MAHARASHTRA METRO RAIL CORPORATION LIMITED

Environmental Impact Assessment (EIA) and Preparation of Environmental Mitigation Plan (EMP) for both the corridors (North-South and East-West) of Pune Metro Rail Project

FINAL DRAFT EIA& EMP REPORT
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NOMENCLATURE

AFD	Agence Francaise De Developpement
AIIB	Asian Infrastructure Investment Bank
ANQS	Ambient Noise Quality Standards
ASI	Archaeological Survey of India
BEV	Battery Electric Vehicle

BGL	Below Ground Level
BIS	Bureau of Indian Standards
BOQ	Bill of Quantities
C&D	Construction and Demolition
CBD	Convention on Biological Diversity
CBTC	Communication Based Train Control
CGWB	Central Ground Water Board
CHD	Coronary Heart Disease
CIRT	Central Institute of Road Transport
CKD	Chronic Kidney Disease
CMP	Comprehensive Mobility Plan
CNG	Compressed Natural Gas
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CSC	Construction Supervision Consultant
CTE	Consent to Establish
CTO	Consent to Operate
DEA	District Environmental Atlas
DG	Diesel Generator
DMRC	Delhi Metro Rail Corporation
DPR	Detailed Project Report
DPSP	Directive Principles of State Policy
DRDO	Defence Research and Development Organisation
E&M	Electrical and Mechanical
EA	Environmental Assessment
EC	Electrical Conductivity
eGFR	Estimated Glomerular Filtration Rate
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EMAP	Environmental Management Action Plan
EMoP	Environmental Monitoring Plan
EMP	Environmental Management Plan
EMS	Environmental Management System
EPA	Environment Protection Act
ESA	Environmental and Social Assessment
ESCP	Environmental and Social Commitment Plan
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESRD	End-Stage Renal Disease
EU	European Union
FHWA	Federal Highway Administration
GC	General Consultancy
GHG	Green House Gases
GIS	Geographic Information System
GoI	Government of India

GoM	Government of Maharashtra
GW	Ground Water
HT	High Tension
HW	Hazardous Waste
IMD	Indian Meteorological Department
IS	Indian Standard
ISO	International Organization for Standardization
KLD	Kilo Litres per Day
LISS	Linear Imaging Self Scanning Sensor
LEVS	Local Exhaust Ventilation System
MLD	Million Litres per Day
MoEFCC	Ministry of Environment, Forests and Climate Change
NABL	National Accreditation Board for Testing and Calibration Laboratories
NGO	Non-Governmental Organisation
NHAI	National Highways Authority of India
NOC	No Objection Certificate
OHE	Over Head Equipment
OHSAS	Occupational Health and Safety Assessment Series
PAP	Project Affected People
PCMC	Pimpri Chinchwad Municipal Corporation
PIU	Project Implementation Unit
PM	Particulate Matter
PMC	Pune Municipal Corporation
PPE	Personal Protective Equipment
PPV	Peak Particle Velocity
PWD	Public Works Department
R&R	Rehabilitation and Resettlement
RAP	Resettlement Action Plan
RDSO	Research Designs & Standards Organisation
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RMC	Ready Mix Concrete
RMI	Rocky Mountain Institute
RTFCT-LARR	Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement
SEA	Strategic Environmental Assessment
SHE	Safety, Health and Environment
SPCB	State Pollution Control Board
STP	Sewage Treatment Plant
SW	Surface Water
TBM	Tunnel Boring Machine
TMC	Thousand Million Cubic ft
UG	Under Ground
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nation Framework Convention on Climate Change

UNISDR	United Nations International Strategy for Disaster Reduction
USEPA	United States Environmental Protection Agency
VEC	Valued Environmental Component
VOC	Vehicle Operating Cost
WB	World Bank
WGS	World Geodetic System

Chapter 1 : Introduction

1.1. BACKGROUND

The history of Pune City is closely related to the rise of Maratha Empire of the 17th and 18th centuries. Pune is situated at the eastern edge of the Western Ghats on the Deccan plateau. The city is second largest city in Maharashtra and is fastest growing city in India. The city with its rich cultural heritage and architectural feats from the Mughal period offer several tourist attractions to the visitors.

Pune is an example of an indigenous Marathi culture and ethos, in which education, arts and crafts, and theatres are given due prominence. It is the birthplace of the poet-saint Tukaram and Jnaneshvara. It is the home of great freedom fighters like Bal GangadharTilak, Agarkar and Gopal Krishna Gokhale. Pune has been an example for the blending of the culture and heritage. Pune is the cultural capital of the Maharashtra.

Maharashtra Metro Rail Corporation Ltd. is a joint venture company of Government of India (GoI) and Government of Maharashtra (GoM) established under the companies act 2013 intends to develop the proposed Pune Metro Rail Project having North-South and East-West Corridors.

Delhi Metro Rail Corporation has carried out the investigation and studies for Pune Metro Rail Project and prepared a Detailed Project Report (DPR) in November, 2015.

1.2. PROJECT AREA

Pune district is located between 17^{o} 54' and 10^{o} 24' North latitude and 73^{o} 19' and 75^{o} 10' East longitude. The district has geographical area of 15.642sq.km. Pune district is bound by Ahmadnagar district on north-east, Solapur district on the south-east, Satara district on south, Raigad district on the west and Thane district on the north-west. It is the second largest district in the state and covers 5.10% of the total geographical area of the state.

1.3. OBJECTIVE OF THE STUDY

The objective of the study is to carry out Environmental Impact Assessment (EIA) and preparation of Environmental Management Plan (EMP) for both the corridors (North-South and East-West) of Pune Metro Rail Project.

1.4. SCOPE OF EIA STUDY

The scope of work for the Environmental Impact Assessment (EIA) Study is given below:

The Environmental Impact assessment & hydraulic studies of 1.45 km alignment of Pune Metro Rail passing parallel to Mutha River is covered by another Consultant identified by the Client. This report has now been incorporated under section 7 of this report .

The EIA study includes the environmental management plan (EMP) and disaster management plan for design, construction and operation phases of project. The EIA study covers the following

- EIA and EMP shall be undertaken in accordance with Environmental Framework/Environmental Assessment Policy of International Funding Agency like World Bank (WB) & AIIB. (OP/BP-4.01, OP/BP-4.02, OP/BP-4.04 etc)
- Review of National, state and local environmental regulatory requirements on environmental aspects and available standards besides requirement of Funding Agencies like WB Bank Guidelines and AIIB,
- Description on all applicable laws and regulations for the project. Description of necessary approvals/consent requirement from the regulatory authorities,
- An environmental screening and categorization framework as per world bank criteria for the proposed project to identify the environmental analysis and planning aspects of the project,
- Identification of hot spots like involvement of forests, roads, rail crossing, bridges, rivers, nallahs, bore wells, surface drainage, and archaeological/historical/religious structures.
- Study and summarize the existing condition of surface and subsurface water flow condition within the project area (From the secondary authenticated published data)
- Earmarking the project Location throughout the city and assessment with respect to environmentally sensitive areas, and community concerns,
- Inventory survey of Sensitive Receptors such as schools, hospitals, religious places within 100 m from central line of the proposed metro rail corridor will be identified using latest satellite images, field survey and interviews with residents,
- Assessment of existing land use pattern and study the possible impacts of the project on land use pattern;
- Description of alternatives considered from the relevant point of views (e.g. route, land use, technical aspects, environmental & social aspects),
- Establish the baseline status of the study area with reference to the air, noise & vibration, water quality, soil quality, solid waste, protected areas, physical environment (e.g. hydrology), biological and social aspects along the section;
- Air & Noise quality monitoring shall be conducted at all proposed metro stations, casting yard and depots location to generate the data for baseline scenario,
- Justification must be given for selection of locations for assessment of baseline,
- Impacts to be identified for pre-construction (Location/design stage), construction phase and operation phase for the proposed Metro Rail project,
- Detailed Ecological and Biodiversity Impact Assessment and suggesting mitigation plan. Ecological study (details inventory chainage/station wise of number of trees to be cut with diameter, height & species.),

- Consultant shall propose the soil & muck disposal plan for construction phase of project. Also the consultant shall propose the areas in or outside the cities where soil could be re-used or muck could be disposed.
- Consultant shall assess in principle impact of project construction and operation specifically w.r.t. air, noise and vibration and shall identify the sensitive receptors for these impacts.
- **Noise Study:** Mapping and modelling of noise resulting from ambient noise and noise due to operation of Metro rail system shall be carried out using the international standard software for rail noise mapping.
- The Noise mapping shall be carried on the GIS platform showing the noise contours. Prediction of noise at these locations due to train operation shall be made for 30 years with an interval of 3 years.
- The outputs of measurement and prediction shall be submitted in the form of noise contours for about 250 meters along the proposed metro rail route.
- Consultant shall propose the mitigation measures for attenuating noise levels below the statutory standards/baseline (whichever is higher) during operation phase of metro rail.
- **Vibration Measurement:** Existing vibration measurement (24 hr. monitoring) at sensitive receptors, structures close to the alignment & Archaeological importance structures and vibration prediction at same sites during construction (TBM) and operation of metro rail. The vibration mapping shall be carried on the GIS platform showing the vibration contours,
- The consultant shall justify the selection of location and methodology for conducting the vibration monitoring,
- Consultation and review with affected sensitive receptors (Major Hospitals) along the corridor due to Noise & Vibration.
- Identification of water body directly or indirectly affected, impact on water quality in the identified rivers/canals/creeks and supplementing the collection of existing and published data on water quality,
- Impact of Hydro geological conditions including aquifer geometry and groundwater flow etc., for tunnelling activities (based on secondary data)
- Identification of major impacts due to Air, Noise & Vibration on Archaeological/historical/cultural/religious structures, sensitive receptors. Assessment of likely impact on, water quality (Surface & Ground), ecological, muck/soil, seepage water, land subsidence and waste. Assessment of impact due to labour camps and depots.
- Suggest suitable measures separately for mitigating the impact of noise and vibration in surrounding environment and habituated area that is likely to be generated during construction and from operation of metro train;
- Consultant shall report socio-economic data on demography, social status, local economy, local culture & custom and land details in the report for the project location. (Such data may be collated from secondary authentic sources).

- Project specific Risk and Hazardous management studies & suggesting construction Workers management plan (Occupational health and safety),
- Preparing and suggesting project specific Environmental Management Plan (EMP) and Environmental Management Action Plan (EMAP) duly following MoEFCC/WB/AIIB guidelines for environmental sustainability, including budget for implementation,
- EMP shall be prepared Reach wise in such a manner that these are amenable to incorporation in the bidding/contract documents.
- EMP shall list all mandatory Government Clearance conditions and procedure for procuring clearances.
- EMP shall suggest mitigation measures, management & monitoring plan for all the significant impacts assessed for the project during design, construction & operation phases of the project.
- EMP shall include the organization structure for implementation of EMP with specific responsibilities for contractors, general consultants and project proponents during design, construction and operation phases of the project,
- Consultant shall undertake a capacity development and training program for the stakeholders who are responsible for implementation of proposed EMP;
- Description of mitigation measures of each environmental factor in each stage by explaining what measures are particularly to be taken instead of explaining "adequate measures" are to be taken,
- Preparation of Environmental Monitoring Plan (EMoP) based on analysis of collected data, impacts, mitigation strategy, EMoP will be finalised incorporating feedback from local residents participated in Public Consultation Meetings,
- Preparation of Environmental Monitoring Forms based on EMP and EMoP,
- Identification of Institutional needs to implement environmental assessment recommendations, (review the authority and capability of institutions and recommend steps to strengthen or expand them so that the management and monitoring plans in the environmental assessment can be implemented.),
- Organising/conducting project level Public Consultation and assist in city level public consultation in obtaining the views of affected groups and local NGO's as part of EIA report,
- Carbon Credit study to explore opportunities for claiming Carbon Credits against this project including methodologies and documentation,
- Content of EIA report should be as per the WB funding agency policy.
- The Consultant will prepare a plan for in-country disclosure, specifying the timing and locations; translate the key documents, such as the Environmental Assessment Summary in local language for disclosure.
- The Consultant shall prepare a non-technical EA Summary Report for public disclosure.

1.5. ENVIRONMENTAL IMPACT ASSESSMENT

The structure of the Environmental Impact Assessment Report is as per Table 1.1.

Table 1.1: Structure of EIA Report

Chapter 1	Introduction	Introduction about the project, objectives and scope of work.
Chapter 2	Policies, Legal and Institutional Requirement	Provides over all legal frame work in relation to required regulatory compliance and institutional arrangement.
Chapter 3	Project Description	This chapter describes the details of the proposed metro corridors.
Chapter 4	Environmental Baseline Data	This chapter provides description on the present environmental setting of the project area.
Chapter 5	Environmental Impacts	This chapter describes the environmental impacts associated with the proposed project during construction and operation phases.
Chapter 6	Positive Environmental Impacts	Project benefits are described under this chapter
Chapter 7	Other Studies	EIA studies for 1.45 km stretch of Vanaz – Ramwadi Corridor, which is passing through left bank of Mutha River. The study was carried out by M/s Mitcon Consultancy and Engineering Services Ltd, Pune
Chapter 7	Environmental Management Plan	Environmental strategy to offset/mitigate the probable adverse impacts has been outlined
Chapter 8	Environmental Monitoring Plan and Environmental Management System	Environmental monitoring and management systems are described
Chapter 9	Cost Estimate	Summary of Environmental Costs are detailed in this chapter

Chapter 2 : Policy, Legal and Institutional Requirements

2.1. ENVIRONMENTAL POLICY FRAMEWORK

The environmental policy framework include existing institutions and legislations relevant to the project at the International, National and State levels. The various statutory clearances/ permissions from state and central government authorities and institutional framework are discussed in the subsequent section.

