4B	Bargad	15													1								
		ST 4E	Bargad	15																			1		
		ST 4F	Umber	10				1																	
		ST 4H	Karanj	10				1																	
			Peepal	15				1																	
		ST 4G	Peepal	20	1																				
5	Hutatma	ST 5H	Gulmohar	10				1																	
			Coconut	20						1															
		ST 5I	Peepal	15													1								

Sl No	Station	Component	Species	Ht m	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
		ST 5K	Peepal	15											1										
6	CST	ST 6E	Gulmohar	15						1															
			Gulmohar	20													1								
		ST CF&G	Ashoka	10	1																				
		ST 6H	Gulmohar	15		1																			
		Platform	Ashoka	8			1																		
			Ashoka	5			1																		
			Ashoka	5		1																			
			Ashoka	10							1														
			Gulmohar	5	1																				
			Ashoka	10						1															
			Ashoka	15					1																
			Gulmohar	8		1																			
			Gulmohar	8					2																
			Tamarind	10							1														
			Pilkhan	5		1																			
			Gulmohar	10			2																		
			Gulmohar	10		2																			
			Gulmohar	6				1																	
			Gulmohar	8				2																	
			Gulmohar	5		1																			
			Pilkhan	10		1																			

Sl No	Station	Component	Species	Ht m	Tree Girth in Centimetres																			
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
			Peepal	8																		1			
			Gulmohar	10																1					
			Badam	5	1																				
			Peepal	8				1																	
			Peepal	10					1																
			Gulmohar	10																1					
			Gulmohar	10																		1			
			Gulmohar	9		1																			
			Gulmohar	10																1					
			Gulmohar	5	1																				
			Pilkhan	10	1																				
			Peepal	10					1																
			Gulmohar	8			1																		
			Gulmohar	3	1																				
			Gulmohar	5	1																				
7	Kalba Devi		NIL																						
8	Girgaon		NIL																						
9	Grant Road	ST 9D	Gulmohar	15				1																	
		ST 9F	Gulmohar	15						4															
			Ashoka	15		1																			
10	Mumbai Central	ST 10I	Jamun	25											1										

Sl No	Station	Component	Species	Ht m	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
			Ashoka	8											1										
			Coconut	10			1																		
			Gulmohar	8		1																			
		Platform	Bargad	10		1																			
			Ashoka	4	1																				
			Badam	5	1																				
11	Mahalaxmi	ST 11E	Gulmohar	10		1																			
		ST 11F	Gulmohar	10		1																			
			Surus	10		1																			
		ST 11G	Peepal	5	1																				
12	Science Museum	ST 12A	Ashoka	10		1																			
		ST 12D	Ashoka	12		2																			
		ST 12F	Rubber	12	1																				
			Coconut	5		1																			
			Other	10				1																	
			Mango	15						1															
			Pilkhan	15		1																			
		ST 12G	Arhule	5	1																				
			Gulmohar	10	1																				
		ST 12E	Neem	15						1															
			Ashoka	15				2																	

Sl No	Station	Component	Species	Htm	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
			Badam	15			1																		
		ST 12C	Ashoka	10			1																		
			Badam	15				1																	
		Platform	Bargad	20																				1	
			Gulmohar	10							1														
			Pilkhan	8									1												
			Other	8		1																			
			Peepal	15												1									
			Gulmohar	20								1													
			Pilkhan	8			1																		
			Gulmohar	15																		1			
13	Acharya Atrey Chowk	ST 13B	Bottle Brush	15			1																		
			Pilkhan	10	1																				
			Peepal	8	1																				
		ST 13E	Peepal	10				1																	
		ST 13A	Bhindi	15				1																	
			Ashoka	15		4																			
			Peepal	15						2															
			Peepal	15				1																	
		Platform	Bargad	10							1														
			Poplar	10									1												
			Poplar	8								1													

Sl No	Station	Component	Species	Ht m	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
			Rubber	8	1																				
			Peepal	10										1											
			Poplar	8						1															
			Guava	3	1																				
			Jamun	10		1																			
			Peepal	10													1								
			Badam	10	1																				
			Poplar	8		1																			
			Peepal	10											2										
			Badam	8			1																		
			Gulmohar	15						1															
			Peepal	15													1								
			Coconut	11		1																			
			Badam	10		2																			
			Gulmohar	10				1																	
			Gulmohar	10		1																			
			Gulmohar	10	1																				
			Poplar	10				1																	
			Badam	10							1														
			Mango	10																					
			Coconut	10			2																		
			Gulmohar	8						1															
			Ashoka	10			1																		
			Peepal	10								1													

Sl No	Station	Component	Species	Htm	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
			Gulmohar	8						1															
			Badam	10				2																	
			Gulmohar	10						1															
			Sirus	15						1															
			Gulmohar	15		1																			
			Jamun	15								1													
			Mango	15																					
			Pilkhan	8		1																			
			Jamun	10						1															
			Badam	4		1																			
14	**Worli**	ST 14H	Neem	15						2															
			Mango	15				1																	
			Ashoka	6	3																				
		ST 14I	Peepal	15	2																				
		ST 14F	Jamun	10		1																			
		ST 14D	Gulmohar	10			2																		
		ST 14G	Ashoka	15				1																	
			Gulmohar	10	1																				
		ST 14C	Badam	20		1																			
			Gulmohar	20	1																				
		ST 14J	Gulmohar	15			1																		
			Ashoka	10		1																			
		Platform	Gulmohar	10			5																		
			Gulmohar	10		1																			

Sl No	Station	Component	Species	Ht m	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
			Gulmohar	10				2																	
			Gulmohar	10						3															
			Gulmohar	10				4																	
			Gulmohar	15				2																	
15	Sidhi Vinayak		Gulmohar	20		1																			
			Gulmohar	25						1															
			Gulmohar	20		1																			
			Badam	10		1																			
			Palm	15				1																	
			Bargad	15				1																	
			Coconut	15						1															
			Gulmohar	20						1															
			Gulmohar	20				1																	
			Coconut	25				3																	
			Gulmohar	25													1								
			Poplar	15						1															
			Gulmohar	15				1																	
			Gulmohar	15								1													
16	Dadar	ST 16C	Gulmohar	20						2															
17	Shitla Devi	ST 17D	Gulmohar	15		1																			
		ST 17H	Gulmohar	10					1																
		ST 17J	Gulmohar	15				1																	

Sl No	Station	Component	Species	Ht m	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
		ST 17F	Gulmohar	15			2																		
		ST 17G	Gulmohar	20				1																	
		ST 17I	Other	25								1													
18	Dharavi		NIL																						
19	Bandra		Gulmohar	8								8													
			Peepal	10							1														
			Gulmohar	8								2													
20	Mumbai Univ.	Platform	Gulmohar	6		36																			
21	Santacruz	Platform	Bargad	7			1																		
			Coconut	10			2																		
			Peepal	6		1																			
			Other	5		1																			
22	CSIA Domestic	Platform	Gulmohar	8			1																		
			Gulmohar	8		1																			
			Gulmohar	10			1																		
			Other	6			1																		
			Other	6		1																			
			Other	7			1																		
			Coconut	10			2																		
			Mango	5		1																			
			Mango	6		1																			

Sl No	Station	Component	Species	Ht m	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
23	Sahar Road		Peepal	10			1																		
			Peepal	10				1																	
			Ashoka	8		1																			
			Gulmohar	8			1																		
			Gulmohar	9			1																		
			Gulmohar	10		1																			
			Gulmohar	8		1																			
			Coconut	10		2																			
			Coconut	8			2																		
			Badam	6		1																			
24	CSIA International		NIL																						
25	Marol Naka		Coconut	5		1																			
			Coconut	10			3																		
			Coconut	10		1																			
			Coconut	6		1																			
			Badam	7		2																			
			Badam	7			1																		
			Mango	5		1																			
			Jamun	9		1																			
			Ashoka	10		1																			
			Neem	6		3																			

Sl No	Station	Component	Species	Ht m	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
26	**MIDC**	Platform	Mango	15		1																			
			Kathal	20				1																	
			Gulmohar	20				1																	
			Other	10				1																	
			Gulmohar	20								1													
			Gulmohar	20											2										
			Gulmohar	20				1																	
			Jamun	15							2														
			Coconut	10			5																		
			Ashoka	15		1																			
			Peepal	20		1																			
27	**SEEPZ**	ST 27C	BER	15		1																			
			BER	15				1																	
		Platform	Gulmohar	20				1																	
			Badam	10				1																	
			Gulmohar	5				1																	
			Neem	20								1													
			Peepal	20											1										
			Gulmohar	20								3													
			Peepal	15								1													
			Bargad	25																					1
			Ashoka	20				6																	
			Ashoka	15				3																	
			Ashoka	20				1																	

Sl No	Station	Component	Species	Htm	Tree Girth in Centimetres																				
					20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 120	120 - 140	140 - 160	160 - 180	180 - 200	200 - 220	220 - 240	240 - 260	260 - 280	280 - 300	300 - 350	450	500
			Other	20											1										
			Peepal	15		1																			
			Gulmohar	25						4															
			Engligh Imli	25													2								
			Ber	10				1																	
			Gulmohar	15		1																			
			Palm	30				1																	
			Total		**60**	**159**	**101**	**98**	**39**	**44**	**14**	**29**	**11**	**1**	**13**	**1**	**8**	**0**	**0**	**3**	**0**	**5**	**1**	**1**	**1**

Appendix 3.2

TREES OBSERVED AT PROPOSED DEPOT SITE (AAREY MILK COLONY)

Depot	Species	Tree Girth in Centimetres																			
		20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-120	120-140	140-160	160-180	180-200	200-220	220-240	240-260	260-280	280-300	300-350	400-450
Arrey	Wild/Others	179	92	135	76	44	98	9	60	17	3	19	7	14		1	11		6	1	
	Gulmohar	30	168	99	152	15	31	13	47	5		18	7	11		1	1		2		
	Mango	6	3	1	1				2		2	7	8	19	2	2	14		2	2	1
	Palm							2			1	2									
	Ber	19	2	1	2	2						2		1		1			1		
	Badam						1					1									
	Palash											2									
	Peepal						1		1			1							1	1	
	Babool		1																		
	Tamarime							1	1					1							
	Neem											1									
	Jackfruit													1							
Road Inside	Others					3	2	1	1	1		4	5	17	2	2	6	1	4		
	Gulmohar					1	1		5			2	4	10	1	3	2		1	3	2
	Mango																1				
Road Outside	Others					1	6						2	15	3		3		3		
	Gulmohar							1	5	1		2	6	15	1	2	3		2		1
	Total	234	266	236	231	66	140	27	122	24	6	61	39	104	9	12	41	1	22	7	4

Appendix 3.3

VARIETY OF BIRDS IN MUMBAI

- Red vented bulbul *(Molpastes cafercafer);*
- Red whiskered bulbul *(Old compsa joacosus fuscicandata);*
- Spotted babbler *(Pellorneum ruficeps);*
- Yellow eyed babbler *(Chrysomma, sinensis);*
- Indian tree pie *(Dendrocitta vagabunda vagabunda);*
- Indian shama *(Kittacincla Malabarica malabarica);*
- Red breasted flycatcher *(siphiaparva subsp);*
- Black *Dxongo (Dicrurus macrocercus);*
- Racket tailed *(Discemurus paradisous malabaricus);*
- Tailor bird *(Orthotomus, sutorius guzeratd);*
- Indian oriole *(Oriolus oriolus, kundoo);*
- Common myna *(Acridotheres tristis tristis);*
- Commom babbler *(Argya candata candata);*
- White throated babbler *(Dumetia hyperythra);*
- Central Indian tora *(Egithina tiphinon humei);*
- Malabar gold fronted chloropise *(Chloropsis auripons frontalis);*
- Blue throat thrush *(Cyapro sybroia succica pallidogularis);*
- White throated ground thrush *(Ceokichla citrina cyamotus);*
- Blue rock thrush *(Monticola solitaris pandoo);*
- Paradise flycatcher *(Tehitrea paradisi paradisi);*
- White spotted fontail flycatcher *(Leucocirca Pectorlispectorlis);*
- Little minivet *(Pericrocotus perogrinus peregrinus);*
- Rupus-backed shrike *{Lanius sehach erythronotus);*
- Streaked fontail warbler *(Cisticola juncidis);*
- Black headed oriole *(Oriolus anthormus maderas patanus);*
- Common weaver-bird or Baya *(Plocens philippinus philippinus);*
- Ashy-crowned or black-bellied finch lark *(Eremoptenix grisea grised);*
- Loten's sun bird *(Cinnyris lotenid);*
- Purple sun bird *(Cinnyris asiatica asiaticd);*
- Indian pitta *(Pitta brachyws);*
- Southern yellow fronted pied woodpecker *(Dryobates mamattensis mamattensis).*

CHAPTER–4
NEGATIVE ENVIRONMENTAL IMPACTS

4.1 GENERAL

The primary function of an environmental impact assessment study is to predict and quantify the magnitude of impacts, evaluate and assess the importance of the identified changes and formulate plans to monitor and mitigate the actual changes. Environmental impacts could be positive or negative, direct or indirect, local, regional or global, reversible or irreversible. The process begins by identifying the development and operational activities resulting from the proposed project as contained in **Chapter-2** and **Chapter-3** is dedicated for providing information on the baseline environmental conditions for various parameters. Attempts have been made to predict the impacts due to proposed project. The pollutants generated due to the proposed project premises during construction and operation phases are solid, liquid and gaseous in nature. This section identifies and appraises the negative impacts on various aspects of the environment likely to result from the proposed development.

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

The impacts on the above environmental components have been assessed during various phases of project cycle namely project Location, design, construction and operation.

4.2 IMPACTS DUE TO PROJECT LOCATION

During this phase, those impacts, which are likely to take place due to the layout of the project, have been assessed. These impacts are:

- Project Affected People (PAPs)
- Change of Land use;
- Loss of trees/forest;
- Utility/Drainage Problems,
- Impact on Historical and Cultural Monuments, and
- Impact on Local Transport Facilities

4.2.1 Project Affected People (PAPs)

The proposed Mumbai metro rail project shall cause involuntary displacement of people along the alignment, which shall include both title holder and non-titled holder land owners. The issue of Rehabilitation and Resettlement (R&R) is addressed in a separate SIA report**.**

4.2.2 Change of Land Use

Development of proposed Mumbai Metro Line III (Coloba-Bandra-SEEPZ) involves acquisition of land for stations, Depot, TSS, Cut & Cover station and for other facilities. For different components of this corridor, out of total 45.81 hectare requirement of land, 4.72 hectare private land and 41.08 hectare government land shall be acquired. The details of land requirement for different components of the project are given in **Table 4.1**. Acquisition of the private land may cause social disruption and economic loss for the project affected families/people. While implementing the project, there is a need to take into account these disturbances and losses due to the project, their impact on socio-economic condition of the people and plan for their mitigation measures to minimise any negative impacts.

TABLE 4.1
LAND REQUIREMENT (Ha)

S.NO	PARTICULARS	PERMANENT LAND REQUIREMENT		TEMPORARY LAND REQUIREMENT	
		GOVERNMENT	PRIVATE	GOVERNMENT	PRIVATE
1	Depot	26.407	--	-	-
2	Stations	1.49	3.23	-	-
3	TSS	0.4	0.2	-	-
4	Cut & Cover Station	-	-	1.84	0.067
5	Construction Depot	-	-	10.95	1.23
Total		**28.297**	**3.43**	**12.79**	**1.29**

Source: DPR

From the data it could be concluded that out of total permanent land requirement about 89.58 % land to be acquired is from Government and 10.42% from private sector. The compensation for land is included in Social Impact Assessment Study Report.

4.2.3 Loss of Trees/Forests

The proposed alignment of metro rail is in urban/ city area and not passing through any forest. Hence no loss of forest is anticipated. The trees are getting affected only at stations and at depot location since proposed alignment is underground. There are 589 trees observed along the alignment at station locations and 1652 trees are at depot (**Refer Section 3.7.1)**. Hence the total number of trees observed on project

site area is 2241. It is observed from the tree survey (Annexure 3.1) that, out of total 70% (i.e 1568) of the tree have girth below 1 metre which will be transplanted and remaining 30% (i.e 673) of the trees needs to be cut. With removal of these trees the process of CO_2 absorption and O_2 production will get affected and the losses are reported in **TABLE 4.2**. The loss of tree will have short term Heat-Island Phenomenon and would be mitigated after construction due to afforestation. The loss of tree will have short term heat-island phenomenon and would be mitigated after construction due to afforestation.

TABLE 4.2
OXYGEN DEFICIT DUE TO TREE LOSS

SI	DESCRIPTION	QUANTITY
1.	Total no. of Trees to be cut	673
2.	Increase in CO_2 @ 21.8 Kg/year/ tree	14672 kg
3.	Decrease in Oxygen production @ 49 Kg/year/ tree	32977 kg

According to Clean Development Mechanism one tonne of CO_2 increase will yield one Carbon credit and 6 Euros (1Euro = Rs.69.00) is earned by one carbon credit. Total loss of carbon credit is 14.67 ton per year due to cutting of 673 trees. About 32,977 kg of Oxygen production will get reduced because of tree loss and loss of Rs. 18.32 lakh (32977 (kg of O_2) X 55.55 (Rs./Kg of O_2) is anticipated.

4.2.4 Utility/Drainage Problems

There will have no impact on utility and drainage on the running section area as the proposed metro rail alignment is underground. But construction of metro station by cut and cover method will affect utilities and drainage of the area. The sub-surface, surface and overhead utility services may be sewer, water mains, storm water drains, telephone cables, electric lines, etc. These utilities services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position. Since these affect construction and project implementation time schedule/ costs for which necessary planning/ action needs to be initiated in advance.

4.2.5 Impact on Historical and Cultural Monuments

The proposed metro rail project will affect residential and commercial structures at some of the metro stations where construction be made by cut and cover method whereas no Archeological Monuments are likely to be affected. Some of the historical structures are close to the proposed metro alignment as depicted in Table 3.13. Chhatrapati Shivaji Terminus (formerly Victoria Terminus) is the World Heritage Cultural Properties located at 40 m from the centre of the proposed metro alignment. Brihanmumbai Municipal Corporation Building located on Mahapalika Marg is declared as Historical Monuments and is 22 metre from the centre of the proposed

metro alignment. Utmost care needs be taken so that no significant impact is anticipated on the historical structures due to project activities during construction and operation.

4.2.6 Impact on Local Transport Facilities

The metro rail has been proposed to cater the additional demand of present and future traffic requirement. Hence, no loss of job to the existing transport facilities is anticipated. The drivers of local transport facilities like buses, taxis, autos and rickshaws may be utilized to cater the requirement of transport from metro stations to work place and vice-versa. Additional employment opportunities are also anticipated due to the proposed metro.

4.3 IMPACTS DUE TO PROJECT DESIGN

Considered impacts, due to project designs are:

- Platform inlets and outlets,
- Ventilation and lighting,
- Metro station refuse, and
- Risk due to earthquake.

4.3.1 Platforms Inlets and Outlets

The platform level is about 13 m below for underground stations. The rail level of the corridor is about at a depth minimum of 15 m below the ground level/road level at station location and 18-20 m for mid sections. Wherever, the station proposed by NATM, the rail level is proposed minimum 20 m below the ground/ road level. With the increase in ridership, 8 coach trains are envisaged in future. To accommodate an increase in ridership, 27 m wide and 290 m long stations are proposed. Station design is planned for considering the growth in traffic demand beyond 2031. Hence the station layout accommodates the worst case scenario at each station. Also the station design is in compliance to the “Guidelines and space standards for barrier free built environment for disabled and elderly persons” published by the Ministry of Urban and Employment India in 1998.

The typical underground station is a two level station with platforms at the lower level and concourse on the upper level. Concourses are provided at the ends in such a manner that the total depth of the underground station and cost is kept to the minimum. Two emergency staircases are also being planned in the traffic islands.

Provision has been made for escalators to connect concourse to platforms. The escalators will be heavy duty “Public” service escalators capable of operating safely, smoothly and continuously in either direction, for a period of not less than 20 hours

per day, seven days per week within the environmental conditions. The escalators will be equipped with energy saving system with protection barriers. Also the design of the escalators will be such that they can be used as fixed staircases under a condition of power failure or activation by safety/protection devices. When the escalators are stationed, no slipping, jerking, sliding and vibration should occur. One lift has been provided on platform to provide access for elderly and disabled. Additional staircases have been provided for the fire escape at the two ends of platform. For emergency evacuation purposes, the maximum distance to an exit route on the platform shall be 50 metre.

Hence, it can be concluded that all stations have necessary provision for space at inlet, outlet, elevators and platforms to accommodate people in normal as well as in emergency situation. Hence no hazard is anticipated due to the proposed sizes of inlets and outlets.

4.3.2 Ventilation and Lighting

The underground stations of the corridors 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 have a limited access from outside and do not have natural ventilation. It is therefore, essential to provide forced ventilation in the stations and inside the tunnel for the purpose of supply of fresh air, preventing concentration of moisture, removing heat from battery, light fittings and air conditioning plant.

With the hot and humid ambient conditions of Mumbai during the summer and monsoon months, it is essential to maintain appropriate conditions in the underground stations in order to provide a “comfort-like” and pollution free environment. An overview of VAC systems in other metros like Jubilee line extension, Bangkok etc have similar climatic conditions and provide valuable information in deciding VAC concept.

The purpose of ventilation system is to provide pollution free comfort environment inside the tunnel (Underground station). Provision of ventilation system leads to air exhaust into the outside environment which has no significant impact on the environment.

In emergency situation, the tunnel ventilation system would be set to operate to control the movement of smoke and provide a smoke free path for evacuation of the passengers and for the fire fighting purposes. The proposed VAC system design has been guided by codes and standards like Subway Environment Design Handbook (SEDH), ASHRAE Handbook and NFPA-130, 2003 edition.

The platforms, concourse, staircase and escalator areas for underground stations will have adequate and uniform fluorescent lighting to provide pleasant and cheerful environment. The lighting system adopted in other metro system in India will guide the design of this system. An Illumination adopted at different locations such as Entrance to stations, Booking/Concourse, Platforms, Passenger staircase and escalator areas, Offices and Tunnels should be in the range of 100 to 250 LUX.

4.3.3 Metro Station Refuse

The collection and removal of refuse from railway stations in a sanitary manner is of great importance for effective vector control, nuisance abatement, aesthetic improvement and fire protection. The refuse from railway station includes;

- Garbage,
- Rubbish, and
- Floor Sweepings.

As per the available data from Delhi Metro Phase I and II, the solid waste generation is about 0.5-1.0 cum/day at underground stations. Thus about 20 cum of solid waste will be generated from all metro stations per day. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of the MMRDA project authorities. The storage containers for this purpose need to be designed. However it is suggested that the capacity of these containers should not exceed 50 litres and these should be equipped with side handles to facilitate handling. To avoid odour and the accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals.

4.3.4 Risk Due to Earthquake

The project area lies in Zone III of Bureau of Indian Standards (BIS) Seismic Zoning Map. Seismic factor proposed by India Meteorological Department (IMD) for the purpose of design of Civil Engineering structures shall be incorporated suitably while designing the structures.

4.4 IMPACT DUE TO PROJECT CONSTRUCTION

The environmental hazards related to construction works are mostly of temporary nature. Appropriate measures should be included in the work plan and budgeted for. The most likely negative impacts related to the construction works are: -

- Soil erosion,
- Traffic diversion and risk of existing building,
- Impact of proposed road improvement works,
- Muck disposal,

- Dust Generation,
- Increased water demand,
- Impact due to construction of Tunnel,
- Impact due to Land subsidence/Landslides,
- Impact due to Supply of Construction Material,
- Loss of Historical and Cultural Monuments,
- Impact due to Construction near Archeological Structures,
- Impact on Ground and Surface Water,
- Air Pollution,
- Noise Pollution,
- Impact due to Vibration,
- Health risk at construction site,
- Impact on Sensitive Receptors, and
- Impact due to Labour Camp,
- Impact due to blasting.

4.4.1 Soil Erosion,

Though the project may not have significant impact on soil erosion, however, minor impact on soil erosion due to runoff from unprotected excavated areas may result in soil erosion, especially when erodibility of soil is high. Problems could arise from dumping of construction soils (concrete, bricks), waste materials (from contractor's camp) etc. causing surface and ground water pollution. Mitigation measures include careful planning, timing of cut-and-fill operations and re-vegetation. It is also proposed to have Ready Mix Concrete (RMC) directly from batching plant for use at site. The construction material such as steel, bricks, etc. will be housed in a fenced stored yard. The balance material from store yards will be removed for use/disposal at the end of work.

4.4.2 Traffic Diversions and Risk to Existing Buildings

During construction period, partial traffic diversions on road will be required, as most of the construction activities are for the entry and exit blocks on the edges of road. Most of the roads where alignment is passing are double lane. It will be advisable to make these roads as one way to allow for operation of traffic together with construction activities. Advance traffic updates/information on communication systems will be an advantage to users of affected roads. The rail corridor does not pose any serious risk to existing buildings as the alignment is passing underground. Still it will be appropriate to carry out stability and ground settlement analysis for proceeding further during construction.

4.4.3 Impact on proposed road improvement works

The proposed metro rail alignment passes through areas where some projects are already under construction and some projects have been proposed for construction

in future. During construction of the proposed metro rail project it is required for proper integration with other on-going and future projects. Area wise details of project under construction and future projects are given in **Table 4.3**.

TABLE 4.3
ON-GOING AND FUTURE PROJECTS

AREA	PROJECT UNDER CONSTRUCTION	FUTURE PROJECTS
Dharavi	--	Redevelopment plan
BKC-ITO	--	Metro Line-II
Kalina	Widening of Sharada devi Raod	
Domestic Airport	--	Construction of terminals/facilities as per Airport Master Plan
Sahar Road	IA Project Raod	Construction of terminals/facilities as per Airport Master Plan
International Terminal	IA Project Raod	Construction of terminals/facilities as per Airport Master Plan
Marol Naka	Metro Line-I	--
Aarey Milk Colony	--	Monorail Alignment on JVLR with integration station at Aarey Milk Colony(only if present metro gets terminated and mono rail comes)

Schedule of construction of other road improvement works may be carefully seen prior to taking up of the construction of proposed metro corridor. EIA reports of the ongoing and future road improvement works should be collected by the developer for review to integrate the project activities of the proposed metro rail project. On the basis of review of impacts due to various activities of ongoing and future projects on the environment, suitable changes in the project schedule may be suggested during construction of the project. The above points will be taken care of by environmental engineer/Environmental expert of project developer.

4.4.4 Muck Disposal

The proposed metro route is completely underground. The underground portion is 33.508 km. The construction activity involves tunnelling, cut and cover, foundation, fill and embankment. All these activities will generate about 5.40 Mm^3 of muck. On land disposal, 130 Ha of area will be required taking an average depth of filling as 4 metre. Owing to paucity of space in busy cities and for safety reasons, elaborate measures need to be adopted for collection, storage, transfer and disposal of soil. To avoid impact on land due to muck disposal, project proponent has identified five options for disposal of muck by utilizing the muck for various purposes as described in chapter-6.

4.4.5 Dust Generation

Protective measures shall be undertaken during construction phase for transportation of earth and establishment of the material due to use of heavy machinery like compactors, rollers, water tankers, and dumpers. This activity is machinery intensive resulting in dust generation. However, this activity will be only short-term. The total 5.40 Mm^3 of muck has to be transported through trucks. The muck will be transported by trucks up to nearest proposed Jetty. The truck movement required for transporting the muck/ earth will be about 591 truck trips per day for the entire length. On an average a truck is anticipated to move about 50 km per trip. Hence total distance travelled would be 29,550 km per day. Being the good road condition in Mumbai, the dust generation due to transportation of muck will be insignificant.

4.4.6 Increased Water Demand

The water demand will increase during construction phase. Sufficient water for construction purpose is made available by digging borehole / borewell within the vicinity of the project site during the construction phase. Hence proper care shall be taken while deciding the location of these activities or drawing water from public facilities.

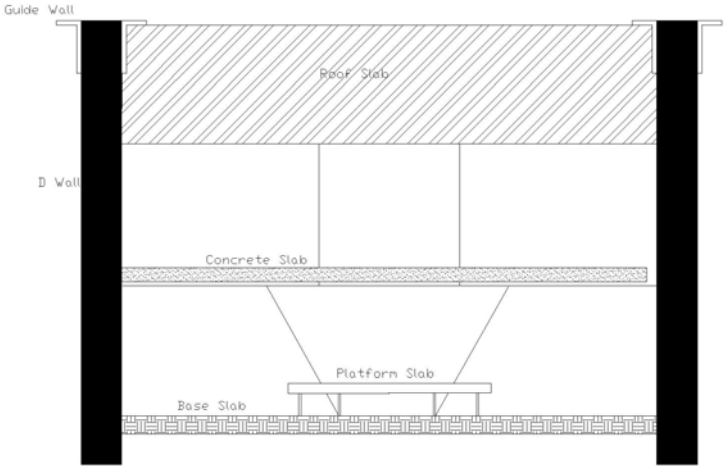
4.4.7 Impact due to Construction of Tunnel

Ground water contamination can take place only if chemical substances get leached by precipitation of water and percolate to the ground water table. This is not the case with the present project, as the activity does not use any harmful ingredients, which could leach down to water table. The tunneling is to be done in hard rock by Tunnel Boring Machine (TBM), which is widely used throughout the world. The proposed project alignment is underground and tunneling will be done through hard rock hence no major impact on flow of water, surface and ground water quality is anticipated. However, care shall be taken that construction activities are not carried out during the monsoon period.

4.4.8 Impact due to Land Subsidence/Landslides

Land subsidence during construction of tunneling will not be anticipated as the whole alignment is passing through the hard rock base. It may be anticipated at the station locations where cut and cover method would be adopted. In a cut and cover method a trench is excavated with necessary ground support. The construction will be in situ concrete, precast concrete and corrugated steel. Use of permanent Diaphragm wall helps to maintain retention of the surrounding soil and ground water. The D-wall method is useful where ground water is high. Typical section of D-wall is shown below.

The tunnel is passing through Basaltic Granite strata hence no land slide is anticipated. However, state of the art technology like Tunnel Boring Machine (TBM), NATM etc will be adopted during construction to prevent the possible landslides.



4.4.9 Impact due to Supply of Construction Material

Metro construction is a material intensive activity. A summary of approximate construction material required for Line III corridors is given in **Table 4.4.** Quarry operations are independently regulated activities and outside the purview of the project proponent. It is nonetheless, appropriate to give consideration to the environmental implications in selection of quarry sources since poorly run operations create dust problems, contribute noise pollution, ignore safety of their employees, or cause the loss of natural resources. About 10-15% of the construction material such as waste material from contractor camps is left behind by the contractor as construction waste/spoils. Dumping of construction waste/spoil in haphazard manner may cause surface and ground water pollution near the construction sites.

TABLE 4.4
CONSTRUCTION MATERIAL REQUIREMENT

MATERIAL	UNIT	TOTAL QTY
Tunnel		
Cement	MT	51698
Fly Ash	MT	8363
Sand	MT	92818
Aggregate 20mm	MT	67504
Aggregate 10mm	MT	82513
Silica	MT	647
Reinforcement	MT	14735
Underground station		
Cement	MT	304846
Fly Ash	MT	110450
Sand	MT	669473
Aggregate 20mm	MT	651652

MATERIAL	UNIT	TOTAL QTY
Aggregate 10mm	MT	485130
Reinforcement	MT	175876
Stone Work	m^2	255360
MS Structure	Kg	645120
Stainless Steel	Kg	926016
Paint	Ltr	161280
Tiles Work	m^2	45696

4.4.10 Loss of Historical and Cultural Monuments

No historical/cultural monuments will be lost as a result of the proposed development.

4.4.11 Impact due to Construction near Archaeological Structures

As per section 4.2.5 of the report, there is no Archeological Monuments near to proposed metro corridor; hence no impact is anticipated during construction. However the tunnel will be constructed by State of Art Technology i.e Tunnel Boring Machine (TBM) which gives negligible vibration and does not affect the surrounding structures. Stations/entry/exit area will be constructed by Cut and Cover method which is widely accepted and the safest technique being adopted by metro in India and abroad.

4.4.12 Impact on Ground and Surface Water

Insignificant impact will be anticipated on surface water as whole alignment is passing underground while ground water may get affected at the location where tunnel crosses the ground water flow. The availability of ground water aquifer in basaltic rock strata seems to be very rare and hence, breaking of water bearing strata is not anticipated. However, as a precautionary measure, detailed hydrological investigation will be undertaken prior to the construction of tunnel to locate the ground water aquifer falling in the alignment of metro tunnel and to safeguard the ground water flow wherever feasible. This will prevent generation of turbid water during construction in the tunnel. No ground water is used by inhabitants staying near at proposed alignment since adequate water supply is available. No ground water is used by inhabitants staying nearby proposed tunnel since adequate water supply is available.

4.4.13 Air Pollution

Construction work of the metro rail has impact on the air quality at station and at depot only since metro alignment is constructed at an average depth of 18-20 metres. In the previous chapter, the existing conditions of air quality along the alignment are described. The monitoring results of pollutants such as NO_2, SO_2 and

CO are much below the national standards (NAAQS, CPCB), the dust concentrations monitored are 2.0 – 2.4 times higher than the standard value. Hence, dust could be the problem when the project is under construction. Any development can have associated health impact that can result directly from changes to the biophysical environment or indirectly as the result of other changes caused by the project. The air pollutants such as particulate matter, sulphur dioxides and nitrogen oxide have adverse impact on human health. The impact of air pollution aggravates bronchitis, respiratory diseases, emphysema, cardiovascular diseases and eye irritation. However, the air pollution during construction is localized and only around the station construction sites only.

4.4.14 Noise Pollution

The major sources of noise pollution during construction are movement of vehicles for transportation of construction material and the construction machinery/equipment at the construction site. No major impacts are anticipated due to noise pollution as the major construction works are underground only. Noise levels at source have been forecasted at various distances as reproduced in **Table 4.5.** As seen from the table, construction activities are expected to produce noise levels in the range of 104 - 109 dB (A) at source which decreases with increase in distance.

TABLE 4.5
FORECASTED NOISE LEVELS

S No	Machine	Noise Levels in dB(A) without Noise Controls		
		At Source**	At 50 feet*	At 150 feet**
1	1.5 cum capacity Excavator / Loader	109	85	65
2	8.33 cum capacity rear end dumper	108	84	64
3	Crawler Dozer	109	85	65
4	Heavy Duty jack Hammer	109	85	65
5	Compressor	104	80	60
6	Crane	107	83	63
7	Generator	105	81	61
8	Rock Drill	122	98	78

* Data taken from “construction equipment noise levels and ranges report” of Federal Highway Administration, ** Calculated using logarithmic equation.

Exposure to noise may lead to complete hearing loss, tension, fatigue, fast pulse/ respiration rates, dizziness & loss of balance, anger, irritation & in extreme case nervousness. Construction of noise barriers, such as temporary walls between noisy activities and receivers reduces noise by up to 15 dB(A). Vegetation cover also reduces the noise level.

Careful planning of machinery operation and scheduling of operations can however reduce the noise levels. The overall noise during construction will be for short-term (for day time only) and can be mitigated as mentioned in Chapter - 6.

4.4.15 Vibration Impact

The whole alignment of the Mumbai metro is underground and will be carried out by Tunnel Boring Machine (TBM). TBM is the worldwide accepted machine having less impact of vibration. Human response to ground-borne vibration is influenced by amplitude, duration and frequency and are subjective in nature. According to the U.S. Department of Transportation, (1998) the perception threshold of humans for particle velocity is about 0.04 mm/s (65 VdB with reference 1e-6 inch/sec). For a person in their residence, the lower threshold for annoyance is 72 VdB (FTA 2006). The vibration affects human health by causing fatigue, increased pulse & respiration rates, dizziness & loss of balance, anger and irritation.

4.4.15.1 Vibration due to Tunnel Boring Machine (TBM)

TBM typically consist of a large rotating cutting wheel in front of large metal cylinder(s) known as shields as well as trailing control and ancillary mechanisms. Behind the cutting wheel is a chamber where the spoil is removed using conveyors to the rear of the machine. The cutting wheel is moved forward by hydraulic jacks supported off the finished tunnel walls. When the cutting wheel has reached maximum extension the TBM head is braced against the tunnel walls and the rear section of the TBM is dragged forward.

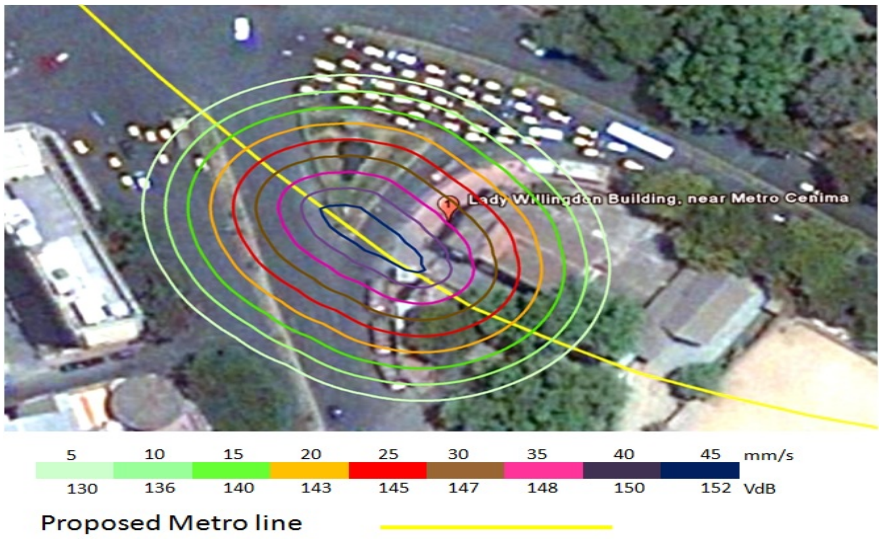
Continuous effect of vibration on the buildings can cause damage to the buildings. Building subjected to the vibration effect with more than 50 mm/s would receive structural damage. Historic buildings are more susceptible to vibration effect due to type of building material and design. Old structures generally lose structure strength over the period. Therefore, it is more important to study the effect of vibration on the historic buildings especially the structures that comes under heritage category.

The vibration that could be generated due to TBM has been calculated at each monitoring location as presented in Chapter-3 using the standard equation. The diameter of the TBM blades is assumed as 10 m with the operating speed of 1 m/ Hr. The TBM operation is considered at a depth of 18 m below ground level. The soil of the site is considered soft soil from 0 to 8m and beyond 8m, it is hard bed rock. The vibration contours has been drawn using GIS software on the satellite image of study location. Vibration is generated at source from 18 m below the ground level and dissipates in all direction.

4.4.15.2 At the Lady Willingdon Building

The **Figure 4.1** shows the predicted vibration contours that could cause due to operation of TBM. The contour in the figure shows the vibration level on the ground surface. The predicted ground borne vibration due to TBM operation at this building is about 144 VdB. Geotechnical investigations is recommended at this location before going for TBM operation.

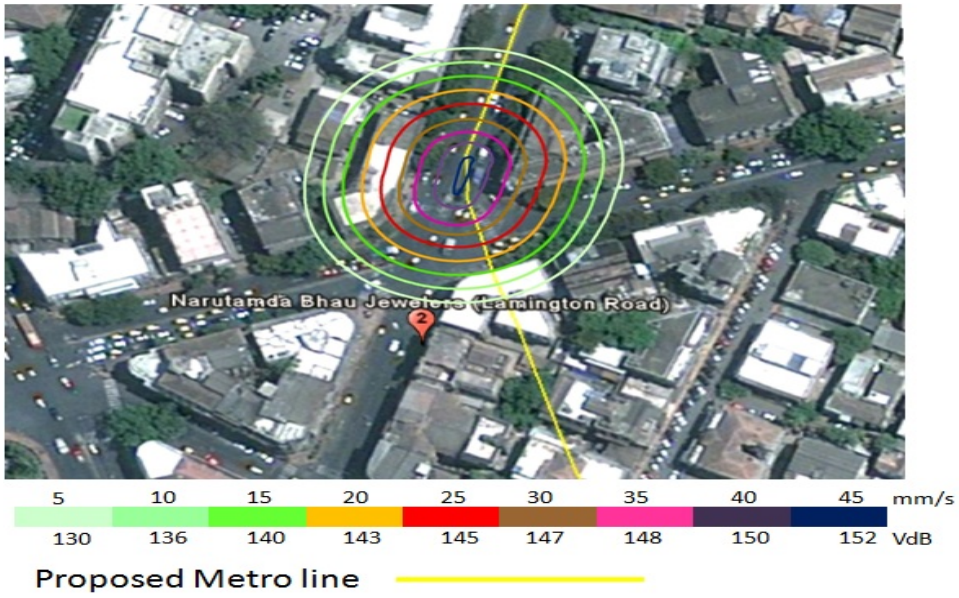
FIGURE 4.1
VIBRATION CONTOURS DUE TO TBM AT LADY WILLINGDON BUILDING



4.4.15.3 At the Narutamdas Bhau Jewelers, K.Gajanan Vertak Chowk, Lamington Road

The predicted vibration contours that could cause from TBM at this location is shown in the **Figure 4.2**. The predicted ground borne vibration due to TBM operation at closest building to road is about 147.8 VdB. Care should be taken during the TBM operation at this location. Geotechnical investigation is recommended before going for TBM operation.

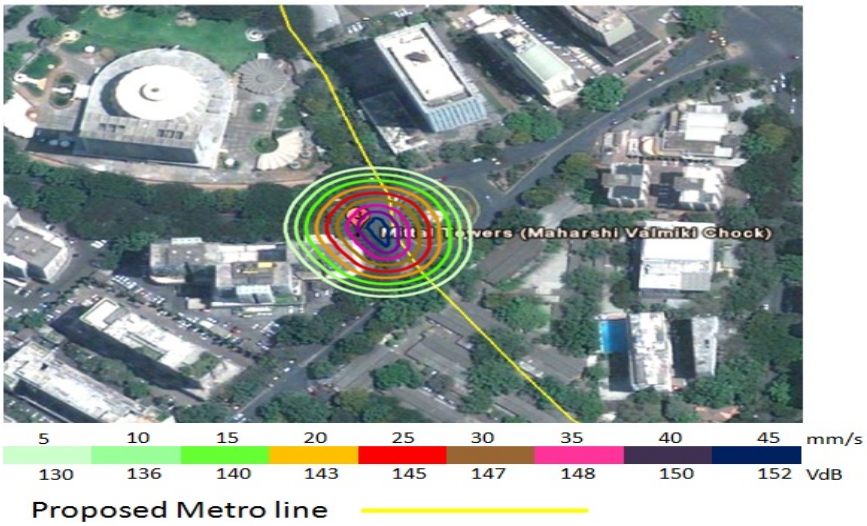
FIGURE 4.2
VIBRATION CONTOURS DUE TO TBM AT LAMINGTON ROAD MUMBAI



4.4.15.4 At Mittal Towers, Maharshi Valmiki Chowk

The **Figure 4.3** shows the predicted vibration contours that could cause from TBM. The predicted ground borne vibration due to TBM operation at closest building to road is about 143 VdB. Geotechnical investigation is recommended before going for TBM operation.

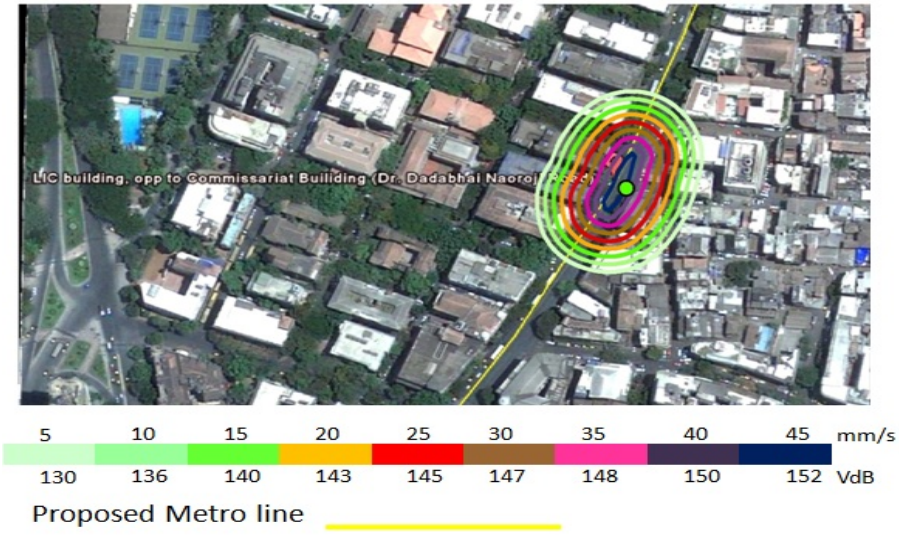
FIGURE 4.3
VIBRATION CONTOURS DUE TO TBM AT MAHARSHI VALMIKI CHOWK



4.4.15.5 At Central Assurance Building, opp. to Commissariat Building

The **Figure 4.4** shows the predicted vibration contours that could cause from TBM operation. The predicted ground borne vibration due to TBM operation at closest building to road is about 147.8 VdB. Special care should be taken during the TBM operation at this location. Geotechnical investigation is recommended at this location before going for TBM operation.

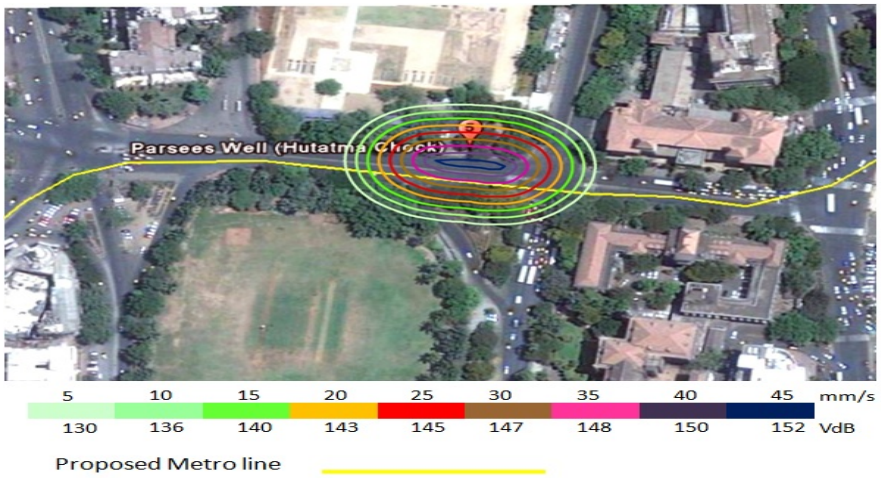
FIGURE 4.4
VIBRATION CONTOURS DUE TO TBM AT CENTRAL ASSURANCE BUILDING



4.4.15.6 At Bhikha, Behram, Parsees Well, Hutatma Chowk

The **Figure 4.5** shows the predicted vibration contours that could cause from TBM operation at this location. The contours show the vibration is high with 152 VdB at the center of road and at the Parsees well is around 145 VdB. The predicted ground borne vibration due to TBM operation at closest building to road is about 143 VdB. Special care should be taken during the TBM operation at this location. Geotechnical investigation is recommended at this location before going for TBM operation.

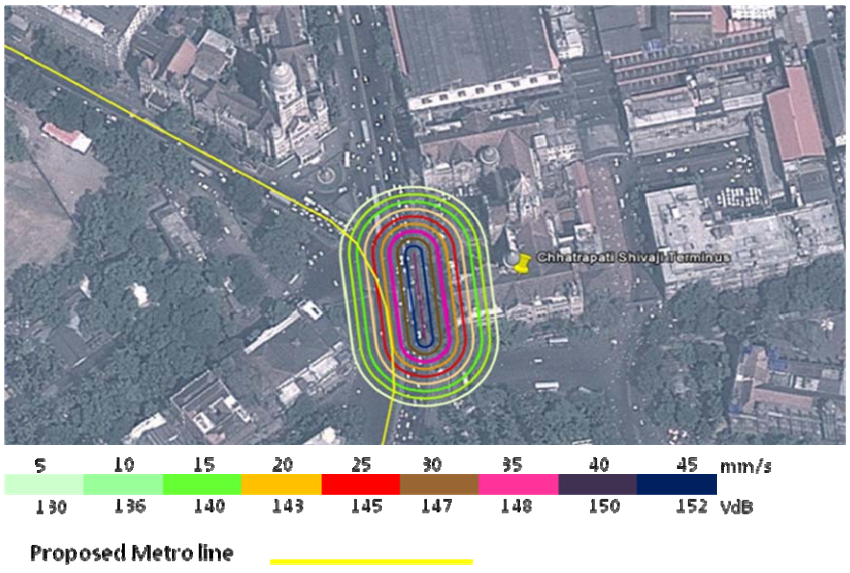
FIGURE 4.5
VIBRATION CONTOURS AT HUTATMA CHOWK



4.4.15.7 At Chhatrapati Shivaji Terminus

The **Figure 4.6** shows the predicted vibration contours that could cause from TBM. The contours show the vibration is about 147.3 VdB at closest building. Care should be taken during the TBM operation at this location. Geotechnical investigation is recommended at this location before going for TBM operation.

FIGURE 4.6
VIBRATION CONTOURS AT CHHATRAPATI SHIVAJI TERMINUS



4.4.16 Health risk at construction site

Health risks include accidents due to improper construction practice and hazard diseases due to lack of sanitation facilities (i.e., water supply and human waste disposal). Implementation of good construction practice may reduce the chance of accident at work place. Mitigation measures should include proper water supply, sanitation, drainage, health care and human waste disposal facilities at construction site. In addition to these, efforts need to be made to avoid water spills, adopting disease control measures, awareness programmes etc.

4.4.17 Impact on Sensitive Receptors

As discussed in section 3.9, there are 76 numbers of sensitive receptors identified within 100 m on either side of the alignment. The nearest receptor is 40 metre away from the centre line of metro alignment. No disturbance to facilities such as School, Hospital and Park (Mahim nature Park) are anticipated as proposed alignment passing underground. No station location is exists in the park area. The major impacts to the sensitive receptors are due to noise and vibration.

The major sources of noise pollution during construction activities would be during excavation, loading, transportation of materials and operation of construction equipments and DG sets etc. Expected noise levels due to use of construction machineries at site are forecasted w.r.t distances are given in Table 4.5.

Construction activities have the potential to produce vibration levels that may be annoying or disturbing to humans living nearby. Federal Transit Administration (FTA) has recommended the typical levels of vibration for construction equipment which are summarized in **Table 4.6**. In the table the values at 25 feet are based on the FTA 1995. On the basis of reference values of vibration at 25 feet, an impact at 75 feet, 100 feet and 150 feet are calculated. The ground borne vibration impacts may be somewhat perceptible to people who are outdoors, it is almost never annoying and does not cause a strong adverse human reaction. According to the California Department of Transportation, (2004), the threshold of perception, or roughly 0.25 mm/s (108 VdB) may be considered annoying to people and the architectural damage criterion for continuous vibrations is 5 mm/s (134 VdB).

TABLE 4.6
TYPICAL LEVELS OF VIBRATION FOR CONSTRUCTION EQUIPMENTS

Sl	Construction Activity	VdB at 25 Feet	VdB at 75 Feet	VdB at 100 Feet	VdB PPV at 150 Feet
1	Rock drilling	115.9	101.6	97.9	94.3
2	Dump trucks	122.7	108.3	104.6	99.3
3	Bulldozer	124.0	109.7	106.0	100.7
4	Excavator 0.089, 106	124.0	109.7	106.0	100.7
5	Crane 0.808, 87	143.2	128.9	125.1	119.8

Source: *Transit Noise and Vibration Impact Assessment, Federal Transit Administration (FTA).*

4.4.18 Impact due to Labour Camp

About 5,000 persons are likely to work during peak construction activity. The skilled workers associated with tunneling and fabrication work are supposed to stay at labour camp while the local workers will be employed for other associated work like earthwork and concreting. About 500 skilled workers will stay at labour camp. Three labour camps will be proposed at appropriate and suitable locations. Considering that 80% of labourers are married, in 80% of married families both husband and wife will be working and taking average family size as 4, total workforce in the labour camps will be about 900. The water requirement at camp will be 63 KLD, waste water generation 50.4 KLD & Municipal solid waste generation 315 Kg per day. Construction workers are more prone to infectious diseases like HIV/AIDS due to migration and lack of education. The three main transmission routes of HIV are sexual contact, exposure to infected body fluids or tissues and from mother to foetus or child during prenatal period. Training and awareness programme will be conducted during construction to avoid the spread of infected diseases and maintain good sanitation in labour camp. After construction, operation of metro does not give significant impact on spreading of infectious diseases.