2.2. LEGAL FRAMEWORK

The proposed project would be governed by various Acts, Rules and regulations set by the Ministry of Environment, Forests and Climate Change (MoEFCC) at the Central level and other regulatory agencies at the State and local level. Various environmental standards, specifications and guidelines of Central Pollution Control Board (CPCB) and state level agencies will also be applicable.

It is important to mention over here that the Central government framed an 'umbrella law', called the Environment (Protection) Act, 1986to broadly encompass and regulate an array of environmental issues. The overall purpose of EPA was to establish an overall coherent policy and provide a basis for the coordinated work of various government agencies with operational responsibility for the environment and natural resources. The legislation also invests authorities with regulatory powers to address specific issues affecting the environment. The Act also does not allow any person to carry on an industry, operation or process that discharge or emit any environmental pollutants in excess of standards prescribed under specific rules and notifications.

The Acts, Rules and Notifications applicable to environmental aspects of the constructional and operational phases of the proposed project are summarized and briefly described in the Table 2.1 below.

Table 2.1: Key Applicable Environmental Legislations

LEGISLATION	ACTIVITY / FEATURE
Environment (Protection) Act, 1986 amended 1991; Environment (Protection) Rules, 1986	• Overall Environmental Protection • Compliance to environmental (Air, Water, Noise) Standards
Air (Prevention and Control of Pollution) Act, 1981 amended in 1987; Air (Prevention and Control of Pollution) Rules, 1981	• Protection of Air Quality • Consent to Establish (CTE) for establishing and • Consent to Operate for activities causing air pollution • Compliance to National Ambient Air Quality Standards
Water (Prevention and Control of Pollution) Act, 1974 amended in 1988; Water (Prevention and Control of Pollution) Rules, 1975	• Protection of Water Quality • Discharge of sewage from project • Obtaining No Objection Certificate (NOC) for establishing and

LEGISLATION	ACTIVITY / FEATURE
	• Consent to Operate for activities causing water pollution from SPCB
EIA Notification 2006 and its amendments (*Amendment of Integration of environmental Conditions in local building byelaws for residential buildings only*).	• For getting Environmental Clearance (PROJECT DOES NOT ATTRACT ENVIRONMENTAL CLEARANCE) • Integration of environmental Conditions in local building byelaws
Noise Pollution (Regulation and Control) Rules, 2000 amendment in 2010	• Compliance with Ambient Noise Standards in accordance to land use of the area
Hazardous and Other Wastes (Management, and Trans boundary Movement) Rules, 2016	• Handling, storage, treatment and disposal of hazardous material (fuel)/ waste like waste oil and lubricants etc.
Solid Waste Management Rules, 2016	• Management (Collection, Handling, Storage and disposal) of solid waste
Construction and Demolition Waste Management Rules, 2016	• Management ofwaste resulting from construction, re-modeling, repair and demolition of any civil structure
Maharashtra Regional and Town Planning Act, 1966	• Permits and sanction for land • Develop the project in accordance with Land use and Master plans
Forest (Conservation) Act 1980 amended in 1988;Forest (Conservation) Rules 2003	• Clearances from forest department • Conservation of forest • Regulating Access to Natural Resources • PROJECT DOES NOT ATTRACT THIS ACT
Indian Wildlife Protection Act, 1972, amended in 2002	• Protection of animals and specified plants • PROJECT DOES NOT ATTRACT THIS ACT
Metro Rail Transit System, Guidelines for Noise and Vibrations, RDSO, Ministry of Railways, September 2015	• Recommended norms for Noise and vibration for metro railway in India • Vibration Screening procedure and Vibration analysis
The Metro Railways (Operation and Maintenance) Act 2002 as amended vide The Metro Railways (Amendment) Act 2009	• Disaster Management
The Ancient Monuments and Archaeological sites and Remains Act,1958 amended in 2010 with Ancient Monuments and Archaeological Sites and Remains (Amendment) Act, 2017.	• Preservation of ancient and historical monuments and archaeological sites and remains of national importance. To regulate the archaeological excavations and protection of sculptures, carvings etc. • Construction of public works in prohibited area of protected monuments is permitted.
Indian Treasure Trove Act, 1878, modified up to the 01/09/1949	• Procedure to manage chance finds
The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	• Hours of Work, Welfare Measures, Safety and Health Measures
The Maharashtra Jeevan Authority Act, 1976 amended in 2013	• To develop and regulate water supply and sewerage services in the State of Maharashtra • Water supply for domestic purposes shall not to be used for non-domestic purposes

LEGISLATION	ACTIVITY / FEATURE
Bombay Provincial Municipal Corporation Act, 1949	• Establishment of Municipal Corporations for certain cities in the Province of Bombay • Water for domestic purposes shall not be used for other purposes.
Maharashtra Ground Water (Development and Management) Act, 1993	• To control overexploitation of ground water resources • To protect public drinking water sources.

2.2.1. Environment Protection Act

The Act is for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating environmental pollution. Protect and improve environment under this Act by

- Planning and execution of a nation-wide programme for the prevention, control and abatement of environmental pollution;
- Laying down standards for the quality of environment in its various aspects;
- Laying down standards for emission or discharge of environmental pollutants from various sources whatsoever;
- Restriction of areas in which any industries, operations or processes or class of industries, operations or processes shall not be carried out or shall be carried out subject to certain safeguards;
- Laying down procedures and safeguards for the prevention of accidents which may cause environmental pollution and remedial measures for such accidents;
- Laying down procedures and safeguards for the handling of hazardous substances.

No person carrying on any industry, operation or process shall discharge or emit or permit to be discharged or emitted any environmental pollutant in excess of such standards as may be prescribed.

2.2.2. 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 like lakes and rivers, marine discharge). Additionally, the water supplied to users for drinking shall also conform to the National Drinking Water Standard; IS-10500 (Annexure 1.1).The general standards for discharge effluent in Inland

Surface Water Bodies are given at Annexure 1.2. Tolerance limits for Inland Surface Water Quality are given at Annexure 1.3.

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. Pune City does not figure in the list of Notified areas where permission to abstract ground water through any energized means will not be accorded for any purpose other than drinking water, it will be advisable to optimize extraction of ground waterfor drinking purpose during construction.

2.2.3. 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_{10}, $PM_{2.5}$ Sulphur dioxide, Nitrogen dioxide, Carbon monoxide, Lead, Ozone, Ammonia, Benzene and Benzo pyrene, Arsenic and Nickel with the intent of managing air quality for different category of areas (Industrial, Residential, Rural and Ecological sensitive areas). Ambient Air Quality Standards have been notified by the CPCB vide Gazette Notification dated 16th November 2009, are given at Annexure 1.4.

2.2.4. 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 2010under the EPA. The noise standards for different category of areas are based on the weighted equivalent noise level (Leq). The notified ambient noise standards are presented in Annexure 1.5.

2.2.5. Solid Waste Management

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

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

- Occupier`s responsibility for safe and environmentally sound management of hazardous and other wastes in terms of sending or selling to an authorised actual user or disposal in an authorised disposal facility.
- Responsibilities of State Government,
- Rules for grant of authorization to manage wastes and for utilization of wastes.

- Roles of waste processor and State Government in treatment, storage and disposal facility for hazardous and other wastes.
- Procedures for packaging, labelling, and transport of hazardous and other wastes.

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

2.2.6. The Ancient Monuments and Archaeological Sites and Remains Act, 2010

The Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010 has been enacted to amend the Ancient Monuments and Archaeological Sites and Remains Act, 1958 and to make provision for validation of certain actions taken by the Central Government under the said Act. The act has come into force on January 23, 2010.

The Act states that the limits of prohibited area and regulated area around the monuments, archaeological sites and remains declared by the Central Government as protected have been specified in the principle Act as 100 m and 200 m respectively. The limits so fixed may be further extended on the basis of gradation and classification of the monuments, archaeological sites and remains to be done by the National Monuments Authority, which is to be constituted by the Central Government by virtue of the Amendment in the principle Act. The Act defines regulated area and prohibited area as follows:

Prohibited Area: It is the areabeginning at the limit of the protected area or the protected monument declared as of national importance, and extending to a distance of 100 m in all directions.There is also a provision in the Act to further extend the prohibited area beyond 100 m having regard to the classification of any protected monument or protected area on the recommendation of National Monument Authority by the Central Government.

Regulated Area: It is the area beginning at the limit of the prohibited area in respect of every protectedarchaeological monument/siteand remains and extending to a distance of 200 m in all directions. This 200 m regulated area could further be extended having regard to the classification of any protected monument or protected area on the recommendation of National Monument Authority by the Central Government. The regulated area has extent not only horizontally but also vertically and covers even below the surface.

The Act provides that in exceptional cases where Central Government or DG/ASI is satisfied that the works/project is in public interest and does not have significant adverse impact on the monument/site, permission can be granted for such work in prohibited area.The Act provides that none other than an archaeological officer can carry out any construction in any prohibited area. The Act provides that no permission, including carrying out any public work or project essential to the public or other constructions, shall be granted in any prohibited area on and after the date on which the Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010 comes in to force.

Amendment to this Act vide The Ancient Monuments And Archaeological Sites And Remains (Amendment) Bill, 2017defines “public works” to mean construction works related to infrastructure financed and carried out by any department or offices of the Central Government for public purposes which is necessary for the safety or security of the public at large and emergent necessity is based on specific instance of danger to the safety or security of the public at large and there is no reasonable possibility of any other viable alternative to such construction beyond the limits of the prohibited area. The Bill 2017 states that the clause in Act 2010 which *barred permission to construct in prohibited area* shall not apply to the public works.

2.2.7. The Building and Other Construction Workers Act, 1996

The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 aims to provide for regulation of employment and conditions of service of the building and other construction workers as also their safety, health and welfare measures in every establishment which employs or employed ten or more workers. The provisions in the Act for health and safety measures for the construction workers are in conformity with International Labour Organisation Convention.

2.2.8. The Maharashtra Jeevan Authority Act, 1976

The Act is to provide for establishment of a Jeevan Authority for rapid development and proper regulation of water supply and sewerage services in the State of Maharashtra. The supply of water for domestic purposes under this Act means supply for any purpose, except for building purposes, including construction of streets. Water supply for domestic purposes shall not to be used for non-domestic purposes under this Act.

2.2.9. Bombay Provincial Municipal Corporation Act, 1949

This Act is to provide for the establishment of Municipal Corporations for certain cities in the Province of Bombay with a view to ensure a better municipal government. Under this act, "water for domestic purposes" shall not include water for cattle, or for horses, or for washing vehicles, when the cattle, horses or vehicles are kept for sale or hire, or by a common carrier, and shall not include water for any trade, manufacture or business, or for building purposes, or for watering gardens, or for fountains or for any ornamental or mechanical purposes.

2.2.10. Policy Statement for Abatement of Pollution, 1992

The objective is to integrate environmental considerations into decision making at all levels. Steps have to be taken to achieve this are:

- Prevent pollution at source;
- Encourage, develop and apply the best available practicable technical solutions;

- Ensure that the polluter pays for the pollution and control arrangements;
- Focus protection on heavily polluted areas and river stretches; and
- Involve the public in decision making

To achieve the objectives maximum use will be made of a mix of instruments in the form of legislations and regulation, fiscal incentives, voluntary agreements, educational programmes and information campaigns. The emphasis will be on increased use of regulations and an increase in the development and application of financial incentives.

2.2.11. National Environment Policy, 2006

National Environment Policy 2006 is a response to India's national commitment to a clean environment, mandated in the Constitution in Articles 48 A and 51 A (g), (DPSP) strengthened by judicial interpretation of Article 21.

The existing policies have recognized the need for sustainable development in their specific contexts and formulated necessary strategies to give effect to such recognition. The National Environment Policy seeks to extend the coverage, and fill in gaps that still exist, in light of present knowledge and accumulated experience. It does not displace, but builds on the earlier policies. The objectives of the National Environmental Policy are:

- Conservation of Critical Environmental Resources
- Intra-generational Equity: Livelihood Security for the Poor
- Inter-generational Equity
- Integration of Environmental Concerns in Economic and Social Development:
- Efficiency in Environmental Resource Use
- Environmental Governance
- Enhancement of Resources for Environmental Conservation

The policy focuses on encouraging the regulatory authorities, Central and State, to institutionalize regional and cumulative environmental impact assessments to ensure that environmental concerns are identified and addressed at the planning stage itself. The policy adopts the civil liability for environmental damage that would deter environmentally harmful actions, and compensate the victims of environmental damage.

2.2.12. Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (RTFCT-LARR) Act, 2013

Key features of the RTFCT-LARR Act are given in Table 2.2.The intent of the Act can be summarised as follows:

- The affected persons get fair compensation when their land is taken away.
- Transparency is brought in the process of land acquisition.
- Adequate provisions are made for rehabilitation of the affected people.
- Local self-Government is consulted in the process of land acquisition.