4.4.19 Impact due to blasting

Controlled blasting will be required during construction of stations to remove hard rock. Blasting will generate ground vibration and noise of which intensity is depends upon the quantity of explosive charge.

Ground Vibration: The intensity of ground vibrations depends on several factors. The most important are how close the person or house is to a blast and how many kilogram of explosives are detonated per delay period. The magnitude of ground vibrations decreases as the distance from the blast increases. The most commonly accepted blast vibration prediction in use was developed by Lewis L. Oriard, a noted seismologist from Huntington Beach, California. The derived equation is:

$$V = K (R/Q^{½})^{B}$$

Where, V: Peak Particle Velocity (mm per second),
K = Site and Rock Factor Constant,
Q = maximum instantaneous charge per delay (Kg),
B = Constant related to the rock and site (usually-1.6),
R = Distance from charge (m)

Typical K Factors in Metric System are 500 for Under Confined hard or highly structured rock, 1140 for Free face average rock (Normal Confinement) and 5000 for heavily (Over) Confined rock.

Putting the value of R = 15 m, Q = 1 Kg (The quantum of explosive should be strictly restricted to 1 Kg per delay), K = 1140, in above equation, we get peak particle velocity of 14.96 mm per second. Table 4.7, indicates the average human response

to vibration and air over pressures that may be anticipated when the person is at rest, situated in a quiet surrounding.

Comparing Peak Particle Velocity of 14.96 mm/second, it is observed from the Table, that the vibration will be strongly perceptible to mildly unpleasant and it will have no damage to the structure.

TABLE 4.7
HUMAN RESPONSE TO BLASTING GROUND VIBRATION

Sl	Average Human Response	PPV (mm/sec)	Air Blast (dB)
1	Barely to distinctly perceptible	0.508–2.54	50-70
2	Distinctly to strongly perceptible	2.54–12.7	70-90
3	Strongly perceptible to mildly unpleasant	12.7–25.4	90-120
4	Mildly to distinctly unpleasant	25.4–50.8	120-140
5	Distinctly unpleasant to intolerable	50.8–254	140-170

Source: Transportation- and Construction-Induced Vibration Guidance Manual, June 2004

The safe ground vibration level for structures for low–frequency blast vibration is 19.05 mm/sec and 50.8 mm/sec for frequencies above 40 Hz. (United State Bureau of Mines, 656, RI 8507).

Noise and Air Blast

A simple estimate of air blast overpressure levels is given using the following cube root scaling formula from AS2187.2 for the estimated Maximum Instantaneous Charge (MIC) of 1 kg of explosive.

$P= K \{R/(Q)^{0.33}\}^{B}$

Where, P= Pressure (KPa)

K= Site constant (State of confinement, Typical K factors are 185 for unconfined, 3.3 for fully confined)

R=Distant from charge (m)

Q=Explosive charge mass per delay (kg)

B= Constant related to Rock & Site (usually K=-1.2)

Now, Take K = 5 (blasting inside and may be assumed as confined), R = 15 m, Q = 1 Kg and B= -1.2

P=0.127 kPa=196 Pa

Equivalent Noise Level would be 136 dB, which will be impacts mildly to distinctly unpleasant.

4.5 IMPACTS DUE TO PROJECT OPERATION

The negative impacts may cause during operation of the project due to increase in the number of passengers and trains at the stations:

- Noise pollution,
- Vibration Impact due to train,
- Water supply and sanitation at Stations,
- Refuse disposal and sanitation, and

- Electromagnetic Interference

4.5.1 Noise Pollution

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. The main sources of noise from the operation of trains include: engine noise, cooling fan noise, wheel-rail interaction, electric generator and miscellaneous noise like passenger's chatting.

US data shows that the noise levels inside the rail transit cars ranges between 65 to 105 dB(A) during normal operation but it will depend on various factors like Train speed, type of way structure, sound insulations of car body, type & design of mechanical equipment, wheel and rail conditions. A study was conducted by National Physical Laboratory for Delhi metro for noise levels in elevated and underground metro stations. The Noise Level at 15 m from track Centre Line and at 25 km/h is 75.0± 10.0 while interior noise level is about 78.0±8.0. The noise generated due to metro is limited within the tunnel area and station and hence users only have impact of noise during operation.

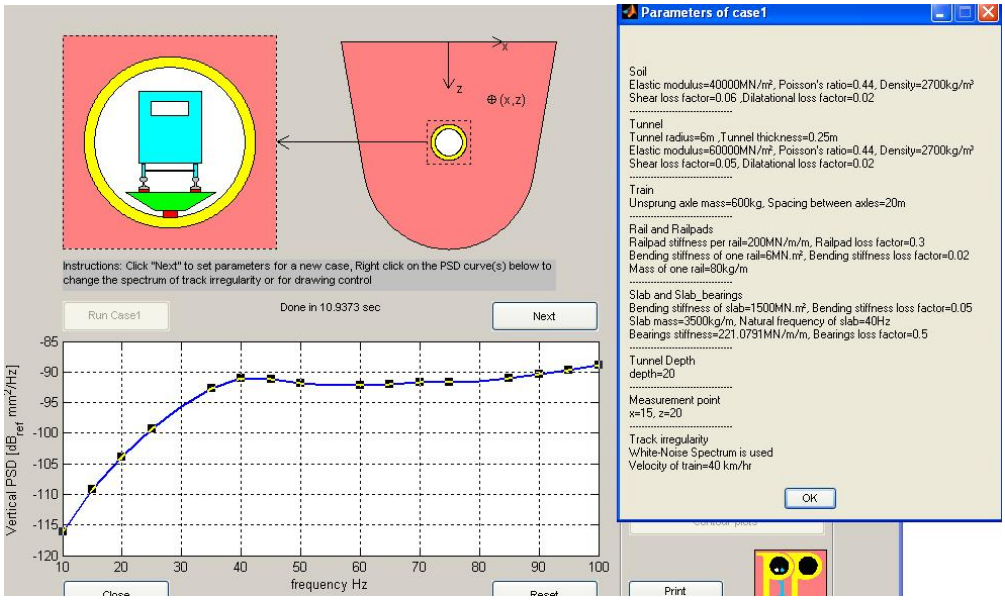
4.5.2 Vibration Impact due to train

The prediction of vibration is computed using the Pipe-in-Pipe (PiP) model using train traffic. PiP model has been developed by the team of experts and scientist from Nottingham University, UK. It is commonly used to simulate the vibration that is generated in the tunnel due to train passage. The vibration is calculated in Power Spectral Density. The prediction of vibration due to train passing is simulated and the results are shown in Power Spectral Density (PSD). The figures plotted shows the assumptions made for the prediction of vibrations. The velocity of the train is considered as 40 km/hr at all locations. Due to limitation in the available modeling tools, the vibration simulation was carried out with single train passby, however there would be increase in vibration when two trains are in tunnel. The increase would be up to 3 VdB. The Power Spectral Density graph plotted in **Figure 4.7, 4.8, 4.9, 4.10, 4.11** & **4.12** are used to calculate the vibration at 6 locations during operation. The calculations are based on the input data as per site condition and operation of metro train. In Mumbai, the cultural heritage structures were constructed as per British Standards.

4.5.2.1 At Lady Willingdon Building.

The result of the vibration prediction using PiP model is shown in **Figure 4.7**. The graph shows that the vertical Power Spectral Density (PSD) is rising with the frequency and has become constant between 85-90 PSD (VdB).

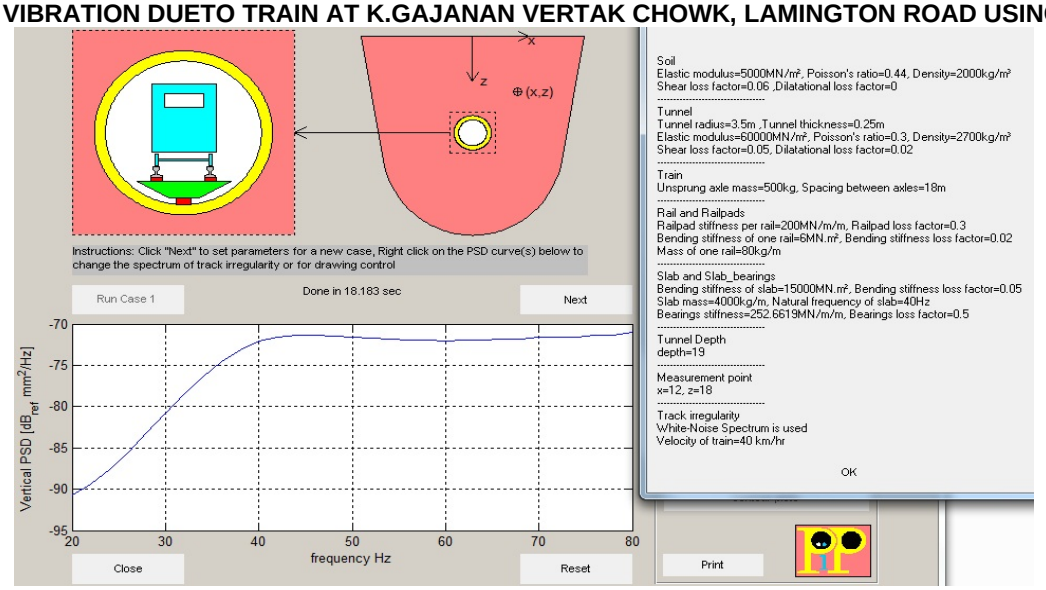
FIGURE 4.7
VIBRATION DUETO TRAIN AT LADY WILLINGDON BUILDING USING PiP



4.5.2.2 At K.Gajanan Vertak Chowk, Lamington Road Mumbai.

The result of the vibration prediction using PiP model is shown in **Figure 4.8**. The graph shows that the vertical Power Spectral Density (PSD) is low from 10 to 20 Hz frequency after that is found rising. The predicted vertical vibration at this location shows between 70 to 75 VdB

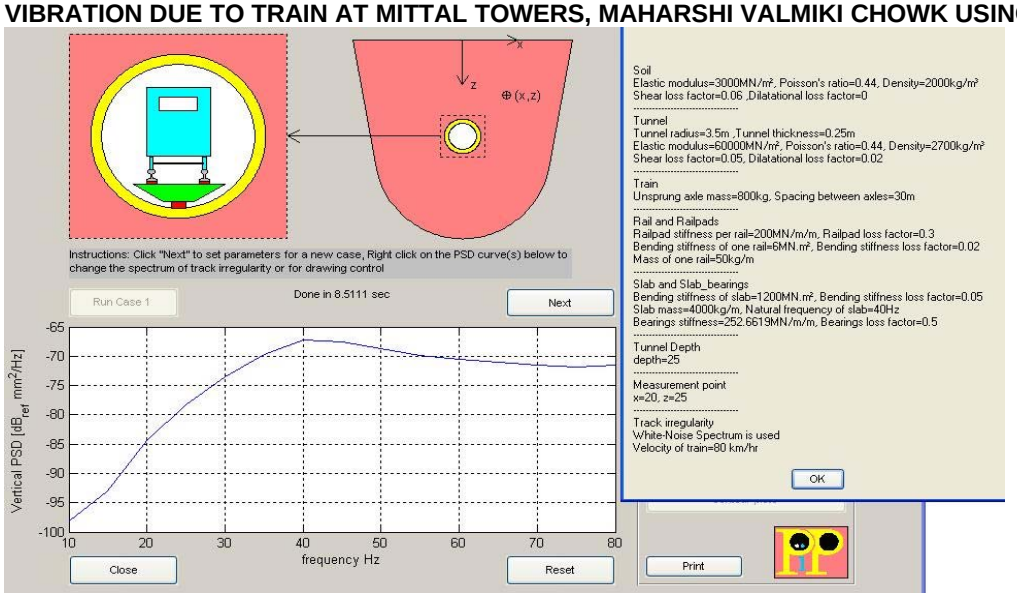
FIGURE 4.8
VIBRATION DUETO TRAIN AT K.GAJANAN VERTAK CHOWK, LAMINGTON ROAD USING PiP



4.5.2.3 At Mittal Towers, Maharshi Valmiki Chowk.

The result of the vibration prediction using PiP model is shown in **Figure 4.9**. The graph shows that the vertical Power Spectral Density (PSD) is high at the frequency 40 Hz and is constant between 65 to 75 PSD (VdB).

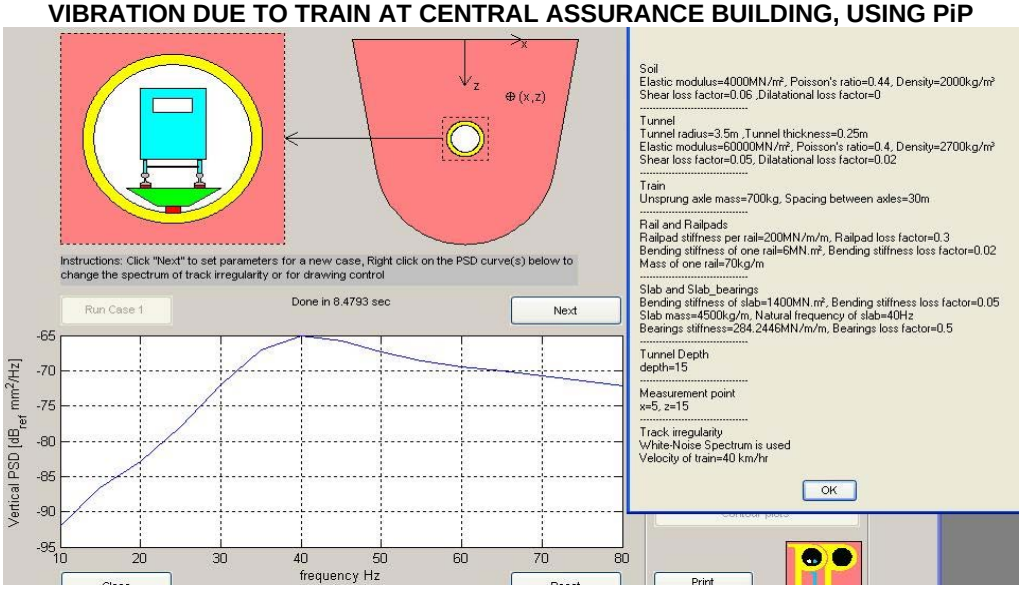
FIGURE 4.9
VIBRATION DUE TO TRAIN AT MITTAL TOWERS, MAHARSHI VALMIKI CHOWK USING PiP.



4.5.2.4 At Central Assurance Building, Opp. to Commissariat Building

The result of the vibration prediction using PiP model is shown in **Figure 4.10**. The graph shows that the vertical Power Spectral Density (PSD) is more at the frequency 40 Hz and is constant between 65 to 75 PSD (VdB). Many building at the road comes under heritage category. Special care should be taken at the time of construction of tunnel and also during metro rail operation.

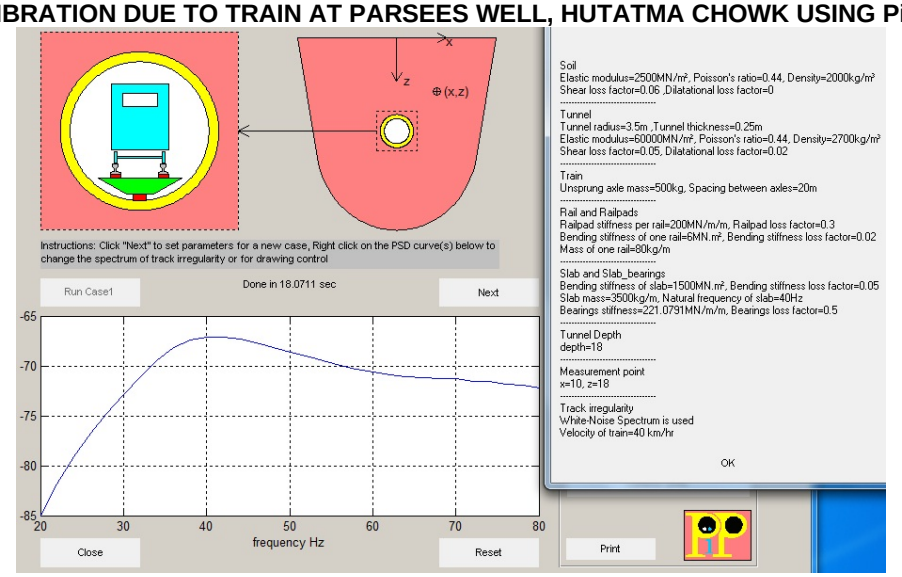
FIGURE 4.10
VIBRATION DUE TO TRAIN AT CENTRAL ASSURANCE BUILDING, USING PiP



4.5.2.5 At Bhikha, Behram, Parsees Well, Hutatma Chowk

The result of the vibration prediction using PiP model is shown in **Figure 4.11**. The graph shows that the vertical Power Spectral Density (PSD) is rising at the beginning with the frequency; it is maximum at frequency 40 Hz. The predicted vertical vibration due to metro rail passby at this location shows between 65 to 70 VdB.

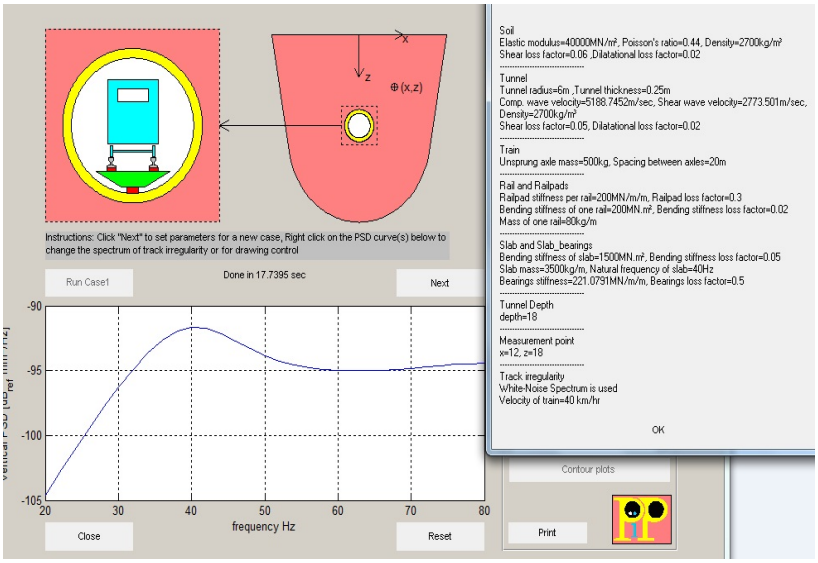
FIGURE 4.11
VIBRATION DUE TO TRAIN AT PARSEES WELL, HUTATMA CHOWK USING PiP



4.5.2.6 At Chhatrapati Shivaji Terminus

The result of the vibration prediction using PiP model is shown in **Figure 4.12**. The graph shows that the vertical Power Spectral Density (PSD) is low from 10 to 20 Hz frequency after that is found rising. The predicted vertical vibration due to metro rail passby at this location shows between 90 to 95 dB.

FIGURE 4.12
VIBRATION DUE TO TRAIN AT CHHATRAPATI SHIVAJI TERMINUS



The result of the vibration impact on the surrounding due to TBM and underground train traffic has been tabulated in **Table 4.8**. The limits for vibration is 65 VdB as per Federal Transit Administration (FTA) whereas 83 VdB is the maximum limit as per ISO -2361-2. The predicted vibration level during construction and operations seems to be higher than the standard limits. This is due to consideration of worst case scenario of having the subsoil condition as rocky structure and may be expected actually less than the predicted value.

TABLE 4.8
OVERALL RESULT OF VIBRATION IMPACT

Sl	Location	Field Measured vertical vibration (VdB)	Vibration due to TBM Operation(VdB)	Vibration due to Metro Train Operation (VdB)	Standards of Vibration in (VdB)
1	Lady Willingdon Building.	113.9	144	85 to 90	65- 83
2	Narutamdas Bhau Jewelers, Lamington Road.	123.5	147.8	70 to 75	65- 83
3	Mittal Towers, Maharshi Valmiki Chowk	126	143	65 to 70	65- 83
4	Central Assurance Building, Dr. Dadabhai Naoroji Road.	124	147.8	65 to 70	65- 83
5	Bhikha, Behram, Parsees Well, Hutatma Chowk	113.9	143	68 to 70	65- 83
6	Chhatrapati Shivaji Terminus	110-126	147.3	90-95	65- 83

Column III: Refer section 3.6 of Chapter-3.
Column IV: Refer section 4.4.15
Column V: Refer section 4.5.2

4.5.3 Water Supply and Sanitation

Public Health facilities such as water supply and sanitation are very much needed at the stations. The water demands will be for drinking, toilet, cleaning and also for other purpose like AC, chiller etc. The demand is presented in **Table 4.9**. It is assumed that there would be similar water requirements in Mumbai Metro corridors also. The Water Demand of existing Delhi Metro is corridors considered for requirement of Mumbai metro. Water should be treated before use upto WHO drinking water standards. Municipal supply/Ground water shall be used for this purpose.

TABLE 4.9
WATER REQUIREMENT AT STATION

S.No.	Particular	Water Demand at Each Station (KLD)	Total Water Demand (KLD)
1	At Stations for Drinking Purpose	6	162
2	For AC, cleaning, chiller and other purposes	240-250	6750
		Total	**6912**

4.5.4 Electromagnetic Interference

Transmission lines do not usually interfere with normal television and radio reception. In some cases, interference is possible at a location close to the ROW due to weak broadcast signals or poor receiving equipment. An impact due to electromagnetic interference is insignificant as the proposed alignment is passing underground.

This interference may arise either from the electric field or from the magnetic field. 25 KV traction currents produce alternating magnetic fields that cause induced voltages to any conductor running along the track.

International consultative committee ontelecommunications and Telegraphy (CCITT) gives the following formula to arrive at the minimum separation between contact wire and the communication line to limit the induced voltage to 300 Volts. The minimum spacing is given by a = 1/3 under-root E. Where, E is the contact wire voltage. For 25 kV systems this works out to 53 m.

4.6 IMPACTS DUE TO DEPOT

The depot at Araey colony is planned for metro corridor Line III. The area of depot is about 26.407 hectares. The area at depot is vegetated with no habitation. The depot will have following facilities:

- Washing Lines,
- Operation and Maintenance Lines,
- Workshop, and
- Offices.

These facilities could generate water and noise issues. The area will be levelled through cut and fill method within the depot and additional earth will be taken from tunnelling to raise the ground level. Problems anticipated at depot sites are:

- Water supply,
- Effluent Treatment,
- Oil Pollution
- Noise Pollution,
- Surface drainage,
- Solid Waste,
- Cutting of trees.

4.6.1 Water Supply

Water supply will be required for different purposes in the depot. The water requirement for train washing purpose will be 500 litres per day. About 159 KLD of

fresh water will be required at Depot for different uses. Projected water demands are summarised in **Table 4.10.** Other water requirement for horticulture, flushing urinals/closet will be met from recycled water.

TABLE 4.10
WATER DEMAND AT AAREY MILK COLONY DEPOTS

S.NO	DEPOT	PROJECTED NUMBER OF CARS	PROJECTED WATER REQUIREMENT PER DAY (LITRES)
1	Car Washing	280	140000
2	Floor Washing @ 0.5 lit/sqm	--	17,500
2	Drinking Purpose: 300 persons @ 5 lit per person per day	--	1500
	Total		**1,59,000**

The water after conventional treatment can be processed through Reverse Osmosis (RO) technology for specific use such as washing of equipment/ trains. This will reduce the fresh water requirement.

4.6.2 Effluent Treatment

About 130 KLD of waste is to be generated at depot, which will be treated at 160 KLD effluent treatment plant. The treated waste water will be tested for Inland Water Discharge Standard before release in to Mithi River, is required. The part of the water will be recycled to use at depot horticulture purpose.

4.6.3 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.

4.6.4 Noise Pollution

The main source of noise from depot is during operation of workshop. The roughness of the contact surfaces of rail, wheel and train speed is the factors, which influence the magnitude of rail - wheel noise. The vibration of concrete structures also radiates noise. No impact on the ambient noise is anticipated due to mild activities.

4.6.5 Surface Drainage

Due to the filling of the low-lying area for the construction of depots, the surface drainage pattern will change. Suitable drainage measures will be adopted to drain off the area suitably in the nearby Mithi River.

4.6.6 Solid Waste

At per available data, it is estimated that about 1.8 Ton per month of solid waste will be generated from the Depot.

4.6.7 Cutting of Trees

About 1652 numbers of trees are observed at Depot at Aarey milk area. The details of tree cut are mentioned in the section 3.7.1. The details of tree likely to be cut and transplanted are given in the Environmental Management Plan.

4.7 EPILOGUE

Based on above negative impacts, a checklist of impacts has been prepared along with positive impacts in **Chapter-5.** The net resultant impacts without management plans are also summarised. The management plans to mitigate the negative impacts are reported in **Chapter-6.**

CHAPTER-5
POSITIVE ENVIRONMENTAL IMPACTS

5.1 POSITIVE ENVIRONMENTAL IMPACTS

This chapter deals with the positive impacts of the project. The introduction of Metro Rail will also yield benefits from non-tangible parameters such as saving due to equivalent reduction in road construction and maintenance, vehicle operating costs, less atmospheric air pollutiom and socio-economic benefits of travel time, better accessibility, better comfort and quality of life. However, all benefits cannot be evaluated in financial terms due to non-availability of universally accepted norms. The parameters such as economic growth, improvement in quality of life, reduction in public health problems due to reduction in pollution, etc have not been quantified.