Table 2.2: Key Features of the Act

Milestone Proceedings under the Act		
Stages	**Title**	**Description**
1	SIA study SIMP by Government	Whenever Government intends to acquire land for a public purpose, it shall consult the concerned Gram Sabha, Panchayat, Municipality or Municipal Corporation and then carry out a Social Impact Assessment (SIA) study in consultation with them. The SIA study and Social Impact Management Plan (SIMP) shall be prepared by Authority identified by the Government. The report of SIA and SIMP shall be made public.
2	Appraisal of SIA report and Preliminary Notification of acquisition	Upon due examination Government would recommend area for acquisition which shall be made public and a Preliminary Notification of acquisition to that effect shall be published. No land transactions can be made till award of R&R by the Collector.
3	Rehabilitation and Resettlement (R&R) Scheme	The Collector, the Administrator for R&R shall conduct a survey and undertake a census of the affected families considering lands and properties, livelihoods of land losers and landless, public utilities, infrastructural facilities and common property resources affected. A draft R&R scheme shall be prepared by the Administrator and then approved by Commissioner. The details of the approved scheme shall be made public
4	Rehabilitation and Resettlement Awards	Collector shall pass R&R Awards for each affected family. The Award shall include R&R amount, house site/house/land to be allotted, allowances/entitlements, etc.
5	Possession of land	Section 38(1): Collector shall take possession after ensuring full payment of compensation is paid within 3 months and full payment of monetary part of R&R entitlements is paid within 6 months from date of award. Section 80: Howeverwhenamountof compensationisnotpaidon orbeforetakingpossessionof theland orwithinone yearfromdateofpossessionthen interestispayableonamountawarded. Components of R&R package relating to infrastructural entitlements shall be provided within 18 months from date of award. Section 38(2): R&R process shall be completed before displacing affected families.
Other key features of the Act		
Affected families who are eligible for benefits include: owners of land or immovable property; tenants of the land or artisans working in the affected area for three years prior to acquisition and whose livelihood stands affected by the acquisition; a member of the family who has been assigned land under any Government scheme; a family residing on any land in urban areas for preceding three years or more prior to acquisition of the land or whose primary source of livelihood for three years prior to acquisitions affected by such acquisition.		
Second ScheduleofAct 2013: With a viewtohelprestoreincomeopportunities the Act provides for assistance and cash allowances. Ifahouseislostinurbanareas,a constructedhouseshallbeprovidedwhichwillnotbelessthan50squaremetersin plintharea.*Replacementcostisnotmandatory.*		

Milestone Proceedings under the Act		
Stages	Title	Description
Assistance to Vulnerable Groups: Item 5 in Second Schedule: Scheduled Castes and Scheduled Tribes displaced from Scheduled Areas shall receive subsistence grant in addition to monthly subsistence allowance.		
Items 4 to 10, Second Schedule: Support during transition period between displacement and livelihood restoration.		
Item 3, Second Schedule: Offer – at a price - of developed land in lieu of equivalent amount in land acquisition compensation in case of land acquired for urbanization purpose. The project involves acquisition for a transport project but not primarily for urbanization purpose.		
Appropriate participation of affected people in planning, implementation, and monitoring of resettlement action plans: Under Section 45 where land to be acquired is equal to or more than one hundred acres a R&R Committee shall be constituted to monitor and review progress of implementation of R&R scheme and carry out post- implementation social audit. The Committee shall include local community and political representatives and officials.		
Appropriate and accessible grievance mechanisms for the affected people and their communities: Monitoring of implementation of R&R through R&R Committee (Section 45), reference of disputes in land acquisition and R&R through Land Acquisition and R&R Authority (Section 51), disputes in award of compensation (Section 64).		
Disclosure of RAP at different stages: After preparation of SIA report and Impact Management Plan by Government (Section 6(1)); Preliminary Notification of acquisition with details of acquisition (Section 11(1));; R&R scheme approved by R&R Commissioner (Section 18).		

Revenue and Forest Department of Maharashtra Government has issued Notification No. LQN. 12/2013/C.R. 190/A-2 on 27th August 2014 (Annexure2.1) framing the rules for Resettlement and Rehabilitation of PAPs for projects in the state of Maharashtra. This notification is in line with the national Act 30 of 2013i.e., The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013.

The Rehabilitation and Resettlement (R&R) Policy is being adopted by Maha-Metro for Pune Metro Rail Project to address any adverse social and economic impacts accrued to identified families or persons in the Affected Area. This Policy has been developed in accordance with the requirements of the Maharashtra Government notification for Resettlement and Rehabilitation on 27th August 2014 and thereafter framed rules on 12 May 2015 and 30th September 2015. Thus, this Policy has adopted the rules framed by Maharashtra Government. The policy provides for acquisition of land by direct purchase method from the owners of the land and structures required for the project.

2.3. INSTITUTIONAL FRAMEWORK

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

- Environmental resource conservation and protection, including environmental impact assessment, clearance of developmental projects;

- Co-ordination with the other ministries and agencies, voluntary organizations and professional bodies for environmental action plans;
- Promotion of research and development, manpower planning and training and creation of environmental awareness;
- Liaison and coordination with international agencies involved in environmental matters.

2.3.1. 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.

2.4. REQUIREMENTS OF ENVIRONMENTAL IMPACT ASSESSMENT AS MANDATED IN EIB

The EIB Environmental and Social Handbook, December 2013 discusses the processes and content of Environmental and Social Impact Assessment which ensure that the assessment meets requirements of EIB Environmental and Social Standards, which are listed in Annexure 2.2. The major features of the Environmental Standards pertain to the proposed metro project among the ten Environmental and Social Standards are discussed briefly in the following sections.

2.4.1. Standard 1: Assessment and Management of Environmental and Social Impacts and Risks

1) All operations shall comply with national legislation and regulations as well as any obligations and standards in the relevant international conventions and multilateral agreements to which the host country is party. Projects outside of the EU will also be subject of an environmental and social impact assessment (ESIA) procedure if they are likely to have significant and material impacts and risks on the environment, human health and well-being and interfere with human rights. The ESIA must be consistent with the principles contained in the 10 EIB Standards and EU EIA Directive and best international practice. Where EU standards are more stringent than national standards, the higher EU standards are required, if practical and feasible, taking local conditions into account. In such cases the EIB will agree the applicable requirements with the promoter on a project by project basis.

2) SEA is relevant for policies, plans and programmes that have the potential to significantly influence a geographic region or area, a particular sector, and/or particular biodiversity or ecosystem services within a region/area or where there is a major risk of cumulative impacts in a sector or a region/area. The SEA is a tool, which can be applied to higher levels of decision-making hierarchy than an EIA (which is more suitable for an individual project).

EU EIA Directive 2011/2014 (Article 4) stipulates that mandatory EIA is required for all projects listed in Annexure I of the EIA Directive (e.g. long-distance railway lines, motorways and express roads, airports with a basic runway length ≥ 2100 m, installations for the disposal of hazardous waste, installations for the disposal of non-hazardous waste > 100 tonnes/day, waste water treatment plants > 150.000 p.e.).

For projects listed in Annexure II, the national authorities have to decide whether an EIA is needed. This is done by the "screening procedure", which determines the effects of projects on the basis of thresholds/criteria or a case by case examination. An environmental impact assessment is only required for projects likely to have significant effects on the environment. However, the national authorities must take into account the criteria laid down in Annex III.

Pune Metro project is not among the project types listed in Annexure I: it belongs to list in Annexure II. Certain features of Pune Metro Project which are listed below attract criteria listed in Annexure III.

1. Characteristics of project: Involves significant production of waste, pollution and nuisance
2. Location of project: Located in densely populated areas
3. Type and characteristics of the potential impact: significant geographical area and size of the affected population, short term as well as long term impacts, measures are available to reasonably reduce the impacts.

There are four categories that result from screening against the EU EIA Directive requirements:

A Minimal or no adverse impacts – Low risk
B Environmental and social impacts can be readily identified and mitigation and/or remedial measures can be put in place – Medium risk
C There may be highly significant, adverse and/or long-term environmental and social impacts, the magnitude of which is difficult to determine at the screening stage - High risk.
D Not acceptable in EIB terms

As this project is likely to be categorised under category B or category C, EIA is being conducted as required by the scope of services issued to this Consultant.

In accordance with Indian laws (EIA Notification 2006) railway projects are not listed among projects requiring prior environmental clearance. In recent Metro railway projectsthe Ministry of Environment Forests and Climate Change, Government of India (MoEFCC) has been issuing confirmation to the effect that such environmental clearance is not required; rather permissions from local authorities like Pollution Control Boards and land use planning agencies are required. Notwithstanding, EIA report is being prepared for this Project so as to meet the objectives of EU EIA Directive.

3) In reference to EU EIA Directive, Articles 3 and 5 (content of EIA report) and Article 4 (need for EIA report) are applicable to Pune Metro project. Article 2 (coordination of requirements of EU EIA Directive and legislation of EU Member States) and Article 7 (Transboundary impact) are not applicable. Providing information to public of the EIA study and information thereof as per Article 6 and grant of development consent and its disclosure as per Articles 8 and 9 are within ambit of the Maharashtra State Government. Operation of Article 10 (commercial and intellectual confidentiality) and Article 11 (legal rights of the public concerned and procedures) will be governed by Indian laws.

   The spirit of the 1998 UNECE Aarhus Convention will be addressed in terms of Links between environmental rights and human rights and involvement of all stakeholders. As the project does not pose transboundary hazards UNECE Espoo Convention 1997 is not applicable.

   The EIA Report will respect the spirit of EU Directive 2009/147/EC (Birds) (Conservation of wild birds in terms of protection of their diversity and habitats and regulating hunting) and EU Directive 92/43/EC (Habitats) (ensuring bio-diversity through Designate and manage special conservation areas for habitats and species for which such areas have been mandated; designate protected animal and plant species; assess project implications for the conservation site; take all compensatory measures), Convention on Biological Diversity of 1992 (CBD) (identify and monitor biodiversity aspects, identify processes affecting them, establish protected areas, Rehabilitate and restore degraded ecosystems and local populations) and United Nation Framework Convention on Climate Change and its UNFCCC's Kyoto Protocol and EC Policy on Climate change addressing mitigation responses. The EIA Report will address the spirit of the United Nations Hyogo Framework for Action Programme which covers disasters caused by hazards of natural origin and related environmental and technological hazards and risks.

   The EIA Report will take into account requirements of EIB Standards 2,3,4 and 5. In connection with Standard 9, the EIA Report will list measures required to be implemented as part of the Construction Procedures for public and occupational health and safety of labour working during construction of the project.

4) The EIA will be conducted in accordance with provisions, listed below, of EIB Environmental and Social Practices Handbook which are relevant to this Project:

   Description of the project comprising information on the site, design, size and other relevant features of the project; baseline analysis; land classification and land use maps, satellite imagery or aerial photographs; applicable laws and regulations within which the project operates and gap analysis between the relevant national legislation and standards and the applicable international framework; description of the likely significant effects of the project on the environment; description of the measures envisaged in order to avoid, prevent or reduce and, if possible, offset likely significant adverse effects on the environment and enhance positive impacts; description of the reasonable alternatives studied by the developer and an indication of the main reasons for the option chosen; a non-technical summary.

The EIA report will also include description of stakeholder identification and analysis, and consultation activities undertaken with different groups of impacted individuals, communities and other relevant stakeholders; recommendation of organisational structure, responsibilities, practices, procedures, processes and resources for implementation of the mitigation plan; recommendation of training actions required under the applicable Standards and the methods required to perform the action items; identification of procedures to monitor and measure the timely implementation and effectiveness of the environmental management plan against the agreed indicators and benchmarks, as well as compliance with any environmental provisions;

The report will identify relevant management systems, measures and actions appropriate for preventing and controlling major-accident hazards and limiting their consequences, such as:

(i) the major accident prevention policy and the safety management system to be put in place for its implementation, (ii) internal and external emergency plans, including actions to ensure that those plans are tested, revised and implemented.

The environmental impacts will be assessed in the context of the project's area of influencethat encompasses one or more of the following, as appropriate:

- The assets or facilities and or associated works directly owned or managed by the promoter that can be considered as an integral part of the main project
- Supporting/enabling activities, assets or facilities owned or under the control of parties contracted for the operation of the promoter business or for the completion of the proposed project (such as sub-contractors);
- Areas and communities likely to be affected by: cumulative impacts that result from theincremental impact, direct impacts due to further planned development of the project, other project-related developments etc
- Areas and communities potentially affected from unplanned but predictable developments caused by the project.

2.4.2. Standard 2: Pollution Prevention and Abatement

The following general principles will be applied:

- All the appropriate preventive measures are taken against pollution;
- Reduce hazardousness of pollutants to human health and the environment, ensuring high quality of reusing, recycling, recovering and conversion of waste into energy; promote environmentally-friendly practices for the treatment, destruction and final disposal

- Energy and resources are used efficiently, providing for significant opportunities in terms of competitiveness, cost reduction, improved productivity and security of supply establish 'without-project' scenario for reference
- The adverse project impacts on ambient conditions will be addressed by considering the following conditions:
  - The environmental sensitivity of geographical areas likely to be affected by projects, with particular regard to existing and planned land use, including land take and fragmentation, the relative abundance, availability, quality and regenerative capacity of natural resources in the area, the absorption capacity of natural environment paying particular attention to those areas designated as sensitive or protected;
  - The size of the project, the cumulation with other projects or activities, the use of natural resources, the overall pollution and nuisance, the natural and man-made disaster risks, the impact of the project on climate change and
  - Characteristics of the potential impacts in terms of: magnitude and spatial extent, the nature, including their transboundary nature, the intensity, complexity and probability, the duration and reversibility, the speed of onset the impacts, etc.

In India permissions to use the standard chemicals in manufacture and use of construction materials and fuels are available: as such project-specific registration / safety reporting / identification and communication of risk reduction measures related to such chemicals will not be required in the context of REACH Regulation 2006.

2.4.3. Standard 3: Biodiversity and Ecosystems

The following principles which are the foundations of the Biodiversity Ecosystems Standard of the EIB will be followed:

- Through the use of available data determine the biodiversity footprint of the project and whether there are no-go areas;
- avert loss of biodiversity and ecosystems, and at a minimum sustaining current biodiversity values through avoiding impact on biodiversity and ecosystems or minimised through mitigation.
- respect the spirit of EU EIA Directive 2011, Birds Directive 2009, Habitats Directive 1992 and Convention on Biological Diversity of 1992 (CBD)
- Ensuring the appropriate participation of local communities and Indigenous communities in the
- decision-making process,
- Efficient monitoring and reporting to track the promoter's overall impact

2.4.4. Standard 4: Climate-Related Standards

Principles

- Rational approach to resource use, including the most effective measures in the field of energy efficiency
- Estimation of GHG emissions

- Information on the climate change risks

2.4.5. Standard 5: Cultural Heritage

The promoter will identify elements of cultural heritage that are likely to be adversely affected by the project and assess the likelihood of any chance finds. If, as an outcome of the screening process, it is deemed necessary to carry out an impact assessment, the promoter will use qualified and experienced cultural heritage specialists to study the cultural resources and to fully characterise the risks and impacts, consistent with a precautionary approach and reflecting the concerns of relevant stakeholders. The scope of the study will be agreed with the EIB on a case-by-case basis, either as part of the overall environmental and social assessment or separately.

Based on the results of the field surveys, expert assessment of the significance of cultural heritage, requirements of national legislation and relevant international conventions, as well as on the results of consultations with affected communities, the promoter will be required to develop appropriate mitigation measures in order to reduce and mitigate any adverse impacts on the cultural heritage, along with the implementation schedule and required budget for such measures. The promoter will also ensure that trained and qualified personnel are available to oversee the implementation of mitigation measures, and that any contractors working on the project have the necessary skills and expertise and are managed and monitored in accordance with the requirements.

The promoter will be responsible for locating and designing the project so as to avoid significant damage to cultural heritage. Where impacts cannot be avoided, the promoter will assess potential impacts and, if necessary, implement mitigation measures and/or any required changes in design, if applicable, providing information, at least on:

- proposed project and reasonable alternatives that were studied during the project preparation phases
- definition of the baseline conditions with a focus on the need for a clear understanding of all heritage values
- identification and definition, as well as investigation of the likely significant impacts through the implementation of an assessment
- consideration of the indirect and cumulative impacts
- Recommendation of new alternatives as needed and feasible and development of mitigation measures.

The promoter will ensure that provisions for managing chance finds, defined as physical cultural heritage encountered unexpectedly during project implementation, are in place. Such provisions shall include notification of relevant competent bodies of found objects or sites; alerting project personnel to the possibility of chance finds being discovered; and fencing-off the area of finds to avoid any further disturbance or destruction.

Such study does not form part of scope of this EIA report.

2.4.6. Standard 9: Occupational and Public Health, Safety and Security

6.1 Projects outside of the EU will be designed and will be operated consistent with EU Occupational and Public Health and Safety requirements. However the promoter will adhere to international good practice and to any obligations and standards to which the host country is party to. Where EU standards are more stringent than national standards, the higher EU standards are required if practical and feasible. In such cases the EIB will agree the applicable requirements with the promoter on a project by project basis. The promoter is responsible for legal compliance whereas regulatory and enforcement tasks lie with the competent authorities.

6.2 The promoter will identify and evaluate occupational and public health and safety risks and potential adverse impacts arising directly or indirectly from the project as early as possible, on a continuous basis throughout the entire project life cycle and along its supply chain. The promoter will develop and implement appropriate and adequate measures aiming at avoiding or preventing, or as a last resort, minimising or reducing, the identified risks and potential adverse impacts. The promoter will be guided by the precautionary principle, the principles that preventive action should be taken and that any impact should as a priority be effectively remedied at its source even if scientific data are insufficient, inconclusive or uncertain. The adopted measures will be applied taking into account differences in risk exposure and the higher sensitivity of the most socially and economically vulnerable and marginalised groups.

Appropriate resources for the implementation, monitoring and reporting of public health and safety measures and requirements will be planned for and budgeted by the promoter. Access to grievance and remedy should be ensured both for the workers and the public: the promoter will ensure that the affected stakeholders within the project's area of influence are properly identified, consulted and informed of their rights in terms of health, safety and security. This consultation shall take place as part of the assessment (e.g. as part of the EIA process when applicable) and subsequently during the project life of the project when judged necessary.

The promoter will ensure that all these requirements are duly inscribed in the procurementand contracting documents of first-tier suppliers and primary contractors. The promoter should establish a unit or team assigned with the above tasks.

Handling of hazardous materials will be done as per Indian law. The promoter shall assess the risks and impacts upon workers, local society and communities in and surrounding the project area of influence resulting from the use of arrangements provided by security personnel.

2.4.7. Standard 10: Stakeholder Engagement

Stakeholder engagement, including disclosure and dissemination of information, will be planned for and carried out in line with the principles of prior, informed and free engagement and informedparticipation, in order to lead to broad community support by the affected communities and longer-term sustainability of the project's activities. Stakeholders' inputs will be documented and carefully considered throughout the project preparation and implementation phases.

Effective and meaningful engagement and consultation to be guided by the following general principles:

- be initiated by the promoter early in the process of identification of environmental risks and potential adverse impacts and continue throughout the project life cycle
- be inclusive of the affected communities, and accessible to any vulnerable groups within, anddifferentiated by various segments
- be inclusive, beyond the affected parties, of any groups or individuals who have been identified as other interested parties; and,
- be adequately documented both in substance and process.

In this project the first round of consultations will be carried out before draft EIA report is prepared and second round carried out in form of disclosure of mitigation measures after EIA report is approved by competent authority.

The promoter will provide the following information to all identified stakeholders who are likely to be affected by adverse environmental or social impacts from the project:

- The purpose nature, objectives and scale of the project;
- The duration of proposed project activities;
- Any risks to and potential adverse impacts with regard to the environment, land tenure changes (resettlement, land acquisition or expropriation), occupational and community health, safety and security, and any other potential adverse impact on communities arising from the project;
- The proposed mitigation plans and associated budget;
- The available grievance mechanisms;
- Any added value and opportunities for benefit-sharing;
- The envisaged consultation process, if any, and opportunities and ways in which the public can participate; and,
- Time and venue of any envisaged public meetings, and the process by which meetings arenotified, summarised, and reported.

In line with Standard 7, the principle of free, prior, informed consent refers to the process whereby an affected community of indigenous peoples arrives at a decision in accordance with their legal provisions, cultural traditions and practices. The UN Declaration on the Rights of Indigenous Peoples ratified in 2007 is the standard to be applied in the implementation of sustainable development projects at all levels, including respect for full participation in decision-making and indigenous peoples' free, prior informed consent to policies, programmes and projects affecting them.

The promoter will ensure that a grievance mechanism is introduced at project level, irrespective of other complementary linkages or access to existing public grievance channels. Promoter is required to monitor the implementation of the stakeholder engagement plan and the performance of the grievance mechanism and report.

2.5. ENVIRONMENTAL AND SOCIAL RISK MANAGEMENT POLICY FOR AFD-FUNDED OPERATIONS

2.5.1 Validity and revision of this policy

This policy was adopted on 13 July 2017 and will apply for 3 years following its adoption (unless it is amended, if necessary). A new policy may once again be drafted, adopted and implemented for a period to be determined in due time.

2.5.2 Overarching Requirements

AFD's financing is conditional upon the implementation by the client of continuous and systematic environmental and social assessment procedures to (i) assess the environmental and social impacts of operations, (ii) propose appropriate measures to avoid the negative impacts or, when they are unavoidable, reduce or offset them in an appropriate manner, (iii) monitor the application of such measures during the implementation phase of the operation, and (iv) conduct an *ex post* evaluation of the effectiveness of the proposed measures.

Environmental and social issues are to be taken into account as early on as possible, right from the design stage.

2.5.3 Categorization of the environmental and social risk

AFD analyzes and classifies all potential projects into High – Substantial – Moderate – Low environmental and social risks, depending on the extent of the potential risks borne by the operation. The classification takes into account the nature and scale of the operation, the location and sensitivity of the affected area, the severity of the potential environmental and social risks and impacts, as well as the client's capacity to manage them.

Categorization is to be done in terms of direct, indirect, cumulative and induced risks and impacts in the area of influence of the operation. **This Report for Pune Metro does not cover cumulative and induced risks and impacts.**

A detailed Environmental and Social Assessment (ESA) is prescribed for projects in both the High and Substantial Risks category. It may be in a simplified form for those in the Moderate Risks category. Generally speaking, no environmental and social assessment is required for projects in the Low Risks category.

This classification system is intended to be used by AFD to review and monitor environmental and social performance – and threats thereto - throughout the project cycle such that agreed commitments are delivered and changes to the project and unforeseen risks and impacts are addressed. Unforeseen impacts and risks for example arising from considerations such as legal, institutional, governance, legislation, conflict etc. could impact delivery of the impact environmental mitigation measures and their outcomes: these factors are also taken into account in classification of the project. ***However such impacts and risks are not assessed in this Report for Pune Metro.***

In general, more significant impacts will result from large scale, Greenfield construction and irreversible impacts. High Risk project has impacts with majority or all of these characteristics: long term, permanent and /or irreversible and impossible to avoid; high in magnitude or spatial extent; cumulative and/or transboundary in nature; high probability of serious adverse effects on human health and/or environment (example due to accidents, toxic waste disposal etc).

Following discussion with Funding Agencies Pune Metro project is classified as `High Risk`.

The Borrower is required to carry out assessment of impacts and risks due to the project during each stage of the project cycle. **This Report is being prepared towards assessment during the design/pre-implementation stage of the project cycle.**

2.5.4 Coordinated approach

The objectives and content of the detailed ESA, ESMP and RAP comply with the provisions of the World Bank's Environmental & Social Standard for the Assessment and Management of Environmental and Social Risks and Impacts.

2.5.5 Environmental & Social Commitment Plan (ESCP)

For projects classified as having High, Substantial or Moderate risks, AFD requires the client to formalize the project's environmental and social commitments in a document called the Environmental & Social Commitment Plan. The ESCP is developed to set out briefly, in a single document laid out in table format, the measures and actions required for the project to comply with the environmental and social performance targets applied by AFD, according to a specific timetable and deemed satisfactory to AFD.

2.5.6 Consultations

For High and Substantial risk projects, the analyses conducted (ESA, ESMP) must be subject to a free, prior and informed consultation of the people potentially affected by the project, the central and local administrations impacted and civil society representatives involved in environmental and social issues. This consultation process may be conducted at various stages of the assessment process, in line with national regulations. Conclusions must be used in the final drafting of the assessment reports submitted for AFD's approval.

2.5.7 Disclosure

Once the environmental and social documents have been approved by AFD, especially the ESA, ESMP and/or RAP, the client will make these documents available to the public; collect relevant feedback from the persons or groups who have accessed these documents; revise the documents if necessary during implementation of a project.

2.5.8 Implementation Monitoring

Throughout project implementation, the client reports to AFD on progress in implementing mitigation measures and results achieved.

2.5.9 Grievance redress mechanism

The client will set up and fund a Project level grievance redress mechanism while providing it with adequate resources.

2.5.10 Management of later amendments

Amendments to the nature and scope of a project which may occur after financing approval has been granted by AFD may have significant environmental and/or social implications. In such case, AFD will conduct environmental and social due diligence on these amendments and if found necessary new stakeholder consultations and/or new environmental and social mitigation measures will be integrated into the project. **Impacts due to such amendments are not assessed in this Report for Pune Metro.**

2.5.11 Co-financing operations

AFD makes every effort to agree on a common approach for the assessment and management of the project's environmental and social risks with the co financier(s). If AFD is not the coordinator of the financing, AFD assesses the environmental and social documents produced under the responsibility of the client and/or lead funder. AFD may request additional information and/or implement complementary due diligence. When AFD is the lead or coordinator of the financing, AFD procedures are used for the due diligence required by the co-financier and implemented by the client.

2.6. IFC PERFORMANCE STANDARDS ON ENVIRONMENTAL & SOCIAL SUSTAINABILITY

The Policy onEnvironmental and Social Sustainabilitydescribes International Finance Corporation(IFC) commitments, roles, andresponsibilities related to environmentaland social sustainability.The PerformanceStandards are directed towards clients,providing guidance on how to identify risksand impacts, and are designed to help avoid,mitigate, and manage risks and impactsas a way of doing business in a sustainableway, including stakeholder engagementand disclosure obligations of the client inrelation to projectlevel activities. Performance standards issued by IFC are given below:

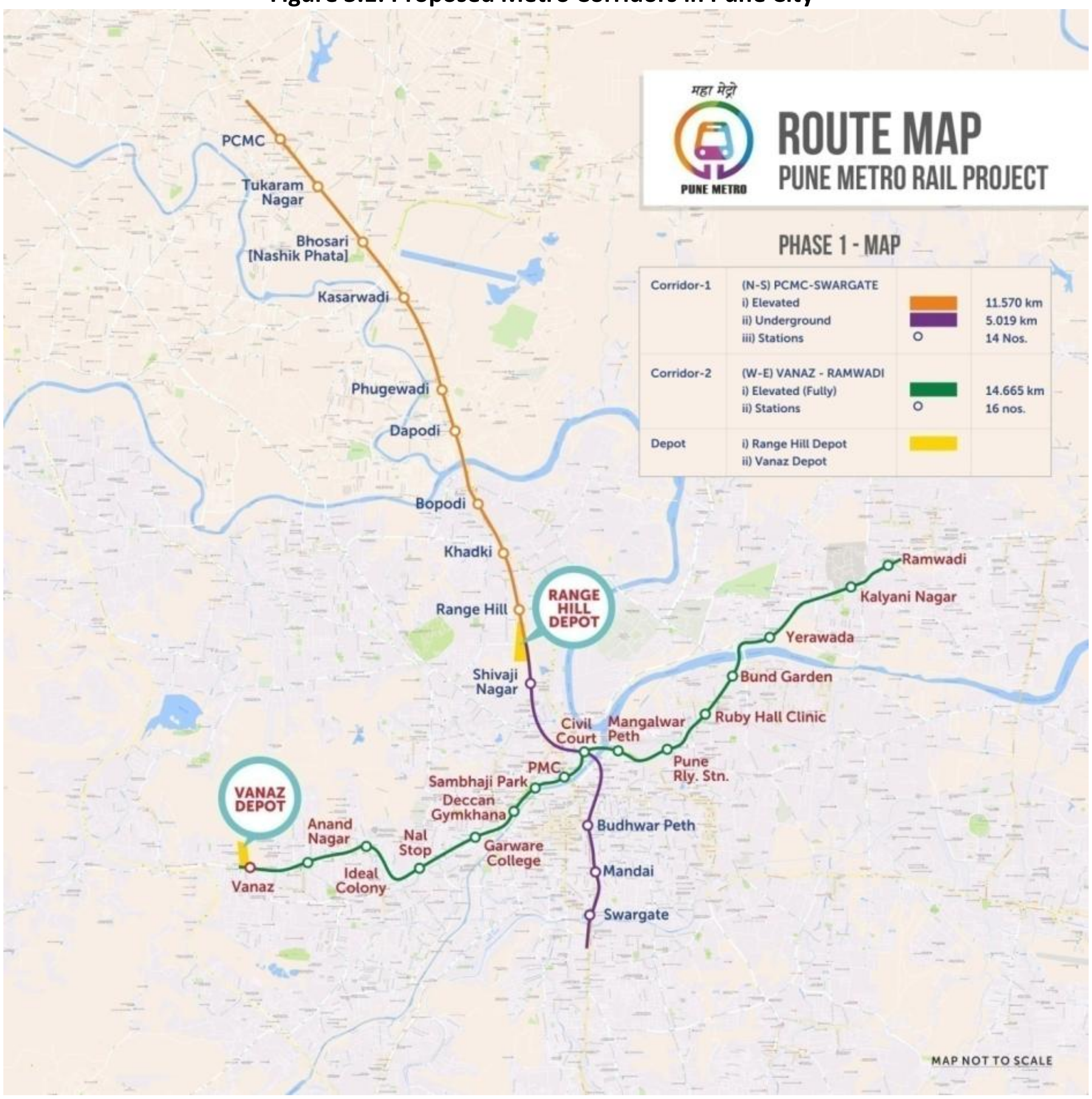
- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts
- Performance Standard 2: Labour and Working Conditions
- Performance Standard 3: Resource Efficiency and Pollution Prevention
- Performance Standard 4: Community Health, Safety, and Security
- Performance Standard 5: Land Acquisition and Involuntary Resettlement
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
- Performance Standard 7: Indigenous Peoples
- Performance Standard 8: Cultural Heritage

Chapter 3 : Project Description

3.1. STUDY AREA

With a view of developing effective and efficient mass transit system in addition to the existing public transportation, the Maharashtra Metro Rail Corporation Ltd intends to develop the proposed Pune Metro Rail Project having North-South and East-West Corridors. The proposed metro corridors in Pune city are shown in Figure 3.1.

Figure 3.1: Proposed Metro Corridors in Pune City



3.2. PROJECT DESCRIPTION

Two corridors have been finalized for implementation of Metro Rail Project in Pune. The details are given below:

- North South Corridor: PCMC to Swargate
- West East Corridor: Vanaz to Ramwadi

Two Corridors vizNorth – South Corridor (PCMC to Swargate) of length 16.59 km and East–West Corridor (Vanaz to Ramwadi) of length 14.67 kmwere proposed. The salient features of the corridors are summarised in the following sections. These corridors will provides connectivity to all congested, important and densely populated areas of the city.Details of the length of corridors, elevated/underground length and number of stations is given in Table 3.1.

Table 3.1: Salient Features of the Corridors

S. NO	ROUTE	LENGTH IN KM			STATIONS
1.	North – South Corridor (PCMC to Swargate)	Elevated	11.570	16.589	9
		Underground	5.019		5
2.	East–West Corridor (Vanaz to Ramwadi)	Elevated		14.665	16
			TOTAL	**31.254**	**30**

North – South Corridor: PCMC to Swargate

The proposed alignment of N-S Corridor starts from PCMC in the North as elevated section and heads towards Swargate in South as UG section. Total 14 stations have been proposed along the N-S corridor of which 9 stations are elevated and 5 stations are UG. Summary list of stations along the corridor is given in Table 3.2. The alignment plan for N-S corridor is shown in Figure 3.2.

Table 3.2: Proposed Stations along N-S Corridor

S. No	Station Name	Chainage (m)	Inter Station Distance (m)	Elevated/ Underground
1	PCMC	-340	-	Elevated
2	SantTukaram Nagar	1763	2103	Elevated
3	Bhosari	2550	787	Elevated
4	Kasarwadi	3818	1268	Elevated
5	Phugewadi	4846	1028	Elevated
6	Dapodi	5712	866	Elevated
7	Bopodi	7334	1622	Elevated
8	Khadki	8205	871	Elevated
9	Range Hill	9608	1403	Elevated
10	Shivaji Nagar	11734	2126	Underground

S. No	Station Name	Chainage (m)	Inter Station Distance (m)	Elevated/ Underground
11	**Civil Court - *Interchange Station***	12849	1115	Underground
12	Budhwarpeth (KasbaPeth)	14144	1295	Underground
13	Mandai	15003	859	Underground
14	Swargate	16539	1536	Underground

Source: Drawings of alignment provided by Maha-Metro for Pune Metro Rail Project

West–East Corridor: Vanaz to Ramwadi

The proposed alignment of W-E Corridor starts from Vanaz in the West and heads towards Ramwadi in East and the whole section is elevated. Total 16 stations have been proposed along the W-E corridor. Summary list of stations along the corridor is given in Table 3.3 and the alignment plan for W-E corridor is shown in Figure 3.2.

Table 3.3: Proposed Stations along W-E Corridor

S. No	Station Name	Chainage (m)	Inter Station Distance (m)	Elevated/ Underground
1	Vanaz	-23	-	Elevated
2	Anand Nagar	972	995	Elevated
3	Ideal Colony	1899	927	Elevated
4	Nal Stop	2761	862	Elevated
5	Garware College	3872	1111	Elevated
6	Deccan Gymkhana	4728	856	Elevated
7	Sambhaji Park	5254	526	Elevated
8	PMC	5970	716	Elevated
9	**Civil Court - *Interchange Station***	6613	643	Elevated
10	MangalwarPeth	7408	805	Elevated
11	Pune Rly. Stn	8300	892	Elevated
12	Ruby Hall Clinic	9177	877	Elevated
13	Bund Garden	10111	934	Elevated
14	Yerawada	10925	814	Elevated
15	Kalyani Nagar	12477	1552	Elevated
16	Ramwadi	13557	1080	Elevated

Source: Drawings of alignment provided by Maha-Metro for Pune Metro Rail Project

3.2.1. Stations

Station Design is dependent on the peak hour traffic load for each station. Accordingly maximum capacity required at any station for emergency evacuation has been adopted. Typical station drawings of Elevated, under ground and Interchange Stations are shown in Figure 3.3 to Figure 3.5.

Figure 3.2: Proposed Corridors of Pune Metro Rail Project

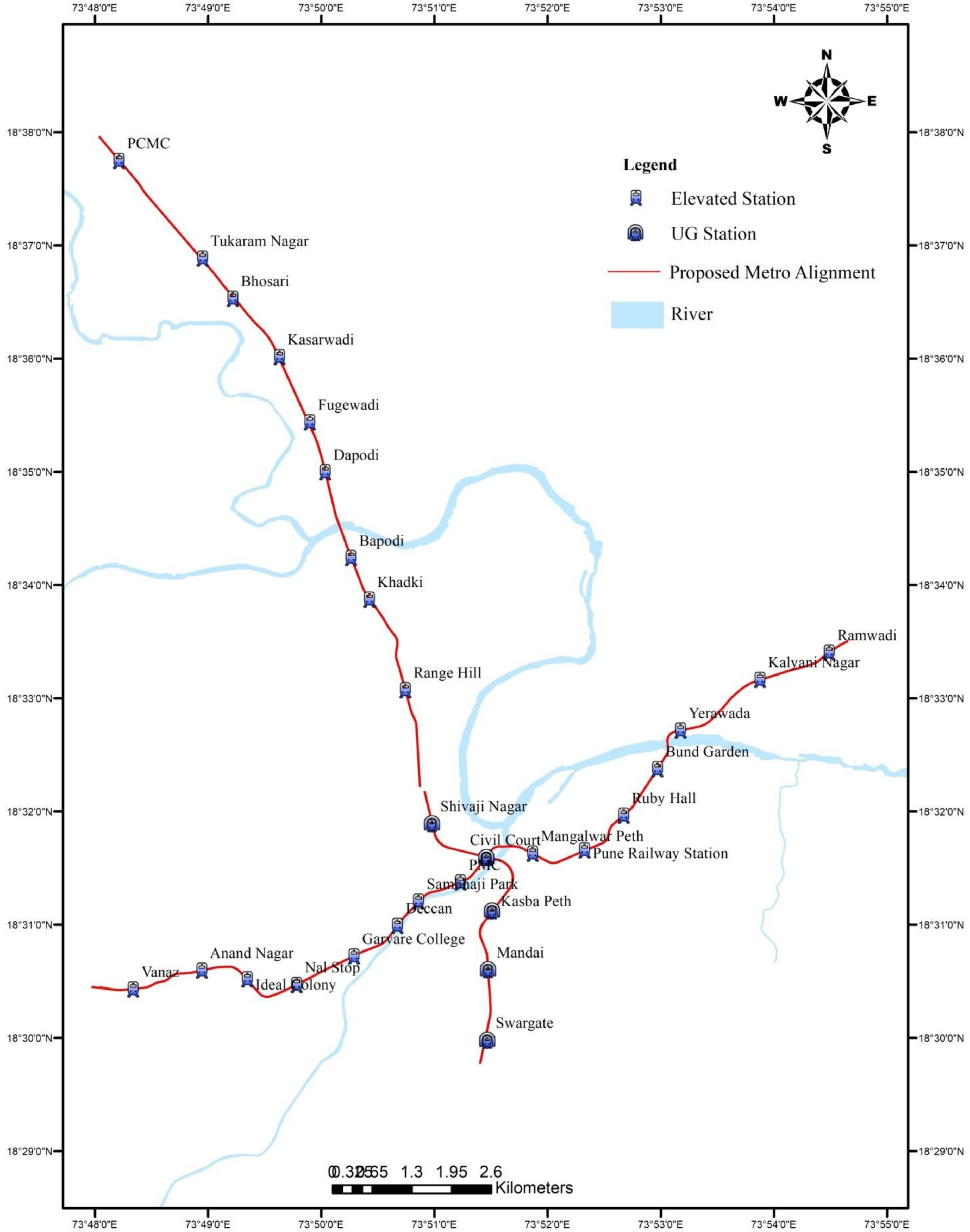
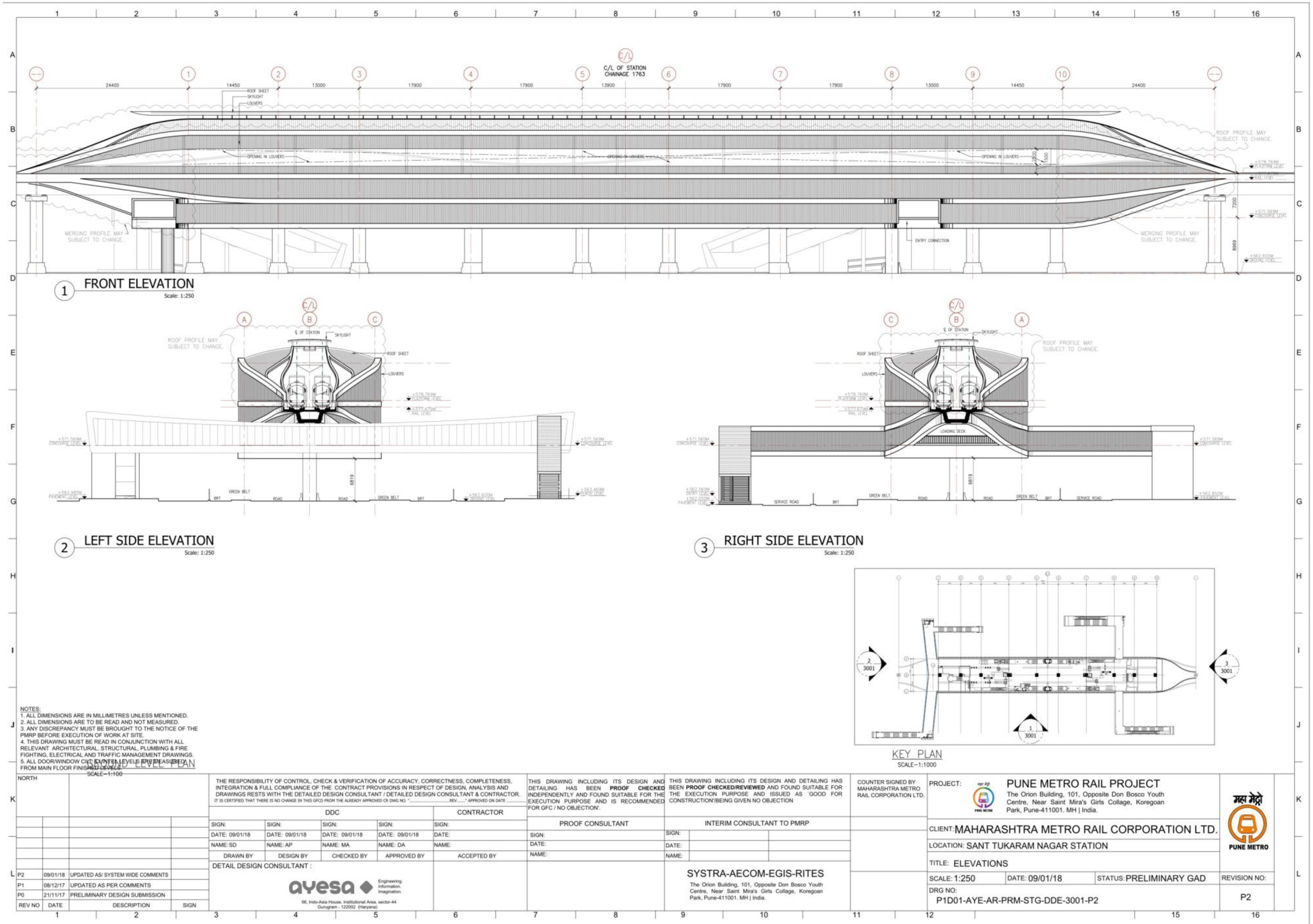
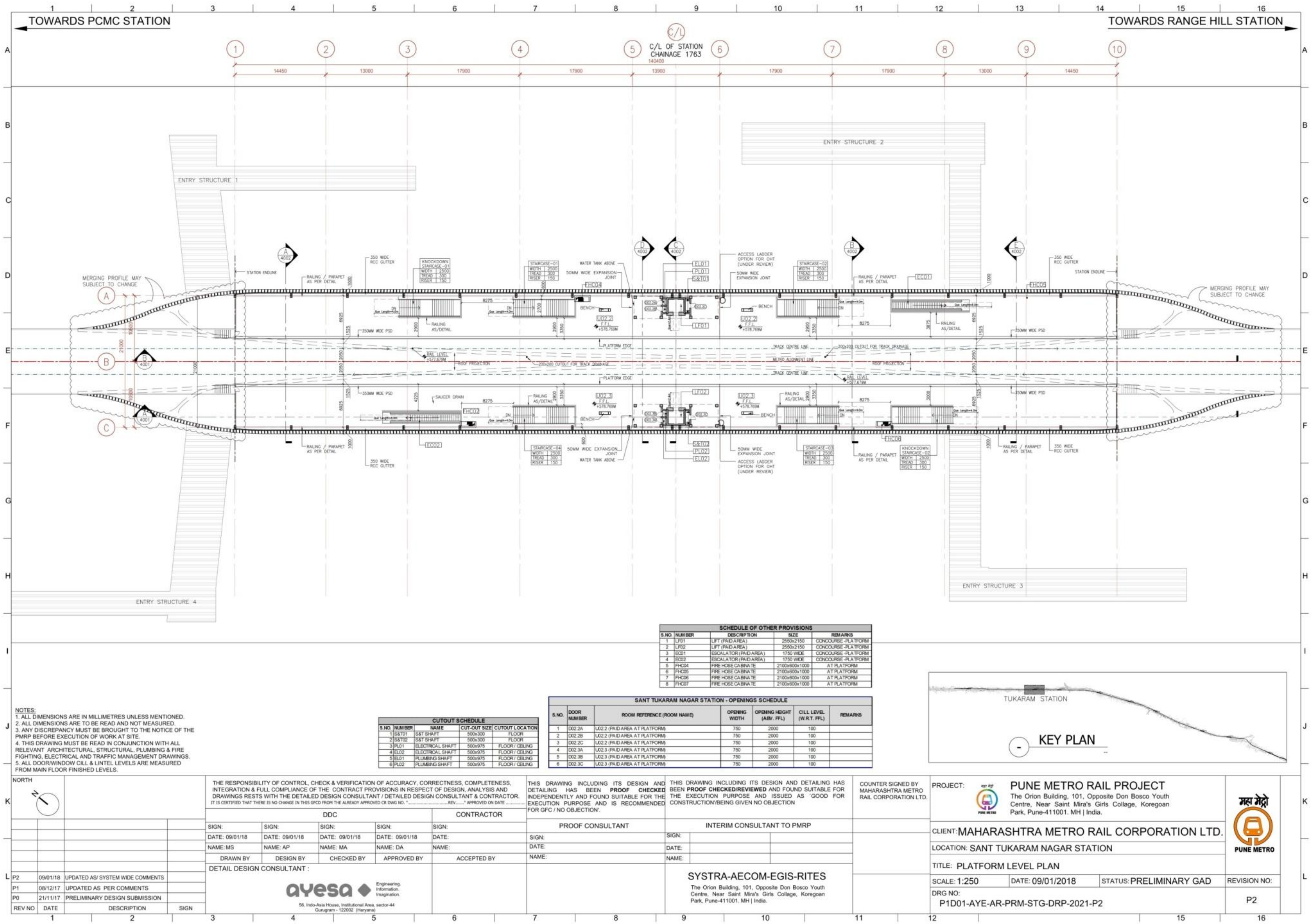