Various positive impacts have been listed under the following headings:

- Employment Opportunities,
- Benefit to Economy,
- Mobility,
- Safety,
- Traffic Congestion Reduction,
- Reduction in the number of Vehicle Trips on the road,
- Less Fuel Consumption,
- Reduced Air Pollution,
- Carbon Dioxide Reduction,
- Reduction in Number of Buses,
- Saving in Road Infrastructure, and
- Traffic Noise Reduction.

5.1.1 Employment Opportunities

The project is likely to be completed in a period of about 5 years. During this period manpower will be needed to take part in various activities. About 5,000 persons are likely to work during peak period of construction activities. In operation phase of the project about 45 persons per kilometre length of the corridor, ie (approx. 1,510 persons) will be employed for operation and maintenance of the proposed system. Thus the project would provide substantial direct employment; besides, more people would be indirectly employed in allied activities and trades.

5.1.2 Benefit to Economy

In the present context, the project will streamline and facilitate easy movement of public in Mumbai city. The metro rail will yield tangible and non-tangible saving due to equivalent reduction in road traffic and certain socio-economic benefits. Introduction of this metro rail project, in Mumbai city will result in the reduction in number of buses and private vehicles. This, in turn will result in significant social and economic benefits due to reduction in fuel consumption, vehicle operating cost and travel time of passengers. This will facilitate the movement of people fast. With the development of this corridor, it is likely that more people will be involved in trade, commerce and allied services.

5.1.3 Mobility

The proposed Mumbai Metro Colaba – Bandra – SEEPZ network are estimated to carry 16.99 lakh passengers per day, in the year 2031. The maximum PHPDT on any section will be more than 24,800 by 2031.Passenger average time saved will be about 60 minutes by year 2031. The proposed development will reduce journey time to an extent as indicated in the **Table 5.1**.

TABLE 5.1

JOURNEY TIME

S. No	Section	Length in km	Journey Time (Min)	Type of Corridor Proposed
1.	Colaba-Bandra-SEEPZ	33.508	60	Underground

5.1.4 Safety

According to the National Crime Record Bureau's report, Mumbai city tops in the list of accidents in India. It accounts for one out of every five fatal accidents in the country. The latest compiled data with the home ministry shows that Mumbai accounts for 18.5% of total accidents in the country. Kolkata, with a record of 1.8%, comes at the bottom of the list. Substantial decrease in road accident has been noticed after 2007 with the implementation of Delhi Metro Phase I & II in Delhi. Hence, operation of Mumbai Metro Rail will also provide improved safety and lower the number of accidental deaths.

5.1.5 Traffic Congestion Reduction

To meet the forecast transport demand in the year 2031, it is estimated that the number of buses will have to be more. During this period personalised vehicles may also been grow. Together, they will compound the existing problems of congestion and delay. The proposed development will reduce journey time and hence congestion and delay.

5.1.6 Reduction in the number of Vehicle Trips on the road

The number of vehicle trips in the years 2016, 2021, 2031 and 2041 with and without metro rail is projected in **Table 5.2**. After the introduction of metro rail system the reduction of vehicles for the years 2016, 2021, 2031 and 2041 is as indicated in **Table 5.3**. Similarly vehicle trip KMs and reduction in vehicle trip KMs are summarized in **Table 5.4** and **Table 5.5** respectively.

The basis of reduction of vehicle is shift of ridership from road vehicle to the proposed system. 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.

TABLE 5.2
NUMBER OF VEHICLES TRIPS WITH AND WITHOUT METRO CORRIDOR (Avg. Daily)

MODE	No of Vehicle Trips without C-B-S Metro				No of Vehicles Trips with C-B-S Metro			
	2016	2021	2031	2041	2016	2021	2031	2041
Car + Taxi	4628346	5365521	6540541	7972882	4552876	5273172	6428421	7838339
2W	7239698	8392794	10230769	12471251	7060698	8173760	9964844	12152141
Bus	160988	186629	227500	277321	151680	175239	213672	260728
Auto	1510263	1750809	2352941	2868222	1400758	1616812	2190258	2673002
Total	13539295	15695754	19351751	23589676	13166012	15238983	18797195	22924209

TABLE 5.3
REDUCTION IN VEHICLE TRIPS (Avg. Daily)

S.NO.	MODE	Reduction of Vehicle Trips with C-B-S Metro			
		2016	2021	2031	2041
1.	Car + Taxi	75470	92350	112120	134544
2.	2W	179000	219034	265925	319110
3.	Bus	9308	11390	13828	16594
4.	Auto	109506	133998	162684	195220
	Total	373283	456771	554556	665468

TABLE 5.4
NUMBER OF VEHICLES TRIP KMs WITH AND WITHOUT METRO CORRIDOR (Avg. Daily)

MODE	No of Vehicle Trip KMs without C-B-S Metro				No of Vehicles Trip KMs with C-B-S Metro			
	2016	2021	2031	2041	2016	2021	2031	2041
Car + Taxi	55540150	64386256	78486486	95674589	54634509	63278060	77141050	94060065
2W	108595469	125891912	153461538	187068759	105910475	122606396	149472663	182282109
Bus	1609880	1866292	2275000	2773212	1516800	1752394	2136719	2607275
Auto	12082107	14006474	18823529	22945777	11206062	12934493	17522061	21384015
Total	177827607	206150934	253046554	308462338	173267846	200571344	246272493	300333465

TABLE 5.5
REDUCTION IN VEHICLE TRIP KMs WITH METRO CORRIDOR (Avg. Daily)

S.NO.	MODE	Reduction of Vehicle Trip KMs with C-B-S Metro			
		2016	2021	2031	2041
1.	Car + Taxi	905641	1108196	1345437	1614524
2.	2W	2684994	3285516	3988875	4786650
3.	Bus	93080	113898	138281	165937
4.	Auto	876045	1071980	1301468	1561762
	Total	4559761	5579590	6774061	8128873

5.1.7 Less fuel Consumption Due to reduction in Vehicle

There will be a reduction in number of vehicle trips on implementation of this project. Therefore, it is estimated that both petrol and diesel consumption will also get reduced. There is an inter-fuel substitution of petrol and diesel to electricity that could result in savings of foreign exchange and a reduction of air pollution. Fuel saved due to traffic diverted to the metro rail is estimated by the diverted traffic described above and the annual run and fuel consumption norms of different vehicles. **Table 5.6** provides information about the savings in fuel consumption due to reduction of vehicles in Mumbai for the years 2016, 2021, 2031 and 2041. These fuel savings are valued at 2011 prices (Rs.67.00/L for petrol and Rs.41.00/L for diesel) the corresponding fuel savings for buses, car + taxi and 2/3 wheelers are as shown in **Table 5.7**.

TABLE 5.6
SAVINGS IN FUEL CONSUMPTION DUE TO REDUCTION OF VEHICLES (Avg. Daily)

MODE	Reduction in Vehicle Trips KMs with CBS Metro				Fuel Consumption Norm (Km/L)	Reduction in Fuel Consumption (litres)			
	2016	2021	2031	2041		2016	2021	2031	2041
Bus (Diesel)	93080	113898	138281	165937	6	15513	18983	23047	27656
Car +Taxi(Petrol)	905641	1108196	1345437	1614524	14	64689	79157	96103	115323
2-3Wheeler (Petrol)	3561039	4357496	5290343	6348412	30	118701	145250	176345	211614

TABLE 5.7
MONEY SAVING DUE TO REDUCTION OF VEHICLES (Avg. Daily)

MODE	MONETARY VALUE(RS LAKH)			
	2016	2021	2031	2041
Bus (Diesel)	6.36	7.78	9.45	11.34
Car (Petrol)	43.34	53.04	64.39	77.27
2-3Wheeler (Petrol)	79.53	97.32	118.15	141.78

5.1.8 Reduced Air Pollution

Reduction in traffic on Mumbai roads due to proposed metro rail could lead to reduce air pollution. Reduction in number of vehicles and the Emission factor of vehicles as per Euro-II norms given in **Table 5.8** and the reduction level of different pollutants like PM, NOx, HC, CO and CO_2 for the years 2016, 2021 and 2031 and 2041 is given in **Table 5.9.**

TABLE 5.8
EMISSION FACTOR OF VEHICLES AS PER EURO-II NORMS (G/KM)

MODE	PM	NOX	HC	CO
Bus	0.05	0.87	2.75	0.66
Car	0.03	0.2	0.25	1.98
2- Wheeler	0.075	0.3	0.7	2.2

TABLE 5.9
REDUCTION IN POLLUTION EMISSION DUE TO REDUCTION OF VEHICLES (TONNES/YEAR)

MODE	Year			
	2016	2021	2031	2041
Emission reduction of Particulate Matter (PM)				
Bus	1.70	2.08	2.52	3.03
Car	9.92	12.13	14.73	17.68
2/3 Wheelers	97.48	119.29	144.82	173.79
Total	109.10	133.50	162.08	194.50
Emission reduction of Oxides of Nitrogen NOx				
Bus	29.56	36.17	43.91	52.69
Car	66.11	80.90	98.22	117.86
2/3 Wheelers	389.93	477.15	579.29	695.15
Total	485.60	594.21	721.42	865.70
Emission of reduction of Hydrocarbons HC				
Bus	93.43	114.33	138.80	166.56
Car	82.64	101.12	122.77	147.33
2/3 Wheelers	909.85	1113.34	1351.68	1622.02
Total	1085.91	1328.79	1613.25	1935.90
Emission reduction of Carbon Monoxide CO				
Bus	22.42	27.44	33.31	39.97
Car	654.51	800.89	972.35	1166.82
2/3 Wheelers	2859.51	3499.07	4248.15	5097.77
Total	3536.44	4327.40	5253.80	6304.57
Emission reduction of Carbon Dioxide CO_2				
Bus	35.24	43.12	52.35	62.82
Car	1028.51	1258.55	1527.97	1833.57
2/3 Wheelers	4493.52	5498.54	6675.66	8010.79
Total	5557.27	6800.20	8255.98	9907.17

5.1.9 Carbon Dioxide Reduction

Carbon dioxide is one of the major greenhouse gases, which directly deplete the ozone layer. To reduce the overall greenhouse gas emissions International Emission Trading (IET) Mechanism has been followed under Kyoto Protocol. Under IET mechanism, countries can trade in the international carbon credit market. Countries with surplus credits can sell the same to countries with quantified emission limitation and reduction commitments under the Kyoto Protocol. Caron credits are measured in units of certified emission reductions (CERs). Each CER is equivalent to one ton of carbon dioxide reduction. Therefore, 5557.27, 6800.20, 8255.98 and 9907.17 Carbon credits per year will be achieved through this project in the 2016, 2021, 2031 and 2041 respectively. In economic terms it will valued as Rs. 23.01 lakh (5557.27 (Caron Credit) X 6 (Amount in Euro) X 69 (Amount in Rs.), Rs. 28.15 lakh (6800.20 (Caron Credit) X 6 (Amount in Euro)

X 69 (Amount in Rs.), Rs. 34.18 lakh (8255.98 (Caron Credit) X 6 (Amount in Euro) X 69 (Amount in Rs.) and Rs. 41.02 lakh (9907.17 (Caron Credit) X 6 (Amount in Euro) X 69 (Amount in Rs.) for year 2016, 2021, 2031 and 2041 respectively.

5.1.10 Reduction in Number of Buses

The requirement of buses is estimated to be 450 numbers to cater the additional ridership due to increase in traffic on road in absence of Mumbai metro. This will save an amount equal to Rs. 2203 million towards capital cost of bus system.

5.1.11 Saving in Road Infrastructure

The total road network in the Mumbai city is 1889 km and additional 182 km road infrastructure will be required to cater the additional load. About 10% of road infrastructure will be saved.

5.1.12 Traffic Noise Reduction

Reduction in traffic volume affects the noise levels. A 50% reduction of the traffic volume may results in a 3 dB reduction in noise levels, regardless of the absolute number of vehicles. Reduction in traffic volume of 10% & 50% reduces noise at the tune of 0.5 dB & 3.0 dB respectively. An introduction of Mumbai Metro Rail Line III substantially reduces the vehicular traffic which ultimately reduces noise level.

5.2 CHECKLIST OF IMPACTS

The impact evaluation determines whether a project development alternative is in compliance with existing standards and regulations. It uses acceptable procedures and attempts to develop a numeric value for total environmental impact. A transformation of the review of multiple environmental objectives into a single value or a ranking or projects is the final step in impact assessment. There are about numerous methods for carrying out impact assessment, which can be grouped into the following categories:

- Ad – hoc method,
- Checklist,
- Matrix,
- Network,
- Overlays,
- Environmental Index and
- Cost Benefit analysis.

Each of the methods is subjective in nature and none of these is applicable in every case. Of the 7 methods listed above, checklist has been used and presented.

Checklist is a list of environmental parameters or impact indicators which encourages the environmentalist to consider and identify the potential impacts. A typical checklist identifying anticipated environmental impacts is shown in **Table 5.10**.

TABLE 5.10
CHECKLIST 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	*		
iii.	Loss of Trees	*		
iv.	Loss of Cultural and Historical Structures		*	
v.	Drainage & Utilities Problems	*		
vi.	Impact on Local Transport Utilities			*
B.	**Impact due to Project Design**			
i.	Platforms - Inlets and Outlets		*	
ii.	Ventilation and Lighting		*	
iii.	Railway Station Refuse	*		
iv.	Risk due to Earthquakes		*	
C.	**Impact due to Project Construction**			
i.	Soil Erosion	*		
ii.	Traffic Diversions and Risk to Existing Buildings	*		
iii.	Air Pollution	*		
iv.	Noise Pollution	*		
v.	Impact due to Vibration		*	
vi.	Health risk at construction site	*		
vii.	Impact on Sensitive Receptors		*	
viii.	Problem of excavated soil disposal	*		
ix.	Dust Generation	*		
x.	Problems of Soil Disposal	*		
xi.	Labour Camp	*		
D.	**Impact due to Project Operation**			
i.	Noise & Vibration	*		
ii.	Water Demands	*		
iii.	Refuse disposal and sanitation	*		
iv.	Electromagnetic Interference		*	
v.	Employment Opportunities			*
vi.	Benefit to Economy			*

S. No.	Parameter	Negative Impact	No Impact	Positive Impact
vii.	Mobility			*
viii.	Safety			*
ix.	Traffic Congestion Reduction			*
x.	Less fuel Consumption			*
xi.	Reduced Air Pollution			*
xii.	Carbon dioxide Reduction			*
xiii.	Traffic Noise Reduction			*
xiv.	Reduction in Buses			*
xv.	Reduction in Infrastructure			*

CHAPTER – 6
ENVIRONMENTAL MANAGEMENT PLAN

6.1 APPROVALS/CLEARANCES REQUIREMENT

On the basis of baseline study and identified negative impacts, issues like tree cutting, development near World Heritage Structures and muck disposal etc needs necessary approvals/clearance from the relevant concerned authorities. PMU will ensure that all necessary approvals/clearances are in place before implementation. Before commencement of the construction the necessary permission required for the project is given in **Table 6.1**.

TABLE 6.1
NECESSARY APPROVALS/CLEARANCES REQUIREMENT

Issues	Provision of Laws & Regulations	Due Date	Required Documentation	Approval Authority
Permission for Tree Cutting	Maharashtra Protection & Preservation of Trees Act, 1975, as modified up to 3rd Nov 2006.	67 days before the construction	Application Format enclosing Detailed Address of Site, Plans & drawings of the proposed construction approved by competent authority, Plan showing indication of trees required to be felled.	The Tree Authority MCGM, Mumbai
Development permission near World Heritage Structures.	Development Control Regulations, 1991, Under MCGM Act, 1988.	Before Construction	Format of submission for MHCC NOC. Detailed Address of Site, Location of Heritage structure w.r.t Metro Alignment. Plans & drawings of the proposed construction activities.	Mumbai Heritage committee, MCGM. (MCGM Act, 1988)
Muck disposal permission	Environment Protection Act	Before Construction	Location of Muck Dumping Site	State Pollution Control Board/ MoEF(Govt. Of India)
Resettlement Permission	Resettlement & Rehabilitation Policy for Mumbai Urban Transport Project (MUTP), 1997 Amended in Dec 2007.	Before Construction	Social Impact Assessment & RAP Report	State Government, Maharashtra.
Consent for Establishment	Environment Protection Act	Before Construction	Site plan, sources of effluent discharge/emissions, Details of Water Pollution Control/Air Pollution Control, Ambient Air Quality Report, Consent fees,	State Pollution Control Board (Maharashtra Pollution Control Board)
Consent to Operate	Environment Protection Act	After Construction	Site plan, Latest analysis report of effluent	State Pollution Control Board

			discharge/emissions, Details of Water Pollution Control/Air Pollution Control, Ambient Air Quality Report, Consent fees.	(Maharashtra Pollution Control Board)

6.2 MANAGEMENT PLANS

The Mumbai Metro Rail Project will provide employment opportunity, quick mobility service and safety, traffic de-congestion, less fuel consumption and reduced air pollution on one hand and problems of muck disposal, traffic diversion, utility dislocation etc. on the other hand during construction and operation of the project.

Protection, preservation and conservation of environment have always been a primary consideration in Indian ethos, culture and traditions. Management of Environment by provision of necessary safeguards in planning of the project itself can lead to reduction of adverse impacts due to a project. This chapter, therefore, spells out the set of measures to be taken during project construction and operation to mitigate or bring down the adverse environmental impacts to acceptable levels based on the proposed Environmental Management Plan (EMP).

The most reliable way to ensure that the plan will be integrated into the overall project planning and implementation is to establish the plan as a component of the project. This will ensure that it receives funding and supervision along with the other investment components. For optimal integration of EMP into the project, there should be investment links for:

- Funding,
- Management and training, and
- Monitoring.

The purpose of the first link is to ensure that proposed actions are adequately financed. The second link helps in embedding training, technical assistance, staffing and other institutional strengthening items in the mitigation measures to implement the overall management plan. The third link provides a critical path for implementation and enables sponsors and the funding agency to evaluate the success of mitigation measures as part of project supervision, and as a means to improve future projects. This chapter has been divided into three sections:

- Mitigation measures,
- Disaster management, and
- Emergency measures.

For every issue discussed for above measures, the implementing agency as well as staffing, equipment, phasing and budgeting have been presented as far as possible. All required funds will be channeled through the project authority. The Environmental Management Plans have been prepared and discussed in subsequent sections.

6.3 MITIGATION MEASURES

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

- Compensatory Afforestation,
- Construction Material Management,
- Safety Management Measures during the construction period
- Labour Camp,
- Energy Management,
- Hazardous Waste Management,
- Environmental Sanitation,
- Utility Plan,
- Archaeological and Historical Preservation,
- Air Pollution Control Measures,
- Noise Control Measures,
- Vibration Control Measures,
- Traffic Diversion/Management,
- Soil Erosion Control,
- Muck Disposal,
- Draining of Water from Tunnel,
- Water Supply, Sanitation and Solid Waste Management,
- Sensitive Receptors
- Electromagnetic Interference
- Management Plans for Depot,
- Training and Extension, and
- Environmental Enhancement Measures.

6.3.1 Compensatory Afforestation

A) Afforestation

The objective of the afforestation programme should be to develop natural areas in which ecological functions could be maintained on a sustainable basis. The Tree Authority of Mumbai is responsible for the tree cutting in the project area under Maharashtra (Urban Areas) Protection and Preservation of Trees Act 1975, as modified up to 3rd Nov 2006. According to the Tree Authority an application with site map should be submitted to authority for inspection and permission for cutting of tree. The Permission letter for removal of trees is enclosed as **Appendix 6.1** .As mentioned in section 3.7.1 about 2241

trees are observed at station and Depot locations. The detail of tree likely to be removed or transplanted is given in the **Table 6.2**.

TABLE 6.2
DETAILS OF TREES CUT AND TRANSPLANTATION

Sr. No	Particulars	Number of Trees observed	Number of trees to be cut	Number of trees to be Transplanted	Remarks
1	Along Alignment	589	177 (30%)	412 (70%)	(Stations, Entry & Exit)
2	Depot	1652	496 (30%)	660 (40%)	30% (i.e 496) trees in depot area will remain as where it is.
	Total	**2241**	**673**	**1072**	

The number of trees to be transplanted depends on the site condition and root condition & health of tree. More stress should have been given for transplantation of the tree rather than removal. The trees which are not possible to transplant will only be cut. The trees which are cut will be compensated by planting two times the number of trees. As per estimation, 673 trees are likely to be cut for which 1346 trees are required to be planted. The compensation for loss of these trees works out to Rs. 10.095 million @ Rs. 15000 per tree.The total area required for afforestation of these trees comes out to about 1.5 ha. It is presumed that Government land will be provided for afforestation; hence no land cost will be involved. Land for plantation of trees will be identified by the project proponent in consultation with Forest Department of State Government. Compensatory afforestation cost (excluding fencing) for 1.5 ha will be about Rs. 0.3 million @ about Rs.200000 per ha. Fencing shall be provided in order to save the saplings from the animals. The cost towards fencing is estimated to be about Rs. 0.2 million. Thus, the total cost of compensatory afforstation and fencing works out to **Rs. 10.595 million**. The Maharashtra Felling of Trees (Regulation) Act, 1964 has recommended native plant species for afforstation. The native plant species[1] recommended for afforestation includes gulmohar, neem, Pilkhan, Ashoka, Jamun, Desi Badam etc. The botanical names of the species to be planted are indicated in the **Table 6.3**.

TABLE 6.3
SCIENTIFIC NAMES OF TREE FOR PLANTATION

S. No	Local Name	Botanical Name
1	Gulmohar	*Delonix regia*
2	Neem	*Azadirachta indica*
3	Ashoka	*Saraca asoca*
4	Jamun	*Syzygium cumini*
5	Desi Badam	*Terminalia catappa*
6	Coconut Tree	*Cocos nucifera*
7	Jackfruit	*Artocarpus integra*
8	Karanj	*Pongamia pinnata*
9	Rubber Tree	*Ficus elastica*
10	Sheesham	*Dalbergia sissoo*

[1] The Maharashtra felling of trees (Regulation) Act, 1964

B) Transplantation

The trees at station location will be transplanted in the nearby open area while transplantation of trees from the depot area will be done in the nearby available area within the Aarey milk colony itself in consultation with MCGM. The structural component of depot should be planned in such a way that about 30% of the trees will get saved. The management plan for transplantation of trees is summarized below:

- Preliminary root investigation should be carried out,
- Health diagnosis of the tree should be carried out for treating infected trees,
- Soil condition where the tree has to be transplanted is thoroughly checked & necessary treatments are applied to the soil after digging a pit,
- The pit size has to be kept in accordance with the root ball of the tree,
- Packing material should be strong enough to hold the soil around the root zone,
- Crane should be used to lift the packed tree and a trolley or truck should be used to transport the tree,
- Timely feeding of the plant should be done with soluble fertilizers and watering,
- JCB should be used for digging pits,
- There should be regular monitoring for fertilizer schedules and the chemicals like insecticides and pesticides.
- Scaffolding should be used wherever required to support the trees,
- Any broken stems during transplantation should be removed cautiously.

After transplantation, there are chances of external infections to the tree which needs maintenance for at least 2-3 months.

The cost towards transplantation of trees varies with its girth. An average girth of 0.75 metre has been taken for the cost estimation. The cost for transplanting 1072 number of trees is about **Rs. 53.60 million** @ Rs. 50,000/- per tree. The cost i.e Rs. 50,000/- for one tree transplantation is including lead of 1.5 km with all tools, testing, man & machinery, necessary preparation and maintenance.

6.3.2 Construction Material Management

The construction material to be used are coarse aggregates, cement, coarse sand, reinforcement steel, structural steel, water supply, drainage and sanitary fittings etc. The material will be loaded and unloaded by engaging labour at both the locations by the contractor.

The duties of the contractor will include monitoring all aspects of construction activities, commencing with the storing, loading of construction materials and equipment in order to maintain the quality. During the construction period, the construction material storage site

is to be regularly inspected for the presence of uncontrolled construction waste. Close liaison with the MMRDA Officer and the head of the construction crew will be required to address any environmental issues and to set up procedures for mitigating impacts. The scheduling of material procurement and transport shall be linked with construction schedule of the project. The Contractor shall be responsible for management of such construction material during entire construction period of the project. Sufficient quantity of materials should be available before starting the each activity. The contractor should test all the materials in the Government labs or Government approved labs in order to ensure the quality of materials before construction. This is also the responsibility of the contractor, which would be clearly mentioned in the contractor's agreement.

6.3.3 Safety Management Measures

Prior to the construction, identification of safety hazard would be made by Project Authority to establish the safety programmes following rules, regulations and guidelines. These would help to avoid and reduce the accidents. The comprehensive safety programmes will include deployment of a full time safety engineer who will prepare safety plan/schedule for their implementation during construction and operation. The emergency measures include tunnel evacuation plan and procedures independent of the tunnel power supply. The tunnel personnel would wear protective headgear, footwear and other special garments that applicable code requires. The specific working areas in underground construction can have their own unique hazards that personnel requires to be made aware of by providing training and displaying the instruction wherever it requires. The weatherproof first aid boxes will be made available at appropriate locations. The tunnel will be provided with mechanically induced reversible flow primary ventilation for all work areas. Detailed instructions will be followed for handling and storage of explosives to be used in controlled blasting if any.

6.3.4 Labour Camp

The Contractor during the progress of work will provide, erect and maintain necessary (temporary) living accommodation and ancillary facilities for labour to standards and scales approved by the MMRDA. All temporary accommodation must be constructed and maintained in such a fashion that uncontaminated water is available for drinking, cooking and washing. Safe drinking water should be provided to the dwellers of the construction camps. Adequate washing and bathing places shall be provided, and kept in clean and drained condition. Construction camps are to be the responsibility of the concerned contractors and these shall not be allowed in the construction areas but sited away. Adequate health care is to be provided for the work force. The labour camps cleanliness and worker's hygiene will be monitored as a part of Labour Laws of the Country during construction of proposed project. Deployment of labour at the construction site will be made by following the fairer process as mentioned in civil contract agreement.

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 will be provided. Suitable transport will be provided to facilitate taking injured and ill persons to the nearest hospital. Construction contractor will provide health check-up camps for construction workers at least once in a month.