Figure 3.3: Typical Drawing of Elevated Station



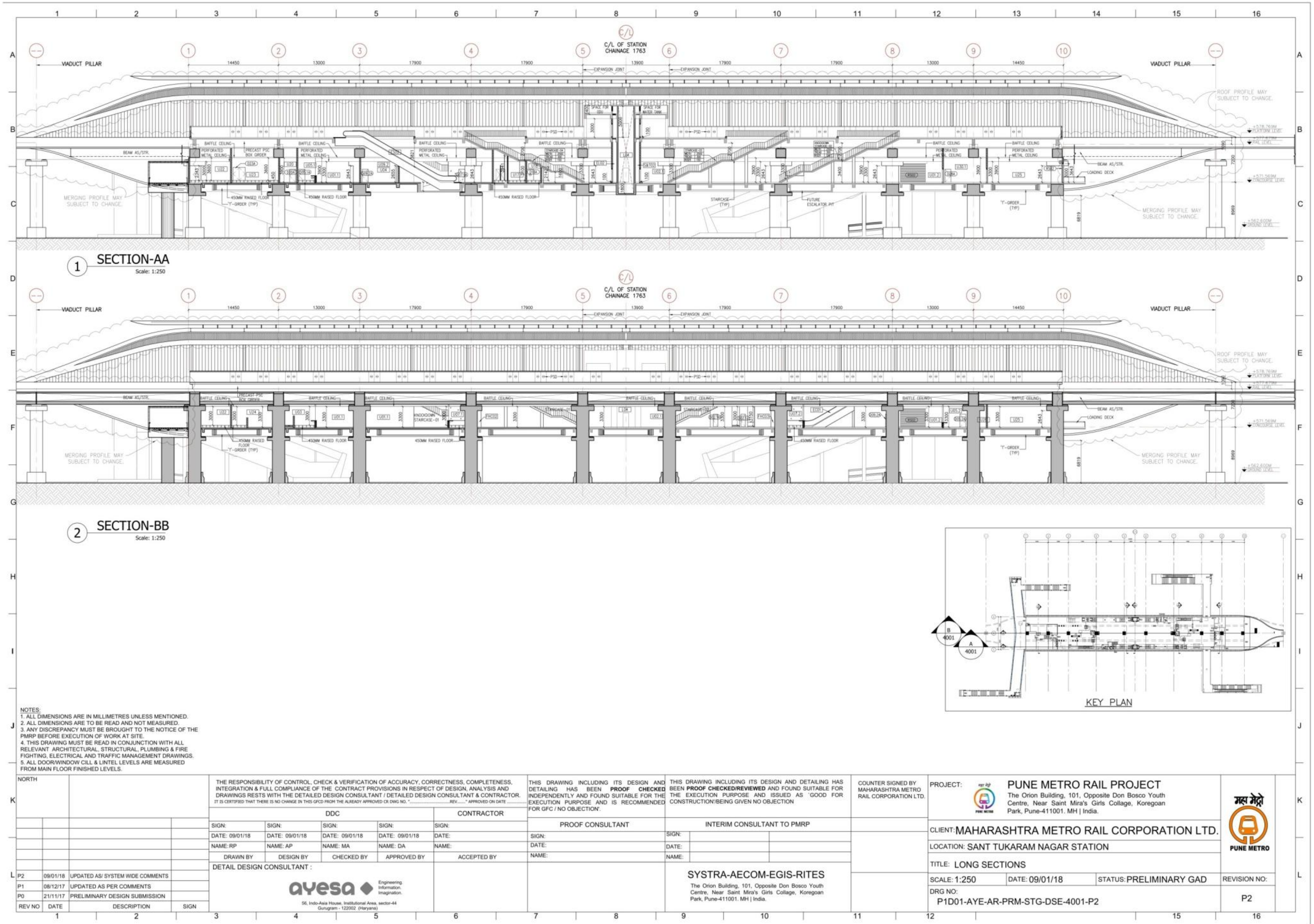

TOWARDS PCMC STATION
TOWARDS RANGE HILL STATION
C/L OF STATION
CHAINAGE 1763
ENTRY STRUCTURE 1
ENTRY STRUCTURE 2
ENTRY STRUCTURE 3
ENTRY STRUCTURE 4
MERGING PROFILE MAY SUBJECT TO CHANGE

SCHEDULE OF OTHER PROVISIONS				
S.NO.	NUMBER	DESCRIPTION	SIZE	REMARKS
1	LF01	LIFT (PAID AREA)	2550x2150	CONCOURSE -PLATFORM
2	LF02	LIFT (PAID AREA)	2550x2150	CONCOURSE -PLATFORM
3	EC01	ESCALATOR (PAID AREA)	1750 WIDE	CONCOURSE -PLATFORM
4	EC02	ESCALATOR (PAID AREA)	1750 WIDE	CONCOURSE -PLATFORM
5	FHC04	FIRE HOSE CABINATE	2100x600x1000	AT PLATFORM
6	FHC05	FIRE HOSE CABINATE	2100x600x1000	AT PLATFORM
7	FHC06	FIRE HOSE CABINATE	2100x600x1000	AT PLATFORM
8	FHC07	FIRE HOSE CABINATE	2100x600x1000	AT PLATFORM

CUTOUT SCHEDULE				
S.NO.	NUMBER	NAME	CUT-OUT SIZE	CUTOUT LOCATION
1	S&T01	S&T SHAFT	500x300	FLOOR
2	S&T02	S&T SHAFT	500x300	FLOOR
3	PL01	ELECTRICAL SHAFT	500x975	FLOOR / CEILING
4	EL02	ELECTRICAL SHAFT	500x975	FLOOR / CEILING
5	EL01	PLUMBING SHAFT	500x975	FLOOR / CEILING
6	PL02	PLUMBING SHAFT	500x975	FLOOR / CEILING

SANT TUKARAM NAGAR STATION - OPENINGS SCHEDULE						
S.NO.	DOOR NUMBER	ROOM REFERENCE (ROOM NAME)	OPENING WIDTH	OPENING HEIGHT (ABV. FFL)	CILL LEVEL (W.R.T. FFL)	REMARKS
1	D02.2A	U02.2 (PAID AREA AT PLATFORM)	750	2000	100	
2	D02.2B	U02.2 (PAID AREA AT PLATFORM)	750	2000	100	
3	D02.2C	U02.2 (PAID AREA AT PLATFORM)	750	2000	100	
4	D02.3A	U02.3 (PAID AREA AT PLATFORM)	750	2000	100	
5	D02.3B	U02.3 (PAID AREA AT PLATFORM)	750	2000	100	
6	D02.3C	U02.3 (PAID AREA AT PLATFORM)	750	2000	100	

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS MENTIONED.
2. ALL DIMENSIONS ARE TO BE READ AND NOT MEASURED.
3. ANY DISCREPANCY MUST BE BROUGHT TO THE NOTICE OF THE PMRP BEFORE EXECUTION OF WORK AT SITE.
4. THIS DRAWING MUST BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTURAL, STRUCTURAL, PLUMBING & FIRE FIGHTING, ELECTRICAL AND TRAFFIC MANAGEMENT DRAWINGS.
5. ALL DOOR/WINDOW CILL & LINTEL LEVELS ARE MEASURED FROM MAIN FLOOR FINISHED LEVELS.
TUKARAM STATION
KEY PLAN
NORTH
THE RESPONSIBILITY OF CONTROL, CHECK & VERIFICATION OF ACCURACY, CORRECTNESS, COMPLETENESS, INTEGRATION & FULL COMPLIANCE OF THE CONTRACT PROVISIONS IN RESPECT OF DESIGN, ANALYSIS AND DRAWINGS RESTS WITH THE DETAILED DESIGN CONSULTANT / DETAILED DESIGN CONSULTANT & CONTRACTOR.
THIS DRAWING INCLUDING ITS DESIGN AND DETAILING HAS BEEN PROOF CHECKED INDEPENDENTLY AND FOUND SUITABLE FOR THE EXECUTION PURPOSE AND IS RECOMMENDED FOR GFC / NO OBJECTION.
THIS DRAWING INCLUDING ITS DESIGN AND DETAILING HAS BEEN PROOF CHECKED/REVIEWED AND FOUND SUITABLE FOR THE EXECUTION PURPOSE AND ISSUED AS 'GOOD FOR CONSTRUCTION'/BEING GIVEN NO OBJECTION
COUNTER SIGNED BY MAHARASHTRA METRO RAIL CORPORATION LTD.
DDC
CONTRACTOR
PROOF CONSULTANT
INTERIM CONSULTANT TO PMRP
DATE: 09/01/18
NAME: MS
NAME: AP
NAME: MA
NAME: DA
DRAWN BY
DESIGN BY
CHECKED BY
APPROVED BY
ACCEPTED BY
DETAIL DESIGN CONSULTANT :
ayesa
SYSTRA-AECOM-EGIS-RITES
P2 09/01/18 UPDATED AS/ SYSTEM WIDE COMMENTS
P1 08/12/17 UPDATED AS PER COMMENTS
P0 21/11/17 PRELIMINARY DESIGN SUBMISSION
PROJECT: PUNE METRO RAIL PROJECT
CLIENT: MAHARASHTRA METRO RAIL CORPORATION LTD.
LOCATION: SANT TUKARAM NAGAR STATION
TITLE: PLATFORM LEVEL PLAN
SCALE: 1:250
DATE: 09/01/2018
STATUS: PRELIMINARY GAD
REVISION NO: P2
DRG NO: P1D01-AYE-AR-PRM-STG-DRP-2021-P2
PUNE METRO