Day Crèche Facilities: At every construction site, provision of a day crèche shall be worked out so as to enable women to leave behind their children. At construction sites, where the number of women workers is more than 25 but less than 50, the contractor shall provide with at least one hut and one maidservant to look after the children of women workers. Size of crèches shall vary according to the number of women workers employed. Huts shall not be constructed to a standard lower than that of thatched roof, mud walls and floor with wooden planks spread over mud floor and covered with matting. Huts shall be provided with suitable and sufficient openings for light and ventilation. There shall be adequate provision of sweepers to keep the places clean. There shall be two maidservants (or aayas) to the satisfaction of local medical, health, municipal or cantonment authorities.

Prevention of Infectious Diseases: Construction workers are more prone to Infectious diseases such as HIV/AIDS. It should be prevented by following actions as depicted below:

- One-one interactions – helps to build confidence,
- Counselling- addressing the myths and misconceptions,
- Community events-street theatre, puppetry, cultural programs are proven communication tools to the illiterate community to message dissemination,
- STD clinic - early identification through testing,
- Condom promotion- encouraging condom usage, an accessible place, made available at all times and free distribution.
- Advertisement board at appropriate location will be put to make aware about the infectious diseases.
- Co-ordination with State Aids Control Society and Health Department

Sanitation Facilities: Construction camps shall be provided with sanitary latrines and urinals. Drains for waste water should be provided for the flow of used water outside the camp. Drains and ditches should be treated with bleaching powder on a regular basis. The sewage system for the camp must be properly designed, built and operated so that no health hazard occurs and no pollution to the air, ground or adjacent watercourses takes place. Compliance with the relevant legislation must be strictly adhered to. Garbage bins must be provided in the camp and regularly emptied and the garbage disposed off in a hygienic manner.

Water Supply and Waste water Treatment Facility for Workers Camps: It is estimated that about 63 KLD water will be required daily for the camps, which will be taken from borewell/Municipal Water Supply. Borewell water will be chlorinated for use as drinking water. About 80% of the water supply will be generated as sewage/waste water, which needs to be treated before disposal or may be connected to nearby sewerage network.

As per the Contract Labour (Regulation & Abolition) Act, 1970, there shall be at least one latrine for every 25 male. The sewage from the community water closet would be treated through septic tank and disposed off through soak pits. The drinking water facilities and sewage disposal sites should be located away from each other. A provision of **Rs. 1.205 million** would be made for these facilities as reported in **Table 6.4**.

TABLE 6.4
COST OF WATER SUPPLY AND SANITATION FACILITIES

Sr. No	Description	Rate (Rs/Unit)	Numbers	Cost (million)
1	Water Treatment & Supply Facilities	1,50,000	3	0.45
2	Community water closet	25,000	20	0.50
3	Septic Tank & Soak pit including connection	85,000	3	0.255
			Total	**1.205**

Solid Waste Management

It is estimated that about 315 Kg per day municipal solid waste will be generated from the labour camp. The collection, conveyance and disposal facilities shall be made available by providing 20 litres capacity bin with handle and cover for 8 workers. In addition, one community bins would be provided for effective collection of the waste. The disposal of the waste will be at municipal corporation landfill site. The cost of these facilities including maintenance for 5 years works out to be about **Rs. 1.207 million** as summarized in **Table 6.5.**

TABLE 6.5
COST OF DOMESTIC SOLID WASTE MANAGEMENT FACILITIES

SI	Description	Numbers	Rate (Rs/Unit)	Cost (million)
1	Solid waste collection bins @ Rs. 200/bin Community bin 3 no. @ Rs. 15,000/bin	60 3	12,000 45,000	0.057
2	Transportation	-	Lump sum	0.250
3	Manpower cost of 3 persons @ 5000 per person per year for 5 years	3	3x60x6,000	0.90
			Total	**1.207**

6.3.5 Energy Management

Energy conservation measures are often the easiest, quickest and cheapest way to reduce costs and implement environmentally pro-active Energy conservation program both on energy demand and supply. The contractor shall use and maintain equipment so as to conserve energy and shall be able to produce demonstrable evidence of the same upon MMRDA request.

Measures to conserve energy include but not limited to the following:

- Use of energy efficient motors and pumps,
- Use of energy efficient lighting,
- Adequate and uniform illumination level at construction sites suitable for the task,
- Proper size and length of cables/ wires to match the rating of equipment, and
- Use of energy efficient air conditioner.

The contractor shall design site offices for maximum daylight and minimum heat gain. The rooms shall be well insulated to enhance the efficiency of air conditioners and the use of solar films on windows may be used where feasible.

6.3.6 Hazardous Waste Management

Hazardous Waste needs to be stored at a secured place. It shall be the responsibility of the contractor to ensure that hazardous wastes are stored, based on the composition, in a manner suitable for handling, storage and transport. The contractor shall identify the nature and quantity of hazardous waste generated as a result of his activities. Hazardous Waste will be handled and disposed as per the Hazardous waste (M& H) Rules, 2008 and shall be authorized with Maharashtra Pollution Control Board. Outside the storage area, the contractor shall place a ‘display board’, which will display quantity and nature of hazardous waste. The labeling and packaging is required to be easily visible and be able to withstand physical conditions and climatic factors. The contractor shall approach only

Authorized Recyclers with MPCB for disposal of Hazardous Waste, under intimation to the MMRDA.

6.3.7 Environmental Safeguard

Environmental sanitation also referred to as Housekeeping, is the act of keeping the working environment cleared of all unnecessary waste, thereby providing a first-line of defense against accidents and injuries. Contractor shall understand and accept that improper environmental sanitation is the primary hazard at any construction site and ensure that a high degree of environmental sanitation is always maintained. Environmental sanitation is the responsibility of all site personnel, and line management commitment shall be demonstrated by the continued efforts of supervising staff towards this activity.

General environmental sanitation shall be carried out by the contractor to ensure for good environmental sanitation at Work Site, Construction Depot, Batching Plant, Labour Camp, Stores, Offices and toilets/urinals. Towards this the Contractor shall constitute a special group of environmental sanitation personnel. This group shall ensure daily cleaning at work sites and surrounding areas and maintain a register as per the approved format by the MMRDA.

Team of environmental sanitation squad shall carry out:

- 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 and endanger to the public. The barricade especially those exposed to public shall be aesthetically maintained by regular cleaning and painting as directed by the Employer. These shall be maintained in one line and level.

- The structural dimension of the barricade, material and composition, its colour scheme, MMRDA logo and other details.

- All stairways, passageways and gangways shall be maintained without any blockages or obstructions. All emergency exits passageways, exit 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 are removed/disposed off from the working areas to officially designated dump sites. Trucks carrying sand, earth and any pulverized materials etc. in order to avoid dust or odour impact shall be covered while moving.

- No parking of trucks/trolleys, cranes and trailers etc. shall be allowed on roads, which may obstruct the traffic movement.

- Roads shall be kept clear and materials like: pipes, steel, sand, boulders, concrete, chips and brick etc. shall not be allowed on the roads to obstruct free movement of road traffic.

- Water logging on roads shall not be allowed.

- Turbid water from construction area shall be treated by sedimentation tank as required.

- Proper and safe stacking of material are of paramount importance at yards, stores and such locations where material would be unloaded 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.

- Unused/surplus cables, steel items and steel scrap lying scattered at different places within the working areas shall be removed to identified locations(s).

- All wooden scrap, empty wooden cable drums and other combustible packing materials, shall be removed from work place to identified location(s).

- Empty cement bags and other packaging material shall be properly stacked and removed.

The Contractor shall ensure that all his sub-contractors maintain the site reasonably clean through provisions related to environmental sanitation (house keeping).

6.3.8 Utility

The proposed Metro alignment is passing through underground, hence utilities like sewers, water mains, storm water drains, telephone cables, electrical transmission lines, electric poles, traffic signals etc. would not get affected except at locations where construction of stations is proposed through cut and cover method. These utility services have to be maintained in working order during different stages of construction by temporary / permanent diversions or by supporting in position. As such, these may affect construction and project implementation time schedule/costs, for which necessary planning / action needs to be initiated in advance.

The Organizations / Departments responsible for concerned utility services are reported in **Table 6.6.** While planning for diversion of underground utility services e.g. sewer lines, water pipe lines, cables etc., during construction of Metro rail, the following guidelines could be adopted:

- Utility services shall be kept operational during the entire construction period and after completion of project. All proposals should therefore, ensure their uninterrupted functioning.

TABLE 6.6
ORGANIZATIONS RESPONSIBLE FOR UTILITIES AND SERVICES

S. NO.	ORGANIZATION/ DEPARTMENT	UTILITY/SERVICES
1.	Brihan Mumbai Municipal Corporation	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.
2.	Public Works Department	Roads, surface water drains, nallahs etc.
3.	NHAI	Roads, surface water drains, nallahs etc.
4.	Brihanmumbai Electric Supply and Transport (BEST) for island city, and Reliance Energy, Tata Power and Mahavitaran (Maharashtra State Electricity Distribut. area	Power cables and their appurtenances, pole mounted transformers.
5.	Mahanagar Telephone Nigam ltd. (MTNL)	Telecommunication cables, junction boxes, telephone posts, O.H. lines etc.
6.	Office of Commissioner of Police, Mumbai	Traffic signal posts, junction boxes and cable connection etc.
7.	Reliance Mobile India Limited, Idea, Airtel and Tata Tele service India Limited	Telecommunication cables, junction boxes etc.
8.	Mahanagar Gas Limited	Gas Pipelines

6.3.9 Archaeological and Historical Structure Preservation

No damage to Archeological Monuments is anticipated. However, during construction, archaeological or historical structures may get affected by direct or indirect construction activity. Chhatrapati Shivaji Terminus (formerly Victoria Terminus) is the World Heritage Cultural Property located at close vicinity to the alignment, for which necessary procedure will be followed to obtain the necessary construction permit from MCGM. No Objection Certificate (NOC) will be taken from the Mumbai Heritage Conservation Committee, MCGM under MCGM Act, 1988. The tentative application format is enclosed at **Appendix 6.2**. Prior to the initiation of construction, MMRDA will conduct condition survey of all historical important structures in the vicinity of alignment. This survey will help to identify the impact on the structures during construction and operation of the project. Any impact would be compensated by adequate management plan to preserve the structures. The

management plan will include ground vibration monitoring during construction and operation of project.

The tunnel will be constructed by using the state of the art technology i.e. Tunnel Boring Machine which gives negligible vibration and does not affect the surrounding structure. The stations are being constructed by cut and cover method which is widely accepted and the safest technique being adopted by metros in India and abroad. The above technology has been adopted and successfully implemented by DMRC in the Delhi while carrying out works in the regulated/prohibited areas (ASI protected monuments) as well as close to public and private buildings and there is no damage to these structures due to the construction activities of Delhi Metro.

6.3.10 Air Pollution Control Measures

During the construction period, the impact on air quality will be mainly due to increase in Suspended Particulate Matter (SPM) along haul roads and emission from vehicles and construction machinery. Though an air quality during construction shows insignificant impact, nevertheless certain mitigation measures which shall be adopted to reduce the air pollution are presented below:

- The Contractor shall take all necessary precautions to minimise 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 during handling of materials, construction or storage activity. The emission should not remain visible in atmosphere beyond the property line of emission source for any prolonged period of time without notification to the Employer.

- The Contractor shall use construction equipment to minimise or control of air pollution. He shall maintain evidence of design and equipment to make these available for inspection by Employer.

- Contractor's transport vehicles and other equipment shall conform to emission standards fixed by Statutory Agencies of Government of India or the State Government from time to time. The Contractor shall carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.

- The Contractor shall use cover for materials of dust generating 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.

- Contractor shall install barriers around the open construction sites before commencing the work.
- The temporary dumping areas shall be maintained by the Contractor at all times until excavate is re-utilised for backfilling wherever necessary or as directed by Employer. Dust control activities shall continue even during any work stoppage.

- The Contractor shall place material in a manner that will minimize dust production. Material shall be wetted each day, to minimize dust production. During dry weather, dust control measures must be used daily especially on windy, dry days to prevent any dust from blowing across the site perimeter.

- The Contractor shall sprinkle water at construction sites to suppress dust, during handling of excavation soil or debris or during demolition. The Contractor will make water sprinklers, water supply and water delivering equipment available at any time that it is required for dust control use. Dust screens will be used, as feasible when additional dust control measures are needed especially where the work is near sensitive receptors.

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

6.3.11 Noise Control Measures

There will be an increase in noise level in the tunnel due to construction and operation of the Metro corridors. However, noise levels in the core city are expected to go down. The increases in levels are marginal; hence local population will not be adversely affected. However the exposure of workers to high noise levels especially, near the engine, vent shaft etc. need to be minimized. This could be achieved by:

- Job rotation to the extent possible,
- Automation,
- Construction of permanent and temporary noise barriers,
- Re-route and regulate the traffic, a main source of noise,
- Use electric instead of diesel powered equipment,
- Use hydraulic tools instead of pneumatic tools,
- Acoustic enclosures should be provided for individual noise generating construction equipment,
- Scheduling of truck loading, unloading and hauling operation,

- Proper operation and maintenance of the construction vehicles and equipments would keep them within noise limit,
- Schedule work to avoid simultaneous activities,
- Anti drumming floor and noise absorption material,
- Low speed compressor, blower and air conditioner,
- Mounting of under frame equipments on anti-vibration pad,
- Smooth and gradual control of door,
- Provision of GRP baffle on the via-duct for elimination of noise transmission,
- Provision of sound absorbing material in the supply duct and return grill of air conditioner,
- Sealing design to reduce the aspiration of noise through the gap in the sliding doors and piping holes, and
- Sound proof compartments/ 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. At work places, where automation of machineries is not possible or feasible, the workers exposed to noise should be provided with protective devices. Special acoustic enclosures should be provided for individual noise generating equipments, wherever possible.

Workers in those sections where periodic adjustment of equipment/machinery is necessary, should be provided with sound proof control rooms so that exposure to higher noise level is reduced. Effective measures should be taken during the construction phase to reduce the noise from various sources. The noise from air compressor can be reduced by fitting exhaust and intake mufflers. Noise proof barriers will be provided on the construction boundary near the residential area.

Noise level from loading and unloading of construction materials can be reduced by usage of various types of cranes and placing materials on sand or sandy bag beds. The ballast-less track is supported on two layers of rubber pads to reduce track noise and ground vibrations. In addition, baffle walls as parapets will be constructed at up to the rail level so as to reduce sound levels.

6.3.12 Vibration Control Measures

The vibration impact analysis has been conducted considering the worst case scenario. An actual vibration impact shall be carried out prior to the start of construction and during the construction on the basis of detailed soil investigation and TBM activities involved. Detailed geotechnical investigation is required prior to the tunnel construction. By adopting good construction practices, generation of vibration will be controlled during construction and operation.

Following measures to be taken during construction of tunnel, the contractor shall prepare a monitoring scheme prior to construction at such locations.

- Detailed vibration investigation should be carried out prior to construction at locations where the alignment is close to historical / heritage structures.
- Continuous vibration monitoring equipment shall be installed during construction.
- Vibration monitoring shall also be conducted inside as well as on the top of the building mainly for old structures and heritage buildings.
- Proper vibration mitigation measures to be taken during construction of tunnels and also during operation of metro rail.
- Pre-construction structural integrity inspections of historic and sensitive structures.
- The local residence staying in the buildings close to the proposed metro rail alignment shall be informed about the vibrations and to vacate the location if needed.
- Install supporting wall piles to reduce vibration and settlement impact,
- Information dissemination about the construction method, probable effects, quality control measures and precautions to be used.
- Inform the public about the project and potential vibration-related consequences, monitor and record vibration from the activities for sensitive receptors.

Vibration emanates from rail - wheel interaction and the same can be reduced by minimizing surface irregularities of wheel and rail, improving track geometry, providing elastic fastenings, and separation of rail seat assembly from the concrete plinth with insertion of resilient and shock absorbing pad.

While designing the track structure for Mass Rapid Transit System all the above points have been taken into consideration in the following ways:

- To prevent development of surface irregularities on the rail, a fairly heavy rail section of 60 kg/m, 90 UTS rail, supported at every 60 cms has been proposed. Further rail grinding at regular intervals by rail grinding machine and also lubrication of rail by vehicle mounted lubricator have been contemplated.

- Rails will be continuously welded and also will be laid to fine tolerances so that any noise/vibration on account of track geometry could be reduced.
- The vibration generated from rail-wheel interaction will be greatly absorbed by the elastic fastening system proposed to be used.

The lower vibration will be achieved by providing of bolster less type bogies having secondary air spring.

6.3.13 Traffic Diversion/ Management

Traffic is most likely to be affected during construction of metro rail project. Hence Traffic Diversion Plans are required in order to look for options and remedial measures so as to mitigate any traffic congestion situations arising out due to acquisition of road space during Metro construction. As the whole alignment of proposed metro is underground little disturbance will took place at the station locations only. Any reduction of road space during Metro construction results in constrained traffic flow. 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 exercises, traffic segregation, one-way movements, traffic diversions on influence area roads, acquisition of service lanes, etc.

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

- In ‘Cut-and-Cover’ method, the stretch between two points will have to be blocked during construction. However, temporary decking may be provided by blocking the road carriageway partially to permit traffic movement along the same stretch if possible.

- Wherever the stations are isolated, areas available around it should be utilized for road diversion purposes such as lay-byes and service roads.

Only temporary diversion plans will be required during construction of the Metro. At the onset, all encroachments from road ROW for stations and entry/exit will have to be removed. These encroachments vary from ‘on-street’ parking to informal activities. During the construction of works on underground section, it is proposed that temporary decking may be provided by blocking the road carriageway partially to permit ‘through’ as well as right-turning traffic movements. Total blockage of traffic along the underground section is not recommended due to non-availability of reasonably good alternate road network.

Keeping in view the future traffic growth and reduction of carriageway due to Metro construction, implementation of traffic management/diversion plans shall become

inevitable for ensuring smooth traffic movement and similar traffic diversion plans shall be formulated and followed during the execution of project.

Traffic Management Guidelines: The basic objective of the following guidelines is to lay down procedures to be adopted by contractor to ensure the safe and efficient movement of traffic and also to ensure the safety of workmen at construction sites.

- All construction workers should be provided with high visibility jackets with reflective tapes. The conspicuity of workmen at all times shall be increased so as to protect from speeding vehicular traffic.
- Warn the road user clearly and sufficiently in advance.
- Provide safe and clearly marked lanes for guiding road users.
- Provide safe and clearly marked buffer and work zones
- Provide adequate measures that control driver behavior through construction zones.
- The primary traffic control devices used in work zones shall include signs, delineators, barricades, cones, pylons, pavement markings and flashing lights.

The contractor will hire a transportation consultant that carryout the traffic survey and suggest alternative routes for smooth flow of traffic.

6.3.14 Soil Erosion Control

Soil Erosion during construction of proposed Metro rail will cause very little impact as whole alignment is passing underground. The surface facilities and related transport will cause soil erosion. Prior to the start of the construction, the Contractor shall submit his schedules to the MMRDA for carrying out temporary and permanent erosion/sedimentation control works as are applicable for the items of clearing and grubbing, roadway and drainage excavation, embankment/sub-grade construction, pavement courses and shoulders. He shall also submit his proposed method of erosion/sedimentation control and his plan for disposal of waste materials. Visual monitoring will be carried out during construction which includes photographic records and site description data. The visual inspection should be conducted on quarterly basis by the contractor in presence and consultation with PMC. Monitoring may be undertaken by staff with good observational skills, the ability to reliably record and report site conditions. Work shall not be started until the erosion/sedimentation control schedules and methods of operations for the applicable construction have been approved by the MMRDA.

The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. The Contractor may be directed to provide immediate control measures to prevent soil erosion and sedimentation that will adversely

affect construction operations, damage adjacent properties, or cause contamination of nearby streams or other watercourses. Such work may involve the construction of temporary berms, dikes, sediment basins, slope drains and use of temporary mulches, fabrics, mats, seeding, or other control devices or methods as necessary to control erosion and sedimentation.

The Contractor shall be required to incorporate all permanent erosion and sedimentation control features into the project at the earliest practicable time as outlined in his accepted schedule to minimize the need for temporary erosion and sedimentation control measures. Temporary erosion/sedimentation and pollution control measures will be used to control the phenomenon of erosion, sedimentation and pollution that may develop during normal construction practices, but may neither be foreseen during design stage nor associated with permanent control features on the Project. Under no conditions shall a large surface area of credible earth material be exposed at one time by clearing and grubbing or excavation without prior approval of the MMRDA.

Temporary erosion is sometimes caused due to the Contractor's negligence, carelessness or failure to install permanent controls. Sedimentation and pollution control measures then become necessary as a part of the work as scheduled or ordered by the MMRDA, and these shall be carried out at the Contractor's own expense. Temporary erosion, sedimentation and pollution control work, which is not attributed to the Contractor's negligence, carelessness or failure to install permanent controls, will be performed as ordered by the MMRDA.

6.3.15 Muck Disposal

Construction of underground tunnel for metro projects is a specialised and complex task. Owing to paucity of space in the busy cities and for safety reasons, elaborate measures need to be adopted for collection, transfer, storage and disposal of excavated muck. Muck collection, transportation, disposal and its treatment need to be carried out in a systematic manner. Muck collection should be in containers from the dredging sites / places. These containers should be such that muck should not spill during movement to disposal site.

As discussed in Chapter-4, 5.40 Mm^3 of muck will be disposed by adopting five options as described below.

i **Use as fill material for JNPT Terminal 4:** It is informed that JNPT is proposing to build a new terminal (Terminal 4) over 200 ha is size. A large quantity of soil and graded material is required as fill material. Muck generated from Metro Line 3 works can be used as fill material for JNPT Terminal 4 construction; however the timing for the construction of the terminal and metro will have to be synchronised.

Further temporary jetties will have to be constructed along the metro alignment to transport the muck to JNPT Terminal 4 site.

ii **Use as fill material for minor ports in Maharashtra:** Several minor ports being developed within 300 km from Mumbai including one at Srivardhan by DAS Offshore who have indicated their willingness to use muck generated from Metro Line 3 for their construction. Apart from this MMB has informed of 5 other minor ports being developed close to Mumbai. This alternative also requires synchronisation of construction activities and temporary jetties will have to be constructed along the metro alignment to transport the muck to the ports.

iii. **Filling of abandoned quarries in Raigad and Thane districts:** Raigad and Thane districts have several abandoned quarries of varying sizes; muck generated could be used to fill these quarries. These quarries are located far from the metro alignment (over 100 km) and require road transportation of the muck. There are 36 Nos of abandoned quarry sites in Raigad district and 59 Nos in Thane district. The details of abandoned quarry sites located in Raigad and Thane district is depicted in **Appendix 6.3.** The total area of abandoned quarry sites is worked out as 498 Ha and 1115 Ha located in Raigad and Thane district respectively.

iv. **Recycle and Reuse:** Muck generated can be reused as aggregate material for road beds, ballast for railways, construction material and graded material can be used in concrete. The use can be decided only after thorough geotechnical investigation, testing of the muck and choice of TBM. This alternative will require land for setting up a plant to convert the muck to a useful form. It is proposed to appoint IIT – Bombay to study this alternative. A separate proposal in this regards is being moved.

v. **Deep Sea Dumping:** There are a couple of deep sea dumping sites within 100 km from the Mumbai coast. Necessary clearances for use of these sites will be ensured before actually resorting to this. The Coordinates of deep sea dumping location is as indicated below.

1. 18°52'33.00"N, 72°45'6.60"E
2. 18°52'32.75"N, 72°45'38.99"E
3. 18°52'43.76"N, 72°45'39.02"E
4. 18°52'43.74"N, 72°45'6.60"E

Capacity of all the five options described above is approximately assessed for the disposal of muck as depicted in **Table 6.7**. Any one or more of the options will be selected on the basis of detailed investigation and getting the necessary clearances/permission from the concerned authority. Out of five options discussed above Recycle and Reuse and Filling of Abandoned Quarries in Raigad & Thane district seems to be most feasible options. Accordingly cost estimate for muck disposal has been

prepared and given in **Table 6.8.** Muck will be monitored/ analyzed for heavy metals prior to their disposal at dumping site and monitoring programme is given in the Environmental Monitoring Plan.

TABLE 6.7
CAPACITY OF MUCK DUMPING OPTIONS

Sl.	Options	Capacity of dumping site in Mm^3	Remarks
1.	JNPT Terminal 4	4.0	Average depth of fill taken as 2.0 m
2.	Ports/Jetties : at Rajauri Creek, Vill – Rohini, Dist. : Raigad	7.8	As Communicated by project proponent M/s Das Offshore Engg Pvt Limited
3.	Abandoned Quarries (Raigad and Thane)	16.13	Average of fill taken as 1.0 m
4	Recycle and Reuse	-	Appointment of IIT – Bombay to study this alternative is in process
5	Deep Sea Dumping	-	Detailed investigation requires to be taken up

TABLE 6.8
COST OF MUCK DISPOSAL

SI	PARTICULARS	COST (Million)
1	Environmental Study/Clearances (Lump sum)	10.00
2	Detailed Investigation (Lump Sum)	30.00
3	Transportation Cost @ 591 trips per day (Considering lead of 35 km on either side)*	3471.8
4	Transportation cost by sea route @ 300/cum for 25 km lead.	16.20
5	Plantation & Beautification works (Rs. 1.20 Lakhs/Hac.)	20.20
6	Miscellaneous (5%)	177.40
	Total	**3725.60**

***** Rate as per DSR Mumbai @ 3218.87/ trip (Including Inflation 8% per year for 4 years)

6.3.16 Draining of Water from Tunnel

In cut and cover type construction, continuous pumping is an economical alternative. The well point system is recommended for dewatering as the volume of water to be pumped out. The deep well system is adopted where the water table has to be lowered over a large depth in a small area. The deep wells can be installed either inside or outside the diaphragm walls or inside the cut.

A suitable piezometer is installed to monitor the water table constantly and to see how much lowering has been effectively done. The dewatering should not be stopped unless it is ensured from design calculations that the load of the constructed box component has reached a stage where it will be able to counter act the hydrostatic pressure from below. The dewatering can be achieved by:

- Leading the ground water to a sump by drains and pump out the water from the sump. To prevent loss of fines, inverted filter may have to be used.

- Dewatering as suggested above may not be effective in preventing sand flows. Lowering of the ground water by properly designed single or double stage well points will be effective in such cases.

- The construction of diaphragm walls of concrete along the side of channels, before the commencement of excavation will be required. The concrete walls are taken down to rest on bed rock or impervious strata or, in their absence, deep enough below the bottom of excavation, to serve as an effective cut off for the inflow of ground water into the proposed excavation. The trenches are kept continuously filled with a thiotropic material like Bentonite slurry, which has the effect of stabilising the trench and preventing any subsidence. As the excavation proceeds, concrete wall can be strutted mutually or anchored with surrounding rocks.

- During operation phase, seepage water will be drained along the side of walls (retaining). Proper drainage system need to be incorporated in design and implemented during construction phase.

The pumped water from sump wells will be put into storm water drain to avoid any load to waste water treatment plants. These storm water drains finally join natural existing streams/nallahs.

6.3.17 Water Supply, Sanitation and Solid Waste Management

The public health facilities, such as water supply, sanitation and toilets are much needed at the stations. Water should be treated before use up to WHO drinking water standards. The collection and safe disposal of human wastes are among the most important problems of environmental health. The safe sewage disposal systems would be provided.

Requirements of drinking water supply at station are about 6 KL/day. Raw water requirement for station is about 240-250 KL/Day. The water requirement at Depot will be 159 KLD. This shall be provided from municipal/ground water source.

Solid waste generated at underground station is about 0.5–1.0 m^3/day. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of the MMRDA project authorities. The storage containers for this purpose need to be designed. However it is suggested that the capacity of these containers should not exceed 50 litres and these should be equipped with side handles to facilitate handling. To avoid odour and the accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals. This should be collected and

transported to local municipal bins for onward disposal to disposal site by municipality. Waste generated during and after construction will be disposed in accordance with relevant National and State laws and Regulations.

6.3.18 Sensitive Receptors

As discussed in section 4.4.17, the impact on sensitive receptors is anticipated due to noise and vibration during construction work of stations. The management plan for noise & vibration control mentioned at section 6.2.10 & 6.2.11 will reduce the noise & vibration level substantially. Furthermore information will be communicated to the land owner of sensitive receptors about the project and potential noise & vibration generation due construction activities. The noise & vibration due to construction activities will be monitored and recorded at sensitive receptors. Construction contractor must provide a mechanism for receiving and responding to complaints arising due to impacts on sensitive receptors. Avoid nighttime construction activities near sensitive receptors if possible. Precautionary measures will also be taken to safeguard the Nature Park during construction.

6.3.19 Blasting Control

The predicted ground vibration and noise due to air blast by blasting is 14.96 mm/sec and 136 dB respectively for 15 meter distance from charge. Explosive charge mass per delay should be strictly restricted to 1 kg for each blast event. Controlled blasting is required at station location to be constructed by NATM and Cut & Cover method. Good planning is essential to mitigate noise, vibration and air blast impacts which might otherwise lead to unacceptable effects on the community or the natural environment. There are a number of factors that can either increase or decrease the intensity of ground vibrations and noise due to air blast. Measures which are commonly adopted include:

- Identify potential problem areas surrounding the project site,
- Prior to start of construction, condition survey of building is required to be done. If any existing cracks are measured initially and it is again measured after blasting to see the impact and mitigation measures to be adopted to safeguard the building,
- Determine the conditions that exist prior to commencement of construction,
- Inform the public about the project and potential blasting-related consequences,
- Schedule the work to reduce adverse effects,
- The blast should be well designed for the geological conditions, rock type and availability of the explosive,
- Design the blast to reduce vibration and air over pressure,
- All blasting operations shall be conducted under the direct supervision of a blaster holding a current license issued under the state or local laws.
- Blasting should generally be carried out during the hours of 0900 hrs to 1700 hrs Monday to Saturday. Blasting should not take place on Sundays and public holidays,

- Blasting mats or back fill material must be utilized to control fly-rock damage to surrounding structures,
- Use blast signals to notify nearby residents that blasting is imminent,
- Monitor and record the vibration and air overpressure effects of the blast,
- Respond to and investigate complaints,
- Information from manufacturer should be collected for the physical properties, performance characteristics and sensitivity of the explosive which will help in correct choice of explosive.

6.3.20 Electromagnetic Interference

Concrete structures are not good electrical earths and therefore, Earthing & Bonding of the power supply & traction system shall be designed in accordance with the latest standards EN50122-1, IEEE80, IS3043 etc. Two earth conductors-Overhead Protection cable (OPC) and Buried Earth Conductors are proposed to be laid along with underground tunnel and all the metallic structures, structural reinforcement, running rails etc will be connected to these conductors to form an equiv-potential surface & a least resistance path to the fault currents. The overhead protection cable will also provide protection against lightning to the 25 KV Rigid OHE on the underground and 25 KV OHE on the elevated viaduct. Detailed specification of equipment e.g. power cables, transformer, switchgear, E&M equipment etc shall be framed to reduce conducted or radiated emissions as per appropriate international standards. The metro system as a whole (trains, signalling & telecomm, traction power supply, E & M system etc) shall comply with the EMC requirements of international standards viz. EN50121, EN50123, IEC61000 series etc. As precautionary measures, the location of sub-station should be away from the dumping yards and sub-station should not be less than 3 km from the airport.

6.3.21 Management Plans for Depot

The depot is planned at Aarey Milk Colony (26.407 hectares) for the proposed metro project. The management plans for depot site includes:

- Water Supply,
- Oil Pollution Control,
- Sewage/Effluent Pollution Control,
- Solid Waste
- Surface Drainage,
- Green belt development,
- Rain water harvesting, and
- Recycling of treated waste water.

Water supply: About 159 KLD of water will be required for operation and functioning of depot. This could be either collected from Municipal Corporation or through boring tube well into the ground. The ground water will need treatment depending upon its use.

Domestic and some of the industrial application, a Reverse Osmosis (RO) plant of 8 liter/ minute capacity will be appropriate. The water treatment plant flow chart is given in **Figure 6.1**. The estimated cost of water supply plant is about **Rs.5.0 million**.

Oil Pollution Control: The oil tends to form scum in sedimentation chambers, clog fine screens, interfere with filtration and reduce the efficiency of treatment plants. Hence oil and grease removal tank has to be installed at initial stage of effluent treatments. Such tanks usually employ compressed air to coagulate the oil and grease and cause it to rise promptly to the surface. Compressed air may be applied through porous plates located in bottom of the tank. The tank may be designed for a detention period of 5 to 15 minutes. This accumulated oil and grease will be disposed off through approved re-cyclers.

Sewage/Effluent Pollution Control: About 130 KLD of sewage/effluent is likely to be generated at depot. The sewage could be treated up to the level so that it could be used for horticulture purpose in the campus and can also be discharged into the stream a process flow chart is presented in **Figure 6.2.** The estimated cost of sewage/effluent treatment plant is about **Rs.6.0 million**. This has to be treated as per the requirement of regulatory pollution control agency of the state (MPCB).

Solid Waste Disposal: About 1.8 Ton per month of solid waste will be generated from the Depot which will be taken by the cleaning contractor weekly and disposed to the Mumbai Municipal Corporation waste disposal sites in accordance with relevant National and State laws and regulations.

Surface Drainage: The Storm water of the depot will be collected through the drain. Rain water harvesting pits are provided at different locations in the drains and for surplus storm water, the drainage system is connected to a nearby disposal site. The drainage costs have been included in project cost.

Green belt development: The greenbelt development / plantation in the depot area not only functions as landscape features resulting in harmonizing and amalgamating the physical features with surrounding environment but also acts as pollution sink / noise barrier. In addition to augmenting present vegetation, it will also check soil erosion, make the ecosystem more diversified and functionally more stable, make the climate more conducive and restore balance. It is recommended to have a provision of **Rs 4 million** in the cost estimate for the green belt development. Treated sewage and effluent in the best combination should be used for green belt development.

Rain water harvesting: To conserve and augment the storage of groundwater, it has been proposed to construct roof top rainwater harvesting structure at the constructed depot site. Depot cum workshop area of 36,938 sq.m is available at Aarey Milk colony depot for roof top rain water harvesting. An annual average rainfall is 2000 mm, 202 KLD rain water will be harvested. The total recharge pit area of 8.5x8.5x3 will be required. A provision of **Rs. 1.5 million** has been kept in the cost estimate.

Recycling of treated waste water: Waste water generated at depot is proposed to be collected at ETP for treatment and recycled for horticulture work of the depot. About 105 KLD of treated waste water will be available for horticulture. The rest of treated water will be release to the Mithi River.

6.3.22 Training Programmes

The training programmes need to be conducted by the experts, for MRTS officers. These programmes could be extended for the local population for their active participation in the project implementation. Apart from training, such programme should include guidelines for safety, methods of disaster prevention, action required in case of emergency, fire protection, environmental risk analysis etc.

Two international training programme per year for 10 numbers of MMRC officers are proposed to acquire the latest know how about the construction, operation and maintenance of Metro rail. During the project construction period 100 numbers of MMRC staff will get the International training for which estimated cost will be Rs. 172.10 Lakhs. The overall cost involved for National and International training programmes will be **Rs. 21.61 million** which is presented in **Table 6.9.**

TABLE 6.9
COST FOR TRAINING PROGRAMME

S. NO	ITEM	COST (Million)
1.	Curriculum Development and course preparation 2 months Rs.50000/month	0.10
2.	10 Extension Officer (1year) Rs.35, 000/month	3.50
3.	Instructor 20 sessions of 10 days each	0.50
4.	Demonstration/Presentation Aids	0.10
5.	Material etc	0.20
6.	International Training for 100 MMRC staff	17.21
	Total	**21.61**

6.3.23 Environmental Enhancement Measures

In addition to mitigation measures adopted for negative impacts during construction and operation of the project, some of the measures for improvement of environment have been undertaken as described below:

- Landscaping & beautification
- Solar energy
- Renovation of Heritage structures & religious places
- Environmental awareness programmes
- Utility facilities to unprivileged people

The cost for environmental enhancement measures has been kept as **Rs. 8.50** million (Lump sum).

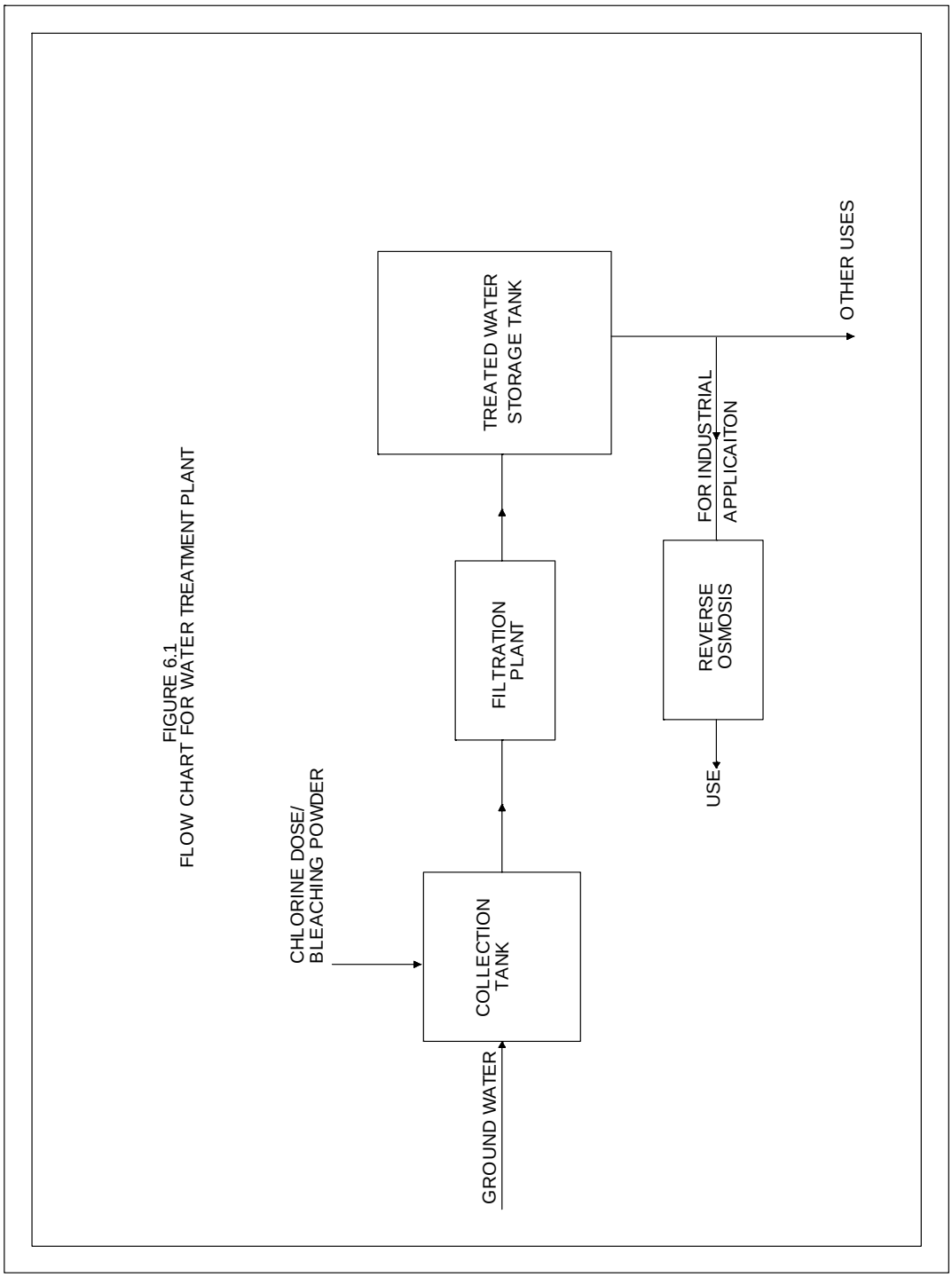


FIGURE 6.1
FLOW CHART FOR WATER TREATMENT PLANT

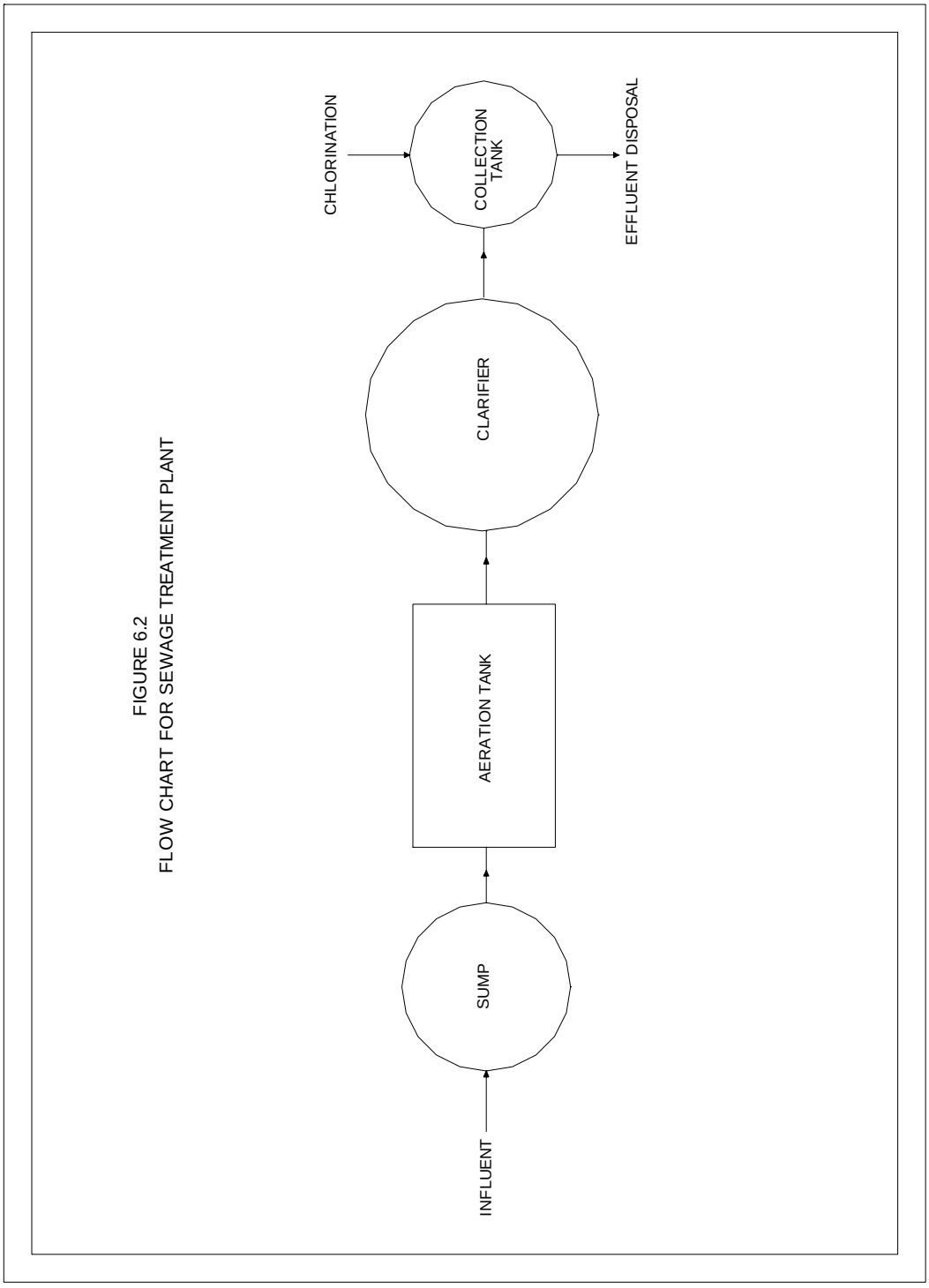


FIGURE 6.2
FLOW CHART FOR SEWAGE TREATMENT PLANT

6.4 EMP Reporting Arrangement and Institutional Strengthening

Supervision involves periodic checking to ascertain whether activities are going according to the plans. It provides necessary feedback for project management team to keep the program on schedule. The supervision and reporting process with respect to implementation status of mitigation measures during construction will initiate from the contractor at the lowest rung who will report to the Project Implementation Agency (PIA) through the project management consultant.

During construction phase of the project, the EMP implementation comprises of the following key activities:

- Implementing various mitigation and enhancement measures within the time frame recommended
- Overseeing the implementing various mitigation and enhancement measures and fine tuning/advocating more measures, if needed, depending on site conditions;
- Project level monitoring of key performance indicators to evaluate the implementation of EMP measures at the recommended intervals.
- Periodical reporting of status of EMP implementation and monitoring results and key performance indicators and
- Constant evaluation of EMP measures implemented based on the data available from project level monitoring and status reports and providing directions accordingly.

These activities to be carried out by various agencies that will be involved in the implementation of Metro project. It is also to be noted that all these activities will be carried out concurrently or at regular intervals and at different duration and location. This makes it pertinent that all agencies involved work within a predefine setup. The coordination model proposed during construction and operation phases is presented in **Figure 6.3** and **Figure 6.4** respectively. The identified agencies and their sphere of work are presented in following section.

Project Implementation Agency (PIA)

The responsibility of implementing environmental mitigation measures lies with the PIA. PIA in this project will be Mumbai Metropolitan Regional Development Authority (MMRDA). The responsibility also includes various tasks such as notifying various affected parties such as the resident and commercial establishment, facilitate the relocation of people, notify other utility departments such as telephone, water supply, sewerage etc. which used the road for providing public utility services.

FIGURE 6.3
INSTITUTIONAL MECHANISM FOR EMP IMPLEMENTATION
(CONSTRUCTION PHASE)

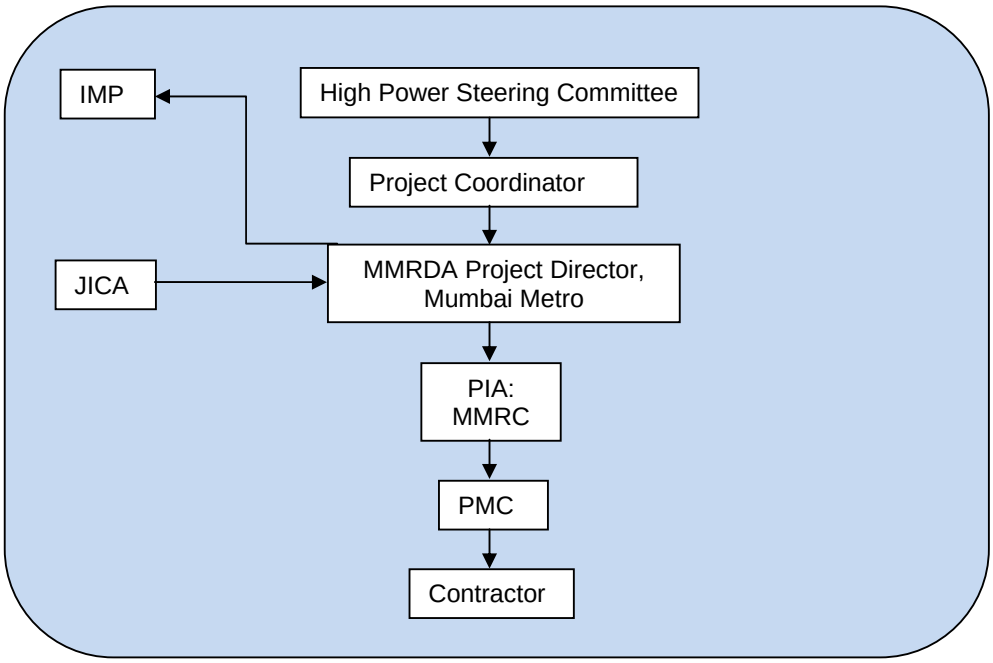
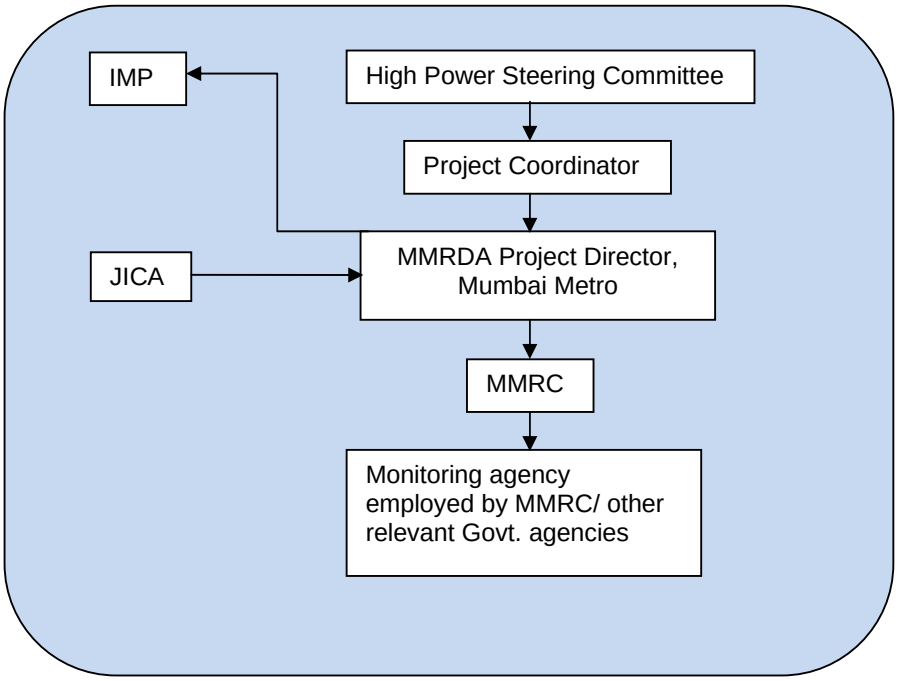


FIGURE 6.4
INSTITUTIONAL MECHANISM FOR EMP IMPLEMENTATION
(OPERATION PHASE)



Project Management Consultant (PMC)

The PIA will get the EMP implanted through the Project Management Consultant (PMC) appointed for managing engineering and construction related activity. The PIA will delivered the responsibility of overseen the implementation of as per the contract agreement. In order to effectively discharge the duties PMC will have an environmental officer/expert in the project management unit. The environmental officer will work for a full time basis at the site office. The officer must possess experience in the environmental management of metro projects.

Project Contractor

Project contractor will implement the EMP measures, enhancement measures and measures as directed by PIA and PMC. The responsibility to implement the EMP measures will be built in to the contractual agreement. The contractor shall submit a report on compliance of environmental mitigation measures periodically to the PMC. The PMC will review and approve the environmental compliance report (ECR) submitted by the contractor and forward the ECR to PIA after approval. The PIA will then submit the ECR to Joint Project Director (JPD), environment which after review and monitoring will submit to Independent Monitoring Panels through the Project Director, MMRC. The Project Director accordingly submits report to the JICA.

MMRDA

MMRDA as an apex organization shall initiate coordinate process among the concern organization for EMP implementation. MMRDA shall take lead in

- Reviewing the progress of the project for the subsequent year- institution wise
- Reviewing and discussing the salient features of the report in the year on environmental aspects and their violations
- Organizing and coordinating training programs for all member organization

Independent Monitoring Panel (IMP)

This has been constituted by MMRDA with the objective to ensure that the Banks policies: related to social and environmental issues are followed. The Chairman of IMP is Ex-Chief Secretary to Government of Maharashtra. The other members are eminent environmental engineers, a senior Journalist and a leading Advocate. The IMP will meet periodically to review the periodical reports, environmental compliance report etc. In addition to above JICA will monitored implementation of environmental management during and post construction.

6.5 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 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.

6.5.1 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 be aware of availability of repair equipments, materials, labour and expertise for use during emergency.

6.5.2 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, and
- Nearest medical facilities.

6.5.3 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.

6.5.4 Emergency Action Committee

To ensure coordinated action, an Emergency Action Committee should be constituted. MD MMRC will be the Chairman of this Committee. The committee may comprise of:

- Head of operations,
- Head of technical services,
- Head of security,
- Fire brigade,
- Police representatives, and
- NGO

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, and
- 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 mock 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.

6.6 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.

6.6.1 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.

6.6.2 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 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:

- Downstand 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, and

- In underground stations the ventilation system will be designed to extract smoke in the event of fire

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 earthen. For electrical fires, non-aqueous extinguishers like chemical dry powder 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 needs to be transported away from the site of the fire. In order to achieve this, 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,
- 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 Mumbai 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. Heat detector shall be installed at roof level, ceiling and floor cavity.