C/L OF STATION CHAINAGE 1763
VIADUCT PILLAR
EXPANSION JOINT
ROOF PROFILE MAY SUBJECT TO CHANGE.
MERGING PROFILE MAY SUBJECT TO CHANGE.
SECTION-AA
Scale: 1:250
SECTION-BB
Scale: 1:250
KEY PLAN
NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS MENTIONED.
2. ALL DIMENSIONS ARE TO BE READ AND NOT MEASURED.
3. ANY DISCREPANCY MUST BE BROUGHT TO THE NOTICE OF THE PMRP BEFORE EXECUTION OF WORK AT SITE.
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5. ALL DOOR/WINDOW CILL & LINTEL LEVELS ARE MEASURED FROM MAIN FLOOR FINISHED LEVELS.
NORTH
THE RESPONSIBILITY OF CONTROL, CHECK & VERIFICATION OF ACCURACY, CORRECTNESS, COMPLETENESS, INTEGRATION & FULL COMPLIANCE OF THE CONTRACT PROVISIONS IN RESPECT OF DESIGN, ANALYSIS AND DRAWINGS RESTS WITH THE DETAILED DESIGN CONSULTANT / DETAILED DESIGN CONSULTANT & CONTRACTOR.
DDC
CONTRACTOR
DATE: 09/01/18
NAME: RP
NAME: AP
NAME: MA
NAME: DA
DRAWN BY
DESIGN BY
CHECKED BY
APPROVED BY
ACCEPTED BY
DETAIL DESIGN CONSULTANT :
ayesa
56, Indo-Asia House, Institutional Area, sector-44 Gurugram - 122002 (Haryana)
P2 09/01/18 UPDATED AS/ SYSTEM WIDE COMMENTS
P1 08/12/17 UPDATED AS PER COMMENTS
P0 21/11/17 PRELIMINARY DESIGN SUBMISSION
REV NO DATE DESCRIPTION SIGN
THIS DRAWING INCLUDING ITS DESIGN AND DETAILING HAS BEEN PROOF CHECKED INDEPENDENTLY AND FOUND SUITABLE FOR THE EXECUTION PURPOSE AND IS RECOMMENDED FOR GFC / NO OBJECTION'.
PROOF CONSULTANT
THIS DRAWING INCLUDING ITS DESIGN AND DETAILING HAS BEEN PROOF CHECKED/REVIEWED AND FOUND SUITABLE FOR THE EXECUTION PURPOSE AND ISSUED AS 'GOOD FOR CONSTRUCTION'/BEING GIVEN NO OBJECTION
INTERIM CONSULTANT TO PMRP
SYSTRA-AECOM-EGIS-RITES
The Orion Building, 101, Opposite Don Bosco Youth Centre, Near Saint Mira's Girls Collage, Koregoan Park, Pune-411001. MH | India.
COUNTER SIGNED BY MAHARASHTRA METRO RAIL CORPORATION LTD.
PROJECT: PUNE METRO RAIL PROJECT
The Orion Building, 101, Opposite Don Bosco Youth Centre, Near Saint Mira's Girls Collage, Koregoan Park, Pune-411001. MH | India.
CLIENT: MAHARASHTRA METRO RAIL CORPORATION LTD.
LOCATION: SANT TUKARAM NAGAR STATION
TITLE: LONG SECTIONS
SCALE: 1:250
DATE: 09/01/18
STATUS: PRELIMINARY GAD
REVISION NO: P2
DRG NO: P1D01-AYE-AR-PRM-STG-DSE-4001-P2
PUNE METRO

Figure 3.4: Street Level Plan Drawing of Underground Station

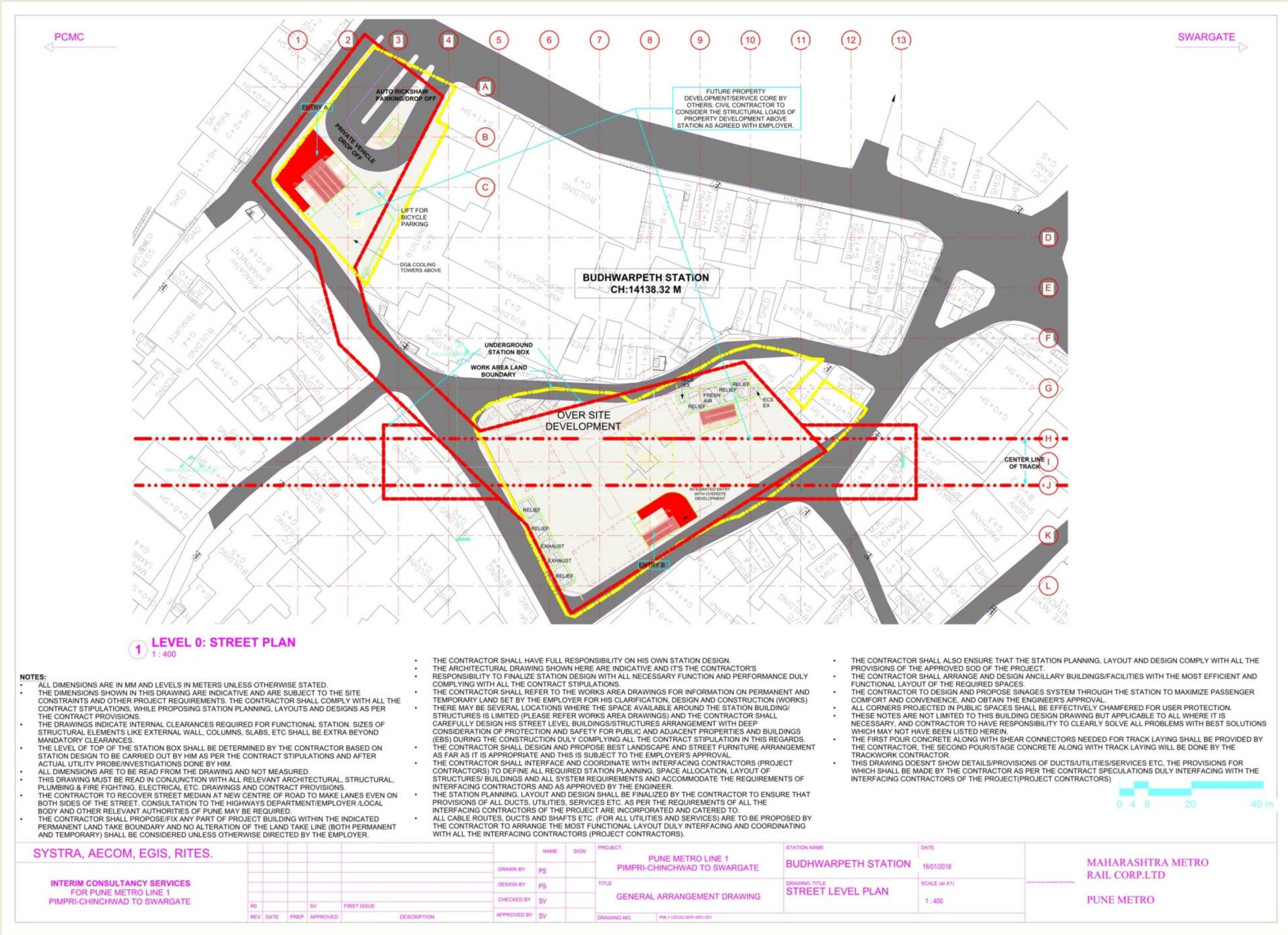
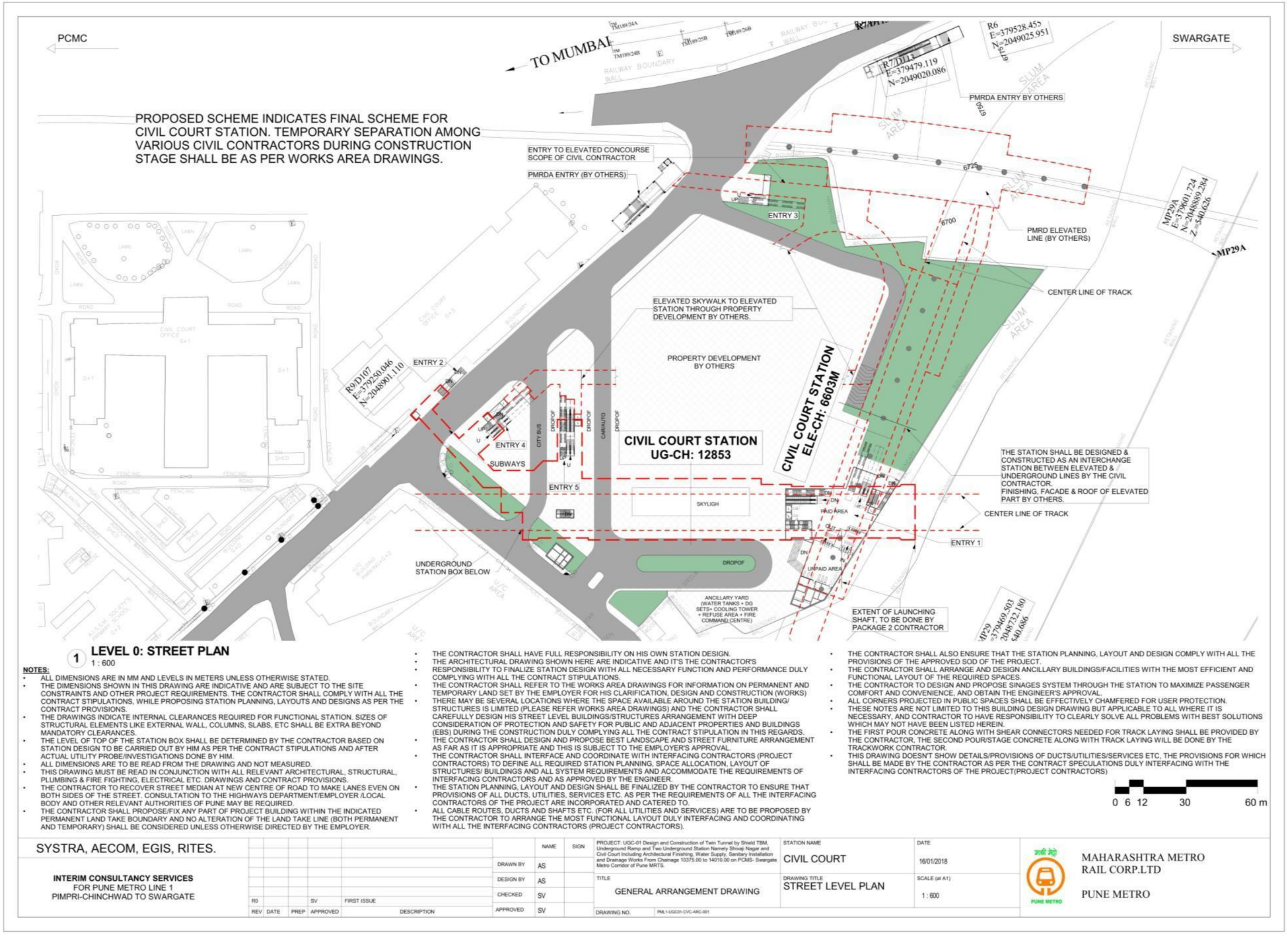
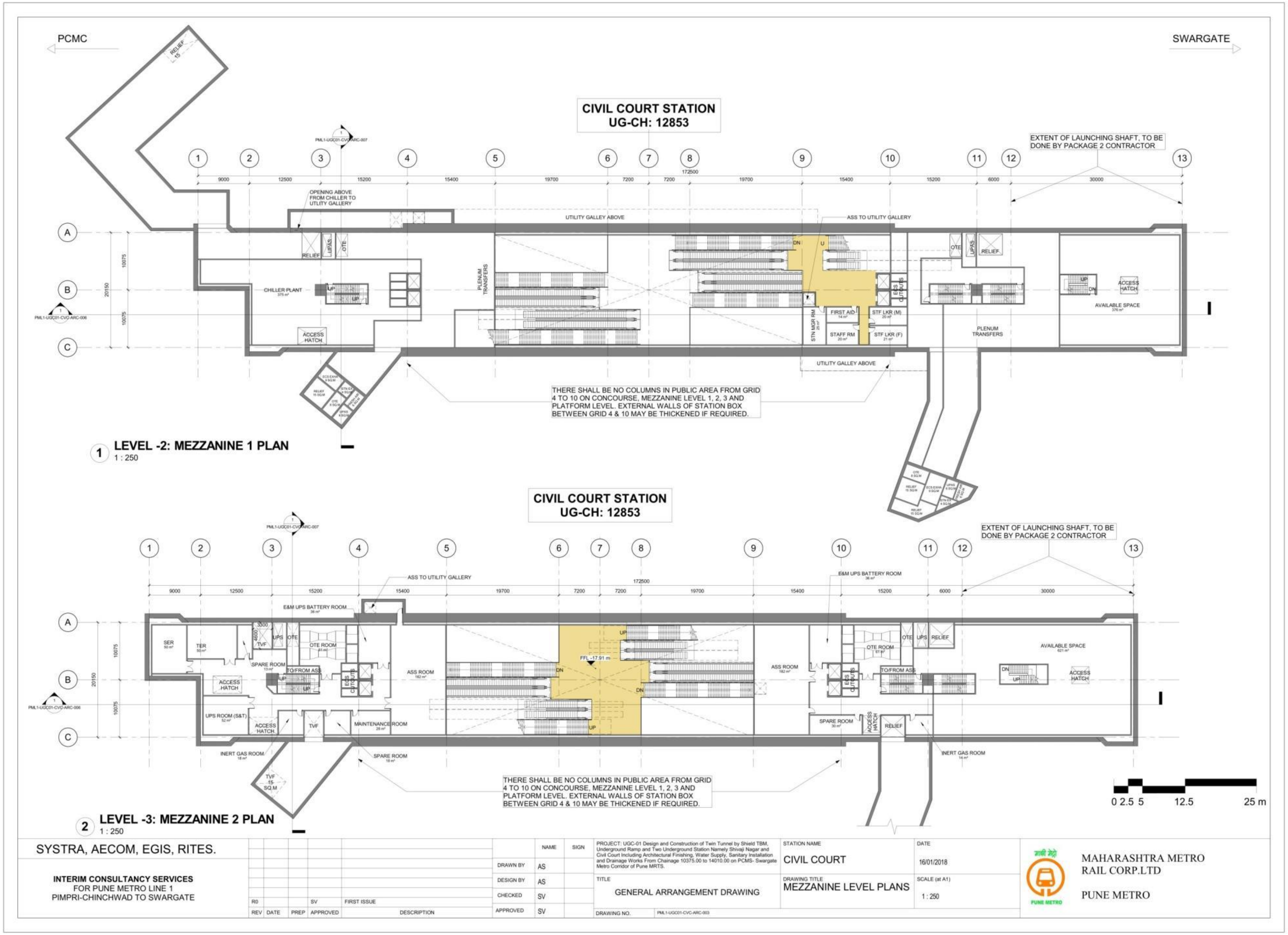