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/ 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 Mumbai 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 when the need arises. 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 is 1.0 m and maximum height should not exceed 60 cm.

6.6.3 Ventilation Shafts

The Environmental Control system for underground stations requires ventilation openings between various plants, plant rooms and the atmosphere. Shafts are required for exhaust air, fresh air intake and draft relief. Ventilation shafts will be provided at each station.

6.6.4 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.

6.7 SUMMARY OF ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The negative environmental impacts stemming out of the proposed project can be mitigated with simple set of measures, dealing with careful planning and designing of the metro alignment and structures. Adequate provision of environmental clauses in work contracts and efficient contract management will eliminate or reduce significantly all possible problems. A common problem encountered during implementation of environmental management plans of such projects is lack of environmental awareness among engineers and managers concerned with day to day construction activities, which can be solved through regular environmental training programs. A set of preliminary EMP is presented in **Table 6.10,** 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.

The major concern during the construction stage is that the contractors, due to lack of enforcement, would not practise good environmental sanitation (housekeeping), may intend to get unauthorized use of the easily available natural resources and other available infrastructure like roads and water resources. This would result in degradation of ambient air quality, water resources and land environment around the construction sites and workers camp. Improper management of earthwork activities would disrupt the natural drainage and increase soil erosion. Improper management may result in spillage of explosives into the hands of unsocial elements. Finally the implementation of the mitigation actions requires that the project implementation unit would record an end-of-construction mitigation checklist, before releasing the final payment of any work contract.

In addition to that MMRDA, should prepare and establish Environmental and Health Policy and Procedures and that should become an integral part of contract document.

Operational phase mitigation would involve good environmental sanitation (housekeeping) practice at metro establishments including effective solid waste collection

and disposal, wastewater disposal, upbringing of plantations and green area. During the operation period, the metro operating unit will be required to confirm receipt of the construction period mitigation report through the PIU and prepare and follow on timetable of actions.

TABLE 6.10
ENVIRONMENTAL MANAGEMENT ACTION PLAN (EMP)

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 minimise the land disturbance to avoid archaeological sites, temples and other environmentally sensitive areas.	During Design	DPR and design consultant	PIU
Cultural Heritage	Avoided by adjustment of alignment.	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 for construction purpose etc., shall be planned and arranged from Municipal water supply/Ground water.	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 avoid 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

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
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
Noise	Workers in vicinity of strong noise will wear earplugs and their working time should be limited as a safety measure. Noise barriers (Stone walls or plantation) for silence zones including schools and hospitals. The use of automation construction techniques.	Beginning and through construction	Contractor	PIU/EMP implementing agency
Vibration	The detailed vibration investigation will be required prior to construction. Awareness about vibration impact to the public residing near to the alignment, if required.	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 rivers and other water bodies.	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
Sewage disposal during construction at Service Centres	A minimum distance of any sewage or toilet facility from water sources should be 200 metres	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 tank and sanitation facilities. Waste in septic tanks will be cleared periodically. Drinking water will meet Indian National Standards. Garbage will be collected in a tank and disposed of daily. 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	During	Contractor	PIU/EMP

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
	licensed quarries only. Soil parameters of the dumping site should be monitored.	construction		implementing agency
FLORA AND FAUNA				
Loss of trees and Plantation	Two times trees will be planted against every tree cut as per norms. Plantation of trees as per Maharashtra (Urban Areas) Protection and Preservation of Trees Act 1975. More importance should be given for transplantation of tree rather than cut.	During construction and after completion of construction activities.	PIU through Contractor	PIU /EMP Implementation Agency
SOCIAL				
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	During construction At start-up Throughout construction	Contractor	PIU/EMP implementing agency
Location of camp and storage areas	Location of camps 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

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
WATER				
Oil pollution	Suitable treatment shall be taken for treatment of oil in depot areas before discharging the wastewater.	During operation of the treatment plant	PIU/EMP implementing agency	PIU/EMP implementing agency
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

Appendix 6.1

Permission letter for removal of trees

Address of the office of the applicant
No.
Date :

To,
The Tree Authority
Municipal Corporation of Greater Mumbai,
Office of the Supdt. of Gardens/Tree Officers,
Veermata Jijabai Bhosale Udyan,
Dr. Ambedkar Road, Byculla(East),
Mumbai-400 027.

Sub : Request for grant of permission for removal of trees coming in the proposed construction of _____ at _____

I, the undersigned, Shri/Smt./Kum._____ as required under section 8 of the Maharashtra (Urban Areas) Protection & Preservation of Trees Act 1975, as modified upto 9th June 2004, submit herewith the details of all the existing trees on the plot alongwith the trees required to be removed with due reasons thereon. The same is duly certified by a qualified Horticulturist and the certificate of the same is attached herewith/duly certified by the Horticultural Assistant of the ward.

Alongwith this application, I am also submitting the following.

1) Detail address of the site with landmark.
2) One copy of complete set of plans, drawings etc. of the proposed construction, approved by the Competent Authority and duly certified by the concerned architect / concerned authority as true copy.
3) Three copies of ground floor plan of proposed construction in case of building, approved by the Competent Authority and duly certified by the concerned authority as true copy. On this plan, all the existing trees are marked correctly as per their location at site and numbered serially. Similarly, out of the existing trees, trees proposed to be removed are marked in red colour, to be retained in green colour. Similarly the trees proposed to be newly planted are marked in yellow colour.
4) Three copies of lay out/block plan of proposed construction, approved by the Competent Authority and duly certified by the concerned authority as true copy. On this plan, all the existing trees are marked correctly as per their location at site and numbered serially. Similarly, out of the existing trees, trees proposed to be removed are marked in red colour, to be retained in green colour. Similarly, the trees proposed to be newly planted are marked in yellow colour. Similarly, marked all actual alignment of the works on the plan in different colours such as existing road line, proposed widening of the road, bridges, service road line, footpath, storm water drain etc. and also demarcated at site.

.. 2 ..

5) The copy of the plan certified by C.F.O. alongwith a copy of letter from him as requirement for removal of trees in the case of building.

6) All existing trees on the plot/site are numerically & serially numbered at site with black and white enamel paint.

The details of existing trees along with proposed requirement is as follows:

Sr.No. of the tree	Kind / Species of the tree	Whether to be removed or retained	Detail reason for removal or retention

The requisite no. of trees will be planted as per the norms of Tree Authority i.e. in open space 2 trees per 100 sq.mtr. and in R.G.Area 5 trees per 100 sq.mtr. and care will be taken for proper growth of the trees and will give report to the Tree Officer about the condition of the trees once in six months for a period of 3 years.

I/We will not cut/transplant the trees for which the permission is granted by the Tree Authority until 15 days after permission is given to fell a tree and will plant two (2) new trees in lieu of one tree permitted to fell within 30 days from the date of tree/trees is/are felled and immediately report the same. A report regarding their proper growth and condition will be submitted once in six months for a period of three (3) years.

I hereby agree to pay requisite process fee for processing the proposal and necessary deposit. (This applies to the applicant other than Municipal Corporation of Greater Mumbai)

Tree Authority is requested to grant the permission for removal of trees as mentioned above at the earliest.

Thanking you,

Yours faithfully,

Full Name of the Applicant

_____

Seal / Rubber Stamp

Appendix 6.2

Format Letter for NOC (Mumbai Heritage Conservation Committee)

FORMAT OF SUBMISSIONS FOR MHCC NOC

(To be submitted by the Applicant in A3/A4 size spiral bind report – A copy to be circulated to ea member for comments).

A ON THE COVER PAGE (To be filled in by the Secretarial Staff or the applicant):

1)	Name of the Structure	:	
2)	Sr.No. of Listing	:	
3)	Grade / name of Precinct and criteria for grading / listing	:	
4)	Name of the Applicant, Architect & Structural Engineer	:	
	Proposal for: i) Restoration ii)Skillful repairs & maintenance iii) Additions & alterations and extensions. iv) Development & Reconstruction. v) Change of user vi) Interior work v) Any other not covered by above.	:	
6)	Checklist of drawings a) complete..... b) Incomplete ..... (to be attested by MHCC secretarial staff)	:	
7)	Submitted on (dt.)	:	
8)	Revision	:	
9)	Whether the proposal was considered by M.H.C.C. earlier & if yes details thereof.	:	

B. DETAILS OF THE PROPOSAL (To be submitted by the applicant):

i)	TEXT
1	Brief description of the structure (physical attributes, architectural features and style, if any)
2	Identify the cultural significance for which it is listed (if its known or else copy the criteria /classification from listing)
3	Photomontage; of immediate surrounding area, the building (facades of all sides), interiors, and overall view from adjoining property or across the road . Archival snaps and Google Earth aerial snap :– Furnish whatever is applicable & appropriate.
4	Clear Description of intervention being done (as specified in A5)
5	Architects appointment letter or Clients letter authorising the architect to represent on his behalf to MHCC.

ii)	DRAWINGS (for all categories of proposals) : Plans , elevations , sections etc. showing clearly the entire scope of proposal.
	FOR REPAIRS / RESTORATION / STRENGTHENING :
i	Location plan: With surrounding buildings, street nodes etc. and the site/bldg./structure in question with an appropriate scale.
ii	Block plan Details of site with its immediate surroundings + location of trees at site.
iii	Floor plans With interventions and specifications marked on it.
iv	Roof plan (tiled roof, water tank, flat terraces etc. all shown)
v	Sections. With interventions and specifications marked on it (essential if major

	interventions are required)
vi	Elevations : With interventions and specifications marked on it
vii	Structural strengthening details alongwith drawings and typical calculation (If major interventions are envisaged)

NOTE : In respect of iii) to vii) please specify the present condition or distress and the details of proposed repairs/ reconstruction /renovation in the same plan (of the set of plans). However, as it is advisable to give clarity to the proposal, indicate the distress in one plan and the proposed repairs/renovation/reconstruction in another plan. Submit a set of plans showing all the facades of the structure or structures, if they are more than one.

	FOR EXTENSION / RECONSTRUCTION / DEVELOPMENT :
i	Detailed Elevation (in different ink) with adjoining buildings shown highlighting height, mass, volume and architectural details in another ink.
ii	Axonometric view and site or block model if so desired.
iii	Details of interventions & specifications shown in drawings.
iv	All strengthening & Structural drawings with typical calculations.

C.	ADDITIONAL DOCUMENTS :
i	Copy of D.P. Remark
ii	Copy of NOC / Remarks from Traffic & Coordination Dept.
iii	Copy of NOC from MHADA / Repairs Board /.....
iv	List of concessions in DCR; sought from the MHCC (eg. Open space concession etc.).
v.	Copy of Lease Agreement / Govt. Covenant / Collectors NOC
vi.	Any other_____

D.	FOR SEEKING NOC FOR THE COMPLETED WORK :
i	Copy of previous approval / NOC from the MHCC.
ii	Copy of IOD / C.C..
iii	Set of drawings showing the plans as constructed at site alongside the plans previously approved (if there are any deviations / modifications)
iv	List of deviations / modifications carried out other than the plans approved by the MHCC
v.	Photographs of the completed work.

Dy. M.A. (D.P.)

Appendix-6.3

DETAILS OF ABANDONED QUARRY SITES IN RAIGAD AND THANE DISTRICT

RAIGAD DISTRICT						
Sr. No	**Taluka**	**Village name**	**Name of quarry**	**Sector number**	**Area (ha)**	**Remarks**
1	Mangaon	Indapur	PWD mine	277	6	
2	Mangaon	Tilore	PWD mine	98c	13	
3	Mangaon	Tilore	PWD mine	98b	10	
4	Mangaon	Potnare	PWD mine	248	3	
5	Mangaon	Makdi	PWD mine	168	6	
6	Mangaon	Koshumbal	PWD mine	189	20	
7	Mangaon	Tale	PWD mine	93	30	
8	Mangaon	Ratwad	PWD mine	42	9	
9	Mangaon	Ratwad	PWD mine	88	7	
10	Mangaon	Ratwad	PWD mine	423	4	
11	Mangaon	Bhuvan	PWD mine	198	13	
12	Mangaon	Bhuvan	PWD mine	205	13	
13	Mangaon	Bhuvan	PWD mine	324	14	
14	Mangaon	Niraj	PWD mine	455	17	
15	Mangaon	Niraj	PWD mine	456	18	
16	Mangaon	Vavediwali	PWD mine	97	42	
17	Mangaon	Vavediwali	PWD mine	117	13	
18	Mangaon	Repoli	PWD mine	301	9	
19	Mangaon	Repoli	PWD mine	137	13	
20	Mangaon	Repoli	PWD mine	117	12	
21	Mangaon	Repoli	PWD mine	112	13	
22	Mangaon	Garol	PWD mine	63b	25	
23	Mangaon	Kalmage	PWD mine	70a	32	
24	Mangaon	Vinchvali	PWD mine	140	4	
25	Mangaon	Khanpale	PWD mine	426	4	
26	Mangaon	Khanpale	PWD mine	429	15	
27	Panvel	Bhokarpada	Stone mine	18	15	
28	Panvel	Bhokarpada	Stone mine	121	10	
29	Panvel	Barvai	Stone mine	76	9	Entrance road not existing
30	Panvel	Barvai	Stone mine	94	5	Entrance road not existing
31	Panvel	Barvai	Stone mine	132	49	Entrance road not existing
32	Panvel	Barvai	Stone mine	133	6	Water line crossing
33	Panvel	Khanavale	Stone mine	7	9	
34	Panvel	Khanavale	Stone mine	10	13	
35	Panvel	Khanavale	Stone mine	135	9	Entrance road not existing
36	Panvel	Khanavale	Stone mine	143	8	Entrance road not existing
				Total	**498**	

THANE DISTRICT					
Sr. No	Taluka	Village name	Name of quarry	Sector number	Area (ha)
1	Bhiwandi	Kaneri	Stone mine	58	9
2	Bhiwandi	Kaneri	Stone mine	26	7
3	Bhiwandi	Vehale	Stone mine	40	1.9
4	Bhiwandi	Aamne	Stone mine	90	3
5	Thane	Kutal	Stone mine	19	7
6	Thane	Turbhe	Stone mine	376	2.6
7	Thane	Turbhe	Stone mine	387	12.15
8	Kalyan	Kachore	Stone mine	30	1.3
9	Vasai	Bhatpada	Stone mine	26	2
10	Vasai	Doleve	Stone mine	132	2
11	Vasai	Poman	Stone mine	218	10.49
12	Vasai	Valeev	Stone mine	33	6.49
13	Vasai	Kherpada	Stone mine	26	1.9
14	Vasai	Mandve	Stone mine	55	3.1
15	Borivali	Borivali	Murum	76	16.5
16	Thane	Turbhe	Murum	387	12
17	Thane	Turbhe / Bhonsari	Murum	203	506
18	Thane	Pawne	Murum	163	135
19	Thane	Pawne	Murum	378	22
20	Thane	Shirawne	Murum	323	64
21	Thane	Kukshet	Murum	183	117
22	Vasai	Dhaneve	Murum	51	4
23	Vasai	Virar	Murum	375	4
24	Vasai	Sirangaon	Murum	352	1.9
25	Vasai	Bilalpada	Murum	132	5
26	Vasai	Shirgaon	Murum	351	3
27	Vasai	Nagale	Murum	62	2
28	Vasai	Dhaneve	Murum	51	1
29	Vasai	Chandansar	Murum	86	2.17
30	Vasai	Depivali	Murum	83	1.95
31	Vasai	Valeem	Murum	26	6
32	Bhiwandi	Dhapode	Murum	115	2
33	Bhiwandi	Lonad	Murum	101	2
34	Bhiwandi	Talivali	Murum	110	2
35	Bhiwandi	Vashere	Murum	60	4
36	Bhiwandi	Taveli	Murum	110/101	11.6
37	Bhiwandi	Taveli	Murum	99	10
38	Bhiwandi	Pise	Murum	90	6
39	Bhiwandi	Paye	Murum	133	2
40	Bhiwandi	Vashere	Murum	27	24
41	Bhiwandi	Samvad	Murum	86	2

42	Bhiwandi	Vashere	Murum	60	2
43	Bhiwandi	Amne	Murum	105	2
44	Bhiwandi	Amne	Murum	102	2
45	Bhiwandi	Amne	Murum	90	2
46	Bhiwandi	Amne	Murum	91	2
47	Bhiwandi	Lonad	Murum	139	2
48	Bhiwandi	Lakhiwadi	Murum	82	3
49	Bhiwandi	Lakhiwadi	Murum	88	3
50	Bhiwandi	Lakhiwadi	Murum	87	3
51	Bhiwandi	Talavli	Murum	105	3
52	Kalyan	Kaba	Murum	59	2.21
53	Kalyan	Kaba	Murum	85	2
54	Kalyan	Kaba	Murum	57	4
55	Kalyan	Dambool Mooheli	Murum	34	2
56	Kalyan	Kaba	Murum	95	1
57	Mokada	Kachole	Murum	162	32
58	Palghad	Virathambu	Murum	102	1
59	Palghad	Mande	Murum	335	8
					1115.26

CHAPTER-7
PUBLIC CONSULTATION

7.1 INTRODUCTION

"Public Consultation" refers to the process by which the concerns of local affected persons and others who have plausible stake in the environmental impacts of the project or activity are ascertained with a view to taking into account all the material concerns in the project or activity design as appropriate. Consultation is used as a tool to inform stakeholders about the proposed action both before and after the development decisions are made. It assists in identification of the problems associated with the project. Initial Public consultation has been carried out in the project areas with the objectives of minimizing probable adverse impacts of the project and to achieve speedy implementation of the project through bringing in awareness among the community about the benefits of the project.

7.2 METHODS & APPROACH FOR CONSULTATION

Public consultation was accomplished to collect the opinion/views of the stakeholders for the construction of the project. Open discussion was held by conducting one to one meeting at project level and district level by disseminating the information by circulating the project summary/ discussing the issue on the desk. At pre-scheduled date and venue, people were communicated to gather for stakeholder consultation. Gathering was explained about the project activities and their consequences in brief. Copy of project summary was also distributed among the stakeholders. Queries of the stakeholder were replied by the environmental expert and at the same time their suggestions were also endorsed. It was held at the doorstep of the people or at a common place of people's gathering. In one to one meeting, people expressed open view and asked openly to understand the project while in gathering combined opinion of the people was collected.

7.3 CONSULTATION AT PROJECT LEVEL

The consultations were conducted during the reconnaissance/ field visit during second and third week of January 2012 and based on informal unstructured interviews and focus group discussion. The objective of the consultation was to disseminate the project information and ascertain stakeholder's views on probable environmental and social impacts that may arise due to the implementation of the proposed project. Public were intimated about the consultation venue, date and time. The venues, date and time of the public consultations are presented in **Table 7.1**. RITES experts with MMRDA officials explained about need of the project describing social and environmental issues like land acquisition, anticipated positive & negative impacts and use of techniques during construction and time frame of construction period during public consultation. About 93 people from different community participated for public consultation at project level. Of the total participants, 5 persons at Girgaon, 9 at Dharavi and 12 persons at Santacruz had raised the questions related to environmental issues.

The following issues were discussed during the consultations**.**

- Overall need of the project;
- Project location;
- Environmental concerns; and
- Social concerns.

TABLE 7.1
PROJECT LEVEL PUBLIC CONSULTATION VENUE

S.No.	Venue of the Public Consultation	No. Of Participant	Time and Venue
1	Girgaon	14	14:30 PM, 13th Jan 2012
2	Dharavi	34	13:30 PM, 16th Jan 2012
3	Dori Nagar, Santacruze	45	14:00 PM, 17th Jan 2012
4	Dori Nagar, Santacruze		16:00 PM, 17th Jan 2012

- Overall need of the project;
- Project location;
- Environmental concerns; and
- Social concerns.

The photographs showing stakeholders participation at public consultation held at various places are shown in **Figure 7.1**.

FIGURE 7.1
PHOTOGRAPHS OF PUBLIC CONSULTATION AT PROJECT LEVEL

7.4 ISSUES, SUGGESTIONS AND MITIGATION MEASURES

Issues raised by the stakeholders with their valuable suggestions were noted down for consideration into the report which is depicted at **Appendix 7.1**. **Table 7.2** depicts the stakeholders' consultation at project level in which some of the important issues raised by stakeholders and their suggestions have been incorporated. The suggestive mitigation measures are taken in detail in the last column of the table.

TABLE 7.2
PROJECT LEVEL STAKEHOLDERS' CONSULTATION

ISSUES RAISED	SUGGESTIONS OF STAKEHOLDERS	MITIGATION MEASURES
Muck Transportation	Compact engineering solution through traffic management, monitoring of air, noise and vibration and safety precautions.	Traffic regulatory measures would be developed during construction. Contractor in consultation with local government will prepare traffic management plan for the construction period. Water, air, noise monitoring will be conducted as per schedule. Vibration Monitoring during construction & Operation.
Air & Noise pollution	Pollution due to air and noise during the construction and insisted for regular air monitoring.	Latest technology will be adopted to minimize pollution during construction. Air & noise monitoring will be conducted regularly as per schedule.
Tree removal	Transplantation and some new trees should be afforested.	Cutting of trees will be minimized wherever possible. Compensatory afforestation will be done by transplanting & planting trees.
Work Schedule	Work should be carried out in systematic manner and working hours should be up to 6 pm.	Work will be carried out in systematic manner and the working hours would be up to 6 pm.
Employment	Job preference should be given to the local people.	As per policy contractors will give preference to affected PAFs.
Muck Disposal	Muck should be disposed at safer site.	Muck will be disposed at identified site & systematic manner. It will be reclaimed immediately after the project completion
Construction Depot	It should be kept away from the habitation zone.	Depot has been planned at Aarey Milk colony area which is well away from the habitation. All necessary pollution measures will be adopted at depot.
Labour Camp	Provide adequate sanitation facilities and safe drinking water at labour camps	Adequate sanitation facilities and safe drinking water will be provided at labour camps.

7.5 CONSULTATION AT CITY LEVEL

Consultation meeting was organized with officers of concerned government department and non-government organizations (NGO) of district vide newspaper Notification dated 5th April 2012. The public hearing notification is enclosed at **Appendix 7.2**. A public hearing for concerned stakeholders of the project were organized on 11th April 2012 the details given in **Table 7.3**.

TABLE 7.3
PUBLIC HEARING NOTICE

Date	Time	Venue
11thApril, 2012	10.00 am - 1.00 pm	Insurance Institute of India (college of Insurance), 'G'block, Plot no.C-46, Bandra-Kurla Complex, Bandra(E) Mumbai-400051

Suggestions / objections from concerned stakeholders were invited for Environmental Impact and Social Impact due to proposed project. Public hearing was attended by 200 stakeholders and about 27 stakeholders raised their objection with suggestions. Details of some objection/ suggestions raised by stakeholders relevant to environment are summarized in **Table 7.4**. The photographs of the City level public consultation are given in **Figure 7.2**.

TABLE 7.4
CITY LEVEL STAKEHOLDERS' CONSULTATION

ISSUES RAISED	SUGGESTION/OBJECTION OF STAKEHOLDERS	MMRC REMARK
Metro Rail Alignment	Metro line 3 to be combined with Metro line 2 and One depot location can be saved. A letter addressed to the then C.S., GoM, Shri Johnny Joseph by Mr/ Shrideran, MD, DMRC was also discussed regarding Charkop-Bandra-Colaba corridor and MMRDA later changed as Charkop-Bandra-Mankhurd corridor.	PPP contract has been awarded for Metro Line 2 (Charkop – Bandra – Mankhurd). Merging with Line 3 is not possible at this stage. Area required for a combined depot will be much greater than the space available at any one site. Combined depot will not be feasible for Metro Train operation of Line-2 and Line-3.

Muck Disposal	Aarey Milk Colony should be taken up very strongly. MMRC has a responsibility for mass public transport; it has also responsibility towards environment. How to dispose of the muck coming out of excavation? Where will it be dumped? Mumbai affected by seismic fault line and how you will evacuate passengers?	MMRC is working on several options for muck disposal. Due care will be taken with regards to environmental impact. Designs will account for Mumbai's seismic zone. Disaster and evacuation plans will be as per Indian standards.
Safety Measures	Expressed doubt regarding completion year 2019 in light of VAG corridor Line 1 experience. How much will be the fare? What are the minimum and the maximum? The area from where the line 3 will go through is a very highly congested area. We have to take great caution because of the underground cables, pipelines, etc.	Based on experience of Line 1 and other underground metros in India MMRC will device a construction plan including comprehensive utility diversion to complete project within given time frame. MMRC is in the process for fare fixation for line 3.
Underground Utilities & DMP	MMRC to take utmost care for underground utilities Disaster Plan and Evacuation Plan etc. to be prepared.	MMRC will device a comprehensive utility diversion plan. Disaster and evacuation plans will be as per Indian standards
Duplication of Metro Line 2 & 3	Difficult to understand the logic of having 2 parallel lines. (Metro Line 2 & 3).	Line 2 and 3 are serving different areas and there is no duplication.
Cost/Km	Enquired about cost per k.m. of underground metro.	Approximate cost of u/g metro is Rs 600 cr / km
Connectivity	Enquired about people living in Ballard Estate, Colaba, Gateway of India to access metro station. How will you connect this metro line with the main line?	CST station, Churchgate, Cuffe Parade Station and Hutatma Chowk stations serve these areas. Metro stations will be integrated with suburban stations at interchange points with main lines.
DMP, evacuation plan, seismic zone	1. High cost of underground metro 2. Suburban train overcrowded , 44% walk trips and 3.1% cars 3. Enquired about technical details of metro line 3	Technical details and DPR is available for review at MMRC office. Tunnelling by TBM, station s by either cut and cover or

	4. DPR not available 5. Method of construction 6. Disaster Management Plan, Evacuation Plan etc. 7. Mumbai affected by seismic zone 8. Commuter dispersal at stations 9. Encouraged BRTS due to less cost and less time for construction. 10. Metro projects are very costly & time consuming	NATM. MMRC will device a comprehensive utility diversion plan. Disaster and evacuation plans will be as per Indian standards MMRC will take due care during detailed design stage Since ridership is in excess of BRTS capacity metro is required to satisfy demand.
Fire Safety	Indian Institute of Shipping are involved in fire safety and can guide MMRC, if associated. How to minimise construction cost?	MMRC will consider the proposal.
Station Location	There are 2 stations. It is going through Marol slum. Why these stations are so close? Why it should go through the slum?	Marol naka station is an interchange station with Line 1. 3 stations have been proposed in Airport as per their requirement.
Metro Corridor	Whether Metro alignment is underground or elevated.	Proposed Metro line-3 is fully U/G

FIGURE 7.2
PHOTOGRAPHS OF STAKEHOLDERS' CONSULTATION AT CITY LEVEL

Appendix 7.1

Project Level Public Consultation

PUBLIC CONSULTATION

NAME OF THE PROJECT : EIA STUDY FOR MUMBAI METRO FROM COLABA TO SEEPZ

	LOCATION	DATE	STAKEHOLDERS	ISSUES DISCUSSED	SUGGESTION BY STAKEHOLDERS	SIGNATURE
① Girgaon Girgaon Elata Co-op Hsg Ltd	Girgaon	13/1/2012	Pramod Purv (Hon. Chairman)	During construction, muck generation would be benificial 1. Traffic congestion 2. Increase in pollution 3. Vibration during con & operation. 4. Risk of seepage of underground water	Compact engineering solution 1. Traffic management during construction 2. Monitoring for air, noise and vibrations etc 3. Safety precautions etc.	13/1/12 9819672720 7303701085
② Girgaon Co-op Hsg Ltd	Girgaon	13/1/2012	Hemant Sagvekar (Hon. Secretary)	1. Tree cutting 2. Mangrove should not be disturbed 3. Mumbai is formed after joining seven islands	Tree should be transplanted and some more trees should be afforested. Precaution during tunneling should be considered.	13/1/2012 9869475757

PUBLIC CONSULTATION

NAME OF THE PROJECT : EIA STUDY FOR MUMBAI METRO FROM COLABA TO SEEPZ

	LOCATION	DATE	STAKEHOLDERS	ISSUES DISCUSSED	SUGGESTION BY STAKEHOLDERS	SIGNATURE
③	Girgaon	13/1/2012	Gaurav Sagvekar (Jt Secretary)	Work in daytime The muck disposal. Dust problem	Water sprinkling Air monitoring	13/1/12 G.S. Sagvekar 9820473721
④	Girgaon	13/1/2012	Shantilal Gada	Progress of work should be in systematic manner	No haphazard work proper safety precautions	Gada Retd C.E., P.W.D. 9967657959
5.	Girgaon	13/1/2012	Ajit Khot	Employment to local people job during operation of metro No cultural conflicts.	First preference should be given to local	13/1/2012 9870077427

PUBLIC CONSULTATION (लोक सुनवाई) at SANTACRUZ was held to discuss environmental and social issues on 17.01.2012 (Tuesday) following were present. Issues discussed and suggestion suggested by stakeholders are given at format attached

Sl No.	Name/Plan	Signature
1.	Basant Dude (9969540856 / 26689153)	17/01/012
2.	Ravindra Lad	
3.	Fatima D'souza	
4.	B.N. Rewool	
5.	Surekha Gaikwad	S.G. Rane
6.	D.M. Kulkarni	D.M.K.
7.	VIJAY. D. Parab	Parab
8.	Sushil Kumar	
9.	Gopi Gupta	
10.	Shanmugam A. Lad	
11.	[illegible]	
12.	[illegible]	
13.	[illegible]	
14.	[illegible]	
15.	[illegible]	
16.	MAHANGIRAL KAMOJI	

Sl no	Name / Phone no	Signature
		[illegible]
17.	MARACHI DEVI	Paivrabay
18.	मनोज म. चांदोरकर	म. चांदोरकर
19.	तुकाराम दा. ठाकुर	तु.दा.ठाकुर
20.	बाळाजी सरनोबत	बा. सरनोबत
21.	अनिल कुमार कनौजिया	अनिल
22.	अनवर अलि खान	अनवर
23.	Paramchha Crowjha	Paramasha
24.	सौ. सुनंदा सुरेश नार्वेकर	सौ. सु. सु. ना.
25.	रेखा रवि मोकल	रेखा मोकले
26	अपर्णा अशोक राणे	अपर्णा
27	श्री. भरत मो. खाडेकर	[illegible]
28.	जितेन्द्र मोरे	Jmore
29.	शकुंतला का. पाटील	शकुंतला.

PUBLIC CONSULTATION

NAME OF THE PROJECT : EIA STUDY FOR MUMBAI METRO FROM COLABA TO SEEPZ

LOCATION	DATE	STAKEHOLDERS	ISSUES DISCUSSED	SUGGESTION BY STAKEHOLDERS	SIGNATURE
Santacruz	17.01.12	Basant Dude Anil Kr Chauhan	Santacruz station at silted ground. & filling done by inhabitants without compaction	Waterlogged area may have own problem during construction of tunnel and station, Precautionary measures: Soil investigation. Ground water study. Sound proof design Safety measures during construction & operation.	
			Muck/Debris	No littering allowed.	
			Labour Camp	Adequate sanitation facilities & safe drinking water	

PUBLIC CONSULTATION

NAME OF THE PROJECT : EIA STUDY FOR MUMBAI METRO FROM COLABA TO SEEPZ

LOCATION	DATE	STAKEHOLDERS	ISSUES DISCUSSED	SUGGESTION BY STAKEHOLDERS	SIGNATURE
Darni Nagar Santa Cruz.	17.01.12	List enclosed.	Air Noise Excavation Soil –	Should be monitored as per parameter It should be within limit during const. & operation. Muddy land before 1966 like creek. 15 ft filling. Filled by only debris, not a compact filling. Debris also used.	Signature in enclosed sheet
			Muck.	It should dumped at identified location or where it is required,	
			Green Belt Development	Beautification of rail corridor.	
			Safety Measure	During Construction & operation safety should be maintained.	

PUBLIC CONSULTATION

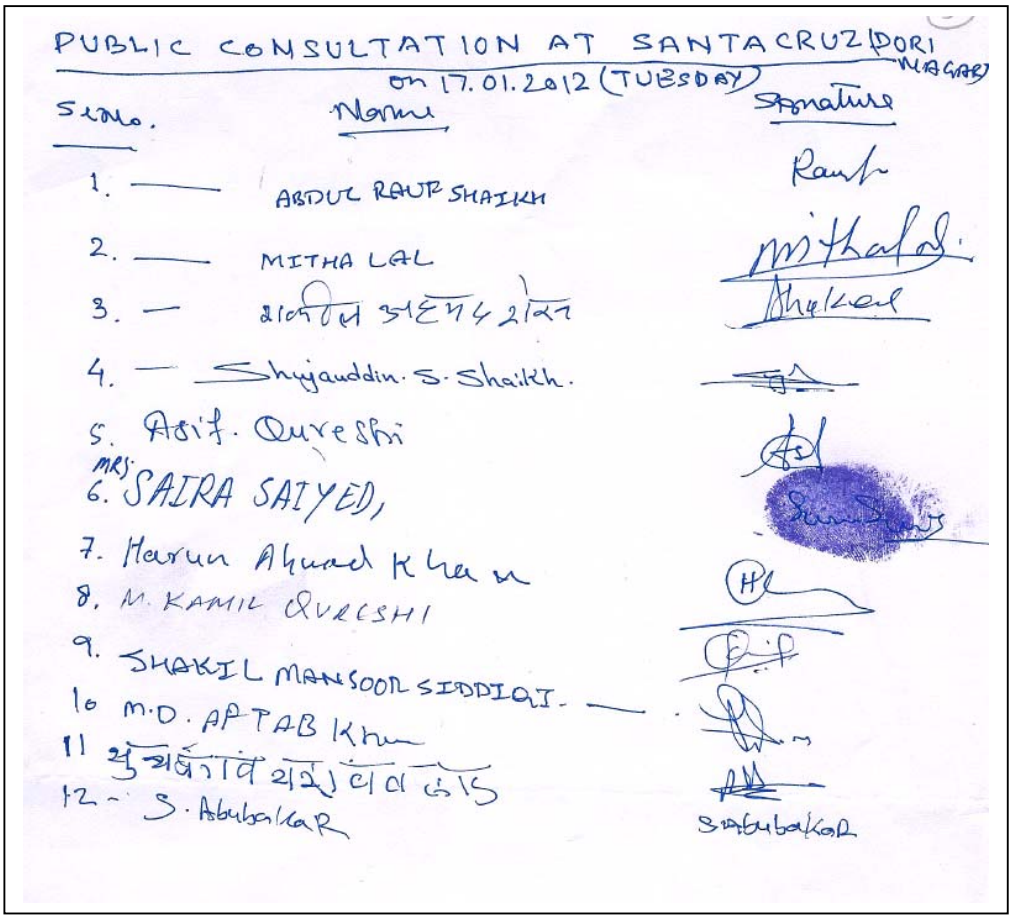
NAME OF THE PROJECT : EIA STUDY FOR MUMBAI METRO FROM COLABA TO SEEPZ

LOCATION	DATE	STAKEHOLDERS	ISSUES DISCUSSED	SUGGESTION BY STAKEHOLDERS	SIGNATURE
Santacruz	17.01.12	List enclosed	Training to workers and staff	As per requirement training prior to deployment needs.	
			Shaking of ground	Shaking of ground during tunnel if should be controlled to have minimal impact to nearby structures & Habitat found during construction & operation. Monitory needs.	
			Air & Noise	to be maintained as per standard.	
			SWM	Disposed at identified MCGM dumping site.	
			Drinking water	Treated MCGM water supply.	

PUBLIC CONSULTATION

NAME OF THE PROJECT : EIA STUDY FOR MUMBAI METRO FROM COLABA TO SEEPZ

LOCATION	DATE	STAKEHOLDERS	ISSUES DISCUSSED	SUGGESTION BY STAKEHOLDERS	SIGNATURE
Dorsi Nagar Santa Cruz.	17.01.12	List of stakeholder attended enclosed.		Local employment to be given opportunity in metro.	Signature in enclosed sheet



PUBLIC CONSULTATION AT SANTACRUZ DORI NAGAR
on 17.01.2012 (TUESDAY)

Sl.No.	Name	Signature
1.	ABDUL RAUF SHAIKH	
2.	MITHA LAL	
3.	[illegible]	
4.	Shujauddin. S. Shaikh.	
5.	Asif. Qureshi	
6.	MRS. SAIRA SAIYED,	
7.	Harun Ahmad Khan	
8.	M. KAMIL QURESHI	
9.	SHAKIL MANSOOR SIDDIQI.	
10	M.D. AFTAB Khan	
11	[illegible]	
12	S. Abubakar	S. Abubakar

1) M.P. Manpal, DGM/VE RITES.
Dr Sanjay Pradhan AM/VE/RITES.

PUBLIC CONSULTATION

NAME OF THE PROJECT : EIA STUDY FOR MUMBAI METRO FROM COLABA TO SEEPZ

LOCATION	DATE	STAKEHOLDERS	ISSUES DISCUSSED	SUGGESTION BY STAKEHOLDERS	SIGNATURE
Dharavi	16/1/2012	M. Shakeel. S Khan	Already congested area	1. Traffic management 2. Water sprinkling	[signatures] 16/01/2012
			Crossing through Mangrove areas	Should be protected being the tunnel below its root.	
			Tunnel below some below ground level	During construction effect of tunneling should be seen.	
Dharavi	16/1/12	Abid Ali Peer. MD. Gausuddin. C.B Anjuman Rehman	Air and Noise	It should be monitored during construction and operation.	[signatures]
			Tree	Although tree would not be affected, where affected, tree afforestation should be done.	

M. B. Mandal, RITES.
Dr S Pradhan, RITES.

PUBLIC CONSULTATION

NAME OF THE PROJECT : EIA STUDY FOR MUMBAI METRO FROM COLABA TO SEEPZ

LOCATION	DATE	STAKEHOLDERS	ISSUES DISCUSSED	SUGGESTION BY STAKEHOLDERS	SIGNATURE
Dharavi	16/1/2012	[illegible] [illegible]	Foundation	To be below ground level. It should be taken care at Dharavi and	[illegible] [illegible]
		Allama [illegible]		other places. MCGM & MMRDA should provide all foundation details	[illegible]
				along the metro alignment to contractor.	
				[illegible] 16/1/2012	

Appendix 7.2

Notice for City Level Public Hearing

5th April 2012.
TOI

S BY BIDS THE TIMES

Mumbai Metro Rail Corporation Limited

MMRDA Building, Bandra Kurla Complex, Bandra (East), Mumbai– 400 051
Phone: +91-022-2659 4000, Fax: +91-022-2659 4182,
e-mail: **mmrcltd2010@gmail.com; web: http://www.mmrdamumbai.org**

NOTICE FOR PUBLIC HEARING

IMPLEMENTATION OF MUMBAI METRO LINE-3 (COLABA-BANDRA-SEEPZ)

Ref: Mumbai Metro Rail Corporation public notification dt. 12th Dec 2011 in Hindustan Times, Navbharat and Lokmat

1. Government of Maharashtra has decided to implement Mumbai Metro Line 3; Colaba - Bandra - SEEPZ (fully underground) project through Mumbai Metro Rail Corporation (MMRC). Vide above referred notification, suggestions / objections for Social and Environmental Impact of the project were invited.
2. In this regard a public hearing for concerned stakeholders of the project is proposed to be organised as per details given below.

Date	Time	Venue
11thApril, 2012	**10.00 am - 1.00 pm**	**Insurance Institute of India (college of Insurance) `G' Block, Plot No. C-46, Bandra-Kurla Complex, Bandra (E), Mumbai- 400051**

3. Interested Stakeholders are invited to attend the public hearing and submit their written and /or oral suggestions / objections.

For further details contact Shri R. Ramana, Additional Chief (Transport Planning), Transportation and Communications Division at above mentioned address.

Place : Mumbai

Date: 5th April 2012

Sd/-
(S. V. R. Srinivas, IAS)
Managing Director
Mumbai Metro Rail Corporation

Shalini Publicity-Mumbai

CHAPTER - 8
ENVIRONMENTAL MONITORING PLAN

The environmental monitoring programme is a vital process of any Environmental Management Plan (EMP) of development project for review of indicators and take immediate preventive action. This 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,
- Soil monitoring,
- Ecological Monitoring,
- 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, vibration, water, soil quality and ecology. The results so obtained are documented in **Chapter 3**.

8.1 ENVIRONMENTAL MONITORING PLAN

8.1.1 Water Quality Monitoring

Though it is expected that, no impact on water quality is anticipated, monitoring of water quality may be required to assess the impact of the project before and after construction. Water quality parameters shall be monitored one year before the construction, during the construction phase and also for at least three years after the completion of the project (Total 9 years). Monitoring shall be carried out at least three times a year to cover seasonal variations. The details water quality monitoring program is given in the **Table 8.1**. The cost for water quality monitoring works out to be **Rs. 1.08 million**.

TABLE 8.1
WATER QUALITY MONITORING PROGRAMME

ITEMS	DESCRIPTION
Parameters to be monitored	pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids, Chlorides, Nitrates, Sulphates, Iron, Calcium, Total Nitrogen, Lead, Total Phosphates, oils and grease.
Location before construction	10 locations as per decision of Engineer in Charge (Including 4 locations of nearest well from the alignment)
Location during construction	10 locations as per decision of Engineer in Charge (Including 4 locations of nearest well from the alignment)
Location during operation	Depot, Caffe Parade station, Dharavi station, MIDC station and at 4 locations of nearest well from the alignment.
Frequency for surface water & well water	Once in a season for three season in a year for nine years.
Monitoring Cost (Rs.)	Rs. 1.08 million.

Monitoring should be carried out by NABL certified private or Government agency. Water quality should be analyzed following the procedures given in the standard methods. Parameters for monitoring will be as per BIS: 10500. The monitoring points could be at source of ground and surface water.

8.1.2 Soil Monitoring

Soil quality monitoring will be carried out for Depot, Labour camp, station location, dumping site and is given in the **Table 8.2.** The soil quality monitoring program for muck will be based on random sampling of soil coming out during tunneling is given in the **Table 8.3**.

TABLE 8.2
SOIL QUALITY MONITORING PROGRAMME

ITEMS	DESCRIPTION
Parameters to be monitored	pH, Sodium, Potassium, Chloride, Nitrogen, Phosphorous, Organic Matter, Heavy Metals, Oil and Grease.
Location during construction	Depot, Labour Camp, Dumping site and Stations (as per decision of Engineer in Charge)
Proposed Site during operation	Depot
Frequency	Three samples in a season and three times in a year for nine years.
Monitoring Cost (Rs.)	Rs. 2.916 million

TABLE 8.3
SOIL QUALITY MONITORING PROGRAMME FOR MUCK

ITEMS	DESCRIPTION
Parameters to be monitored	pH, Electrical conductivity, Alkalinity, Moisture content, texture, Heavy Metals and Specific gravity.
Location	Every Kilometer
Frequency	At random sampling @ three sample in one km.
Monitoring Cost (Rs.)	Rs. 0.63 million

8.1.3 Air Quality, Noise and Vibration monitoring

Ambient air quality and Noise levels should be monitored one year before the construction, during the construction phase and for at least three years after the completion of the project. Vibration monitoring during construction will be carried out at five predefined locations and other locations as per the requirement. Together the cost for ambient air quality, Noise levels and Vibration Monitoring works out to be **Rs. 15.282 million** as per the break up given in **Table 8.4, Table 8.5 and Table 8.6** respectively.

TABLE 8.4
AIR QUALITY MONITORING PROGRAMME

ITEMS	DESCRIPTION
Parameters to be monitored	$PM_{2.5}$, PM_{10}, SO_2, NO_x, CO, HC
Location during construction	6 locations including depot and sensitive locations as per decision of Engineer in Charge
Proposed Site during operation	Depot, Vidhan Bhawan station, CST Station, Dharavi station, CSIA (Domestic Airport) and MIDC station.
Frequency	Twice in a week for each season for three season in a year for nine years.
Monitoring Cost (Rs.)	**Rs. 4.86 million**.

TABLE 8.5
NOISE QUALITY MONITORING PROGRAMME

ITEMS	DESCRIPTION
Parameters to be monitored	Leq, L90, L50, L10, Lday, Lnight, Lday-night
Location during construction	6 locations including depot and sensitive locations as per decision of Engineer in Charge
Proposed Site during operation	Near Vidhan Bhawan station, Siddhi Vinayak Temple, Dharavi station, CSIA (Domestic Airport) and MIDC station and at Depot.
Sampling duration for during & after construction period	Twice in a week for each season for three season in a year for nine years.
Monitoring Cost (Rs.)	**Rs. 0.972 million**.

TABLE 8.6
VIBRATION MONITORING PROGRAMME

ITEMS	DESCRIPTION
Parameters to be monitored	For Construction: Field Measured Average Ambient vibration (VdB) & Vibration due to TBM Operation (VdB). For Operation: Vibration due to Metro Train Operation (VdB).
Proposed Site during construction	At CST, BMC Building, Lady Willingdon Building, Mittal Towers, DN Road and other locations as required.
Proposed Site during operation	At CST, BMC Building, WR Head Quarter, Girgaon station, Lady Willingdon Building, Mittal Towers & DN Road.
Frequency	Continuous monitoring during tunnelling at work stations and 4 years during operation.
Monitoring Cost (Rs.)	**Rs. 9.45 million**.

8.1.4 Ecological Monitoring

The project authority in coordination with the Department of Forest shall monitor the status of ecology/trees along the project corridors at regular interval during construction phase in order to maintain the ecological environment. The plantation/afforestation of trees by Department of Forest, Government of Maharashtra will be reviewed regularly by MMRDA during construction Phase.

8.1.5 Workers Health and Safety

Monitoring of health risk issues that might arise throughout the project life time will be done. Epidemiological studies at construction sites and workers camp 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 recurring incidents such as irritations, rashes, respiratory problems etc shall be recorded and appropriate mitigation measures shall be taken. Contractor will be responsible to take care of health and safety of workers during the entire period of construction and project proponent will review/audit the health and safety measures/plans regularly.

8.2 ENVIRONMENTAL MONITORING DIVISION

It is recommended that MMRDA establishes an Environment Division at the initial stage of the project itself. The division should be staffed with an Environmental Engineer/Officer and a Technical Assistant (environment background). 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 Project Director of the project authority. Organizational setups for Environmental Monitoring during construction and operation phase are presented in section 6.3. Costs for the first ten years (including 10% annual increase has been) given **Table 8.7**.

TABLE 8.7
ENVIRONMENTAL DIVISION COSTS

S. No	Particulars	Cost (Million)
Per Year		
1.	Environmental Engineer (1No.)	0.54
2.	Technical Assistant (1No.)	0.30
3.	Miscellaneous Expenditure	0.20
	Total Cost per One Year	**1.040**
	Total Cost for Ten Years with 10% annual increase	**11.440**

8.3 MONITORING AND REPORTING SYSTEM

The environmental monitoring involves regular checking of the environmental management issues to ascertain the implementation of mitigation measures according to the progress of the project work. It provides the necessary feedback for the impact of the project on environment which ultimately leads to human health. The monitoring report of environmental parameters will be prepared by the environmental engineer and submitted to the PMC. The monitoring report of Air, Noise, Water and soil should be prepared and submitted within fifteen days from end of quarter (Season). The muck and vibration monitoring report should be submitted as per progress of construction work.

CHAPTER-9
COST ESTIMATES

9.1 SUMMARY OF COSTS

The environmental costs towards implementation of environmental management plan and mitigation measures during pre-construction, construction and operation of the proposed project are estimated of **Rs. 4,379.845** million and described in **Table 9.1**. These costs are computed in Chapter 6 and Chapter 8. Certain items in the environmental management plan make part of the contractual obligations of the construction contractor. Breakdown of the cost may be referred as per the section described in Table 9.1.

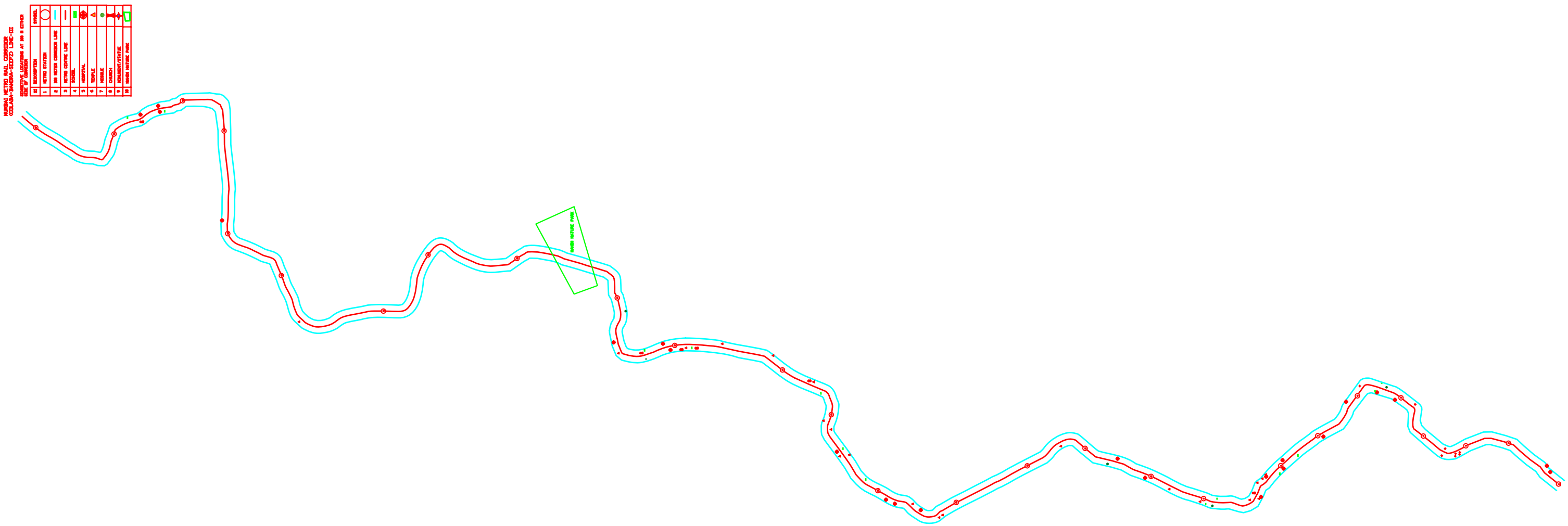
TABLE 9.1
ENVIRONMENTAL COSTS

S. No.	ITEM	REFERANCE	COST (million)
1.	Tree Plantation and Transplantation	Section 6.3.1	64.195
2.	Sanitation facilities at Labour camp	Section 6.3.4	2.412
3.	Water supply & Sewage/ Effluent Treatment at Depot	Section 6.3.20	11.00
4.	Green Belt Development & Rain Water Harvesting at Depot	Section 6.3.20	5.50
5.	Environmental monitoring during construction and operation	Section 8.1	19.908
6.	Muck Disposal	Section 6.3.15	4235.28
7.	Training Programmes	Section 6.3.21	21.61
8.	Establishment of Environment Division	Section 8.2	11.44
9.	Environmental Enhancement Measures	Section 6.3.22	8.50
		Total	**4379.845**

Cost of Rehabilitation and Resettlement has been presented in separate report. The Environmental management plan should be implemented in phases so that optimum benefit could be achieved and should be synchronized with the construction schedules.

CHAPTER-10
CONCLUSION

The proposed Metro line is proved to have significant positive effects to the development of Mumbai City. Benefits to the economy, traffic congestion reduction, quick and safety transport, employment opportunities, fuel consumption reduction, and air quality improvement are the obvious positive effects from this Metro line. Besides, the potential adverse environmental impacts on air quality (during construction phase), water environment, noise and vibration, solid waste, ecology, population resettlement are also taken into consideration. Hence the current project is classified as Category 'A' as per the JICA Guidelines for confirmation of Environmental and Social Considerations. Based on these detailed potential adverse environmental impacts, appropriate mitigation measures have been developed for consideration. The EIA concluded that project impacts from both construction and operation will be minimal, and can be mitigated through the use of prevailing current practices and appropriate technologies. With the implementation of the EMP and the monitoring plan, the Project is not expected to have significant environmental impacts.



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