Figure 3.5: Typical Drawing of Interchange Station




PCMC
SWARGATE
CIVIL COURT STATION
UG-CH: 12853
EXTENT OF LAUNCHING SHAFT, TO BE DONE BY PACKAGE 2 CONTRACTOR
UTILITY GALLEY ABOVE
ASS TO UTILITY GALLERY
CHILLER PLANT
ACCESS HATCH
PLENUM TRANSFERS
FIRST AID
STAFF RM
STF LKR (M)
STF LKR (F)
AVAILABLE SPACE
THERE SHALL BE NO COLUMNS IN PUBLIC AREA FROM GRID 4 TO 10 ON CONCOURSE, MEZZANINE LEVEL 1, 2, 3 AND PLATFORM LEVEL. EXTERNAL WALLS OF STATION BOX BETWEEN GRID 4 & 10 MAY BE THICKENED IF REQUIRED.
1 LEVEL -2: MEZZANINE 1 PLAN
1 : 250
CIVIL COURT STATION
UG-CH: 12853
EXTENT OF LAUNCHING SHAFT, TO BE DONE BY PACKAGE 2 CONTRACTOR
ASS TO UTILITY GALLERY
E&M UPS BATTERY ROOM
OTE ROOM
SPARE ROOM
ASS ROOM
UPS ROOM (S&T)
MAINTENANCE ROOM
INERT GAS ROOM
AVAILABLE SPACE
ACCESS HATCH
THERE SHALL BE NO COLUMNS IN PUBLIC AREA FROM GRID 4 TO 10 ON CONCOURSE, MEZZANINE LEVEL 1, 2, 3 AND PLATFORM LEVEL. EXTERNAL WALLS OF STATION BOX BETWEEN GRID 4 & 10 MAY BE THICKENED IF REQUIRED.
2 LEVEL -3: MEZZANINE 2 PLAN
1 : 250
0 2.5 5 12.5 25 m
SYSTRA, AECOM, EGIS, RITES.
INTERIM CONSULTANCY SERVICES
FOR PUNE METRO LINE 1
PIMPRI-CHINCHWAD TO SWARGATE
STATION NAME
CIVIL COURT
DATE
16/01/2018
TITLE
GENERAL ARRANGEMENT DRAWING
DRAWING TITLE
MEZZANINE LEVEL PLANS
SCALE (at A1)
1 : 250
MAHARASHTRA METRO
RAIL CORP.LTD
PUNE METRO

3.2.2. Permanent Way

Gauge: Standard Gauge which is adopted for this metro railway permits sharper curves, which is advantageous for metro alignment in urban scenario and results in minimized property demolition and property acquisition. The Land requirement for the maintenance depots is also lower in Standard Gauge. Standard Gauge rolling stock results in recurring saving in energy consumption during operation as for the same passenger carrying capacity, gross weight of a metro coach is lower.

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

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

3.2.3. Signalling & Train Control System

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

3.2.4. Fare Collection System

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

3.2.5. Traction System

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

3.2.6. Ventilation and Air-Conditioning System

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

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

3.2.7. Rolling Stock

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

3.2.8. Depots

Two depots are planned for the above Project, one near Range Hill Station (Agriculture College Land) to cater the need of North-South Corridor and the other near Vanaz Station (Katchra Depot Land) to cater the need of East-West Corridor. The depots are to be developed with full/light/heavy repair facilities, stabling and light inspection facilities. Both these depots will have test tracks. Layout maps of Range Hill Depot and Vanaz Depot are shown in Figure 3.6 and 3.7 respectively.

3.2.9. Construction Activities

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

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

3.3. COST ESTIMATE

Detailed cost estimates for Corridor-1 (PCMC - Swargate) and Corridor-2 (Vanaz - Ramvadi) have been prepared in DPR covering civil, electrical, signalling and telecommunications works, rolling stock, environmental protection, rehabilitation, etc., considering 25 kV ac Overhead Traction System at November 2015 price level.

3.3.1. Capital Cost Estimate: PCMC -Swargate

The overall capital cost for PCMC - Swargate Corridor, at November 2015price level, works out to Rs.5333 crores, excluding taxes and duties, but including general charges & design charges @ 5% on all items except land and 3% contingencies on all items. The abstract capital cost estimates are shown in Table 3.4 below:

Figure 3.6: Layout Map of Range Hill Depot

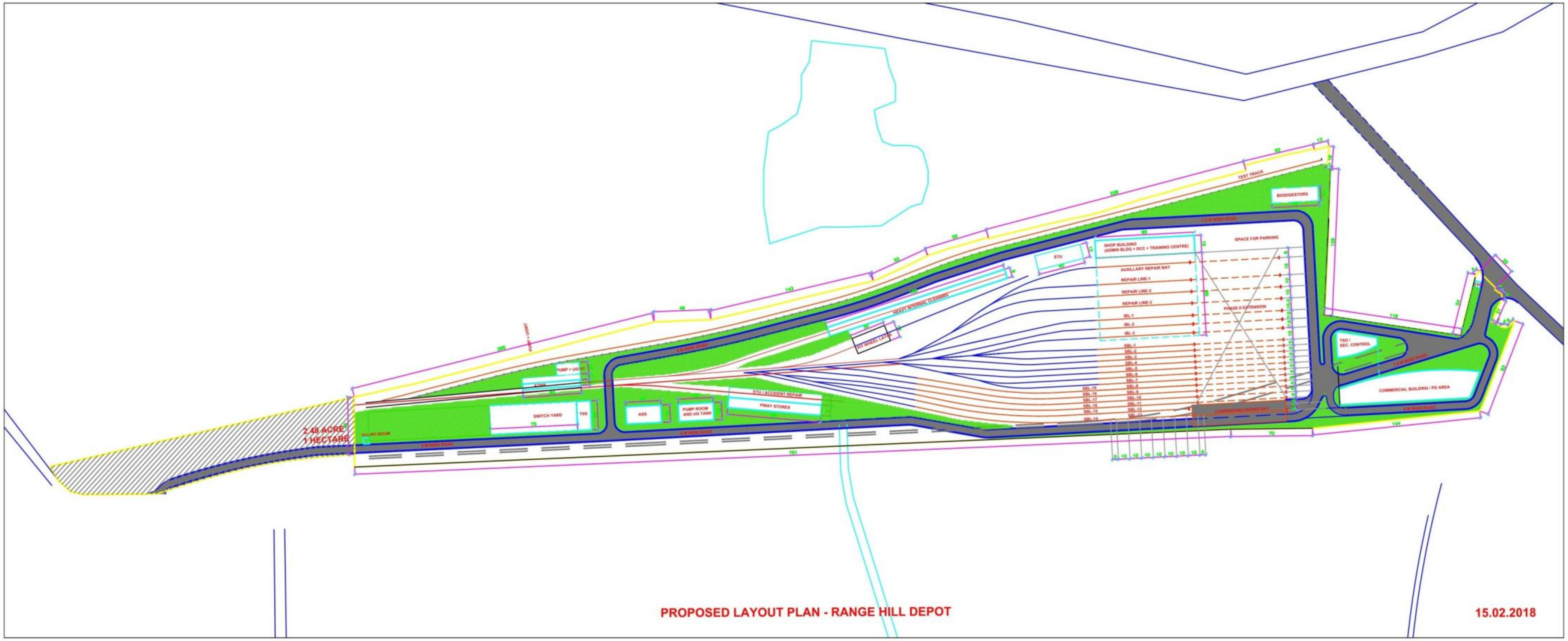


Figure 3.7: Layout Map of Vanaz Depot

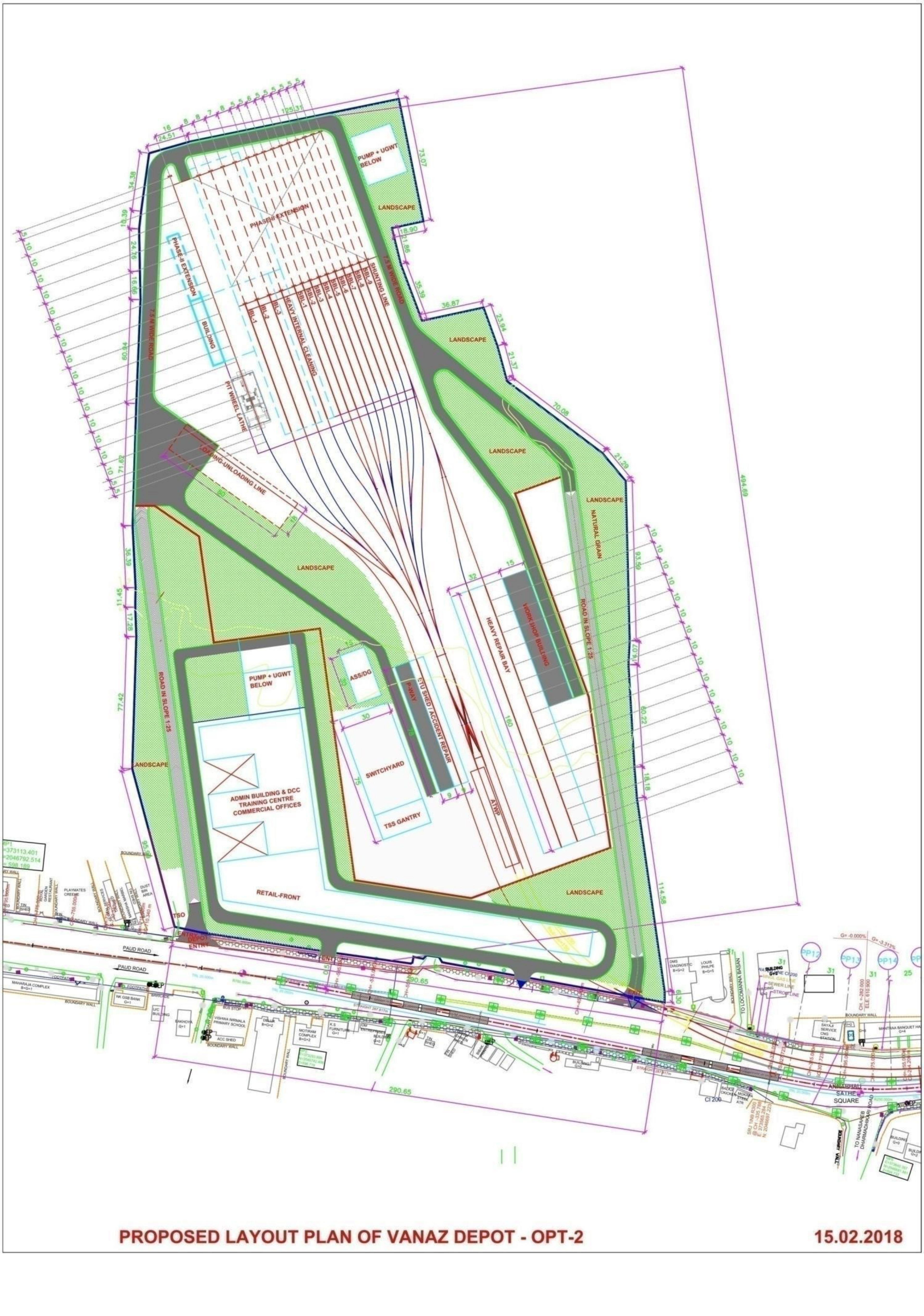


Table 3.4: Capital Cost Estimate: PCMC - Swargate

Total length = 16.589 km, UG= 5.019 km and Elv = 11.570 km Total Station = 14 nos, UG = 5 and Elv =9		
S. No	**Item**	**Amount in Rs. Crore**
1.	Land	566.34
2.	Alignment and Formation	901.21
3.	Station Buildings	1681.09
4.	Depot	150.00
5.	P-Way	149.85
6.	Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators	207.23
7.	Signalling and Telecom.	357.75
8.	Misc. Utilities, roadworks, other civil works such as median stn.signages Environmental protection	119.15
9.	Rolling Stock	805.62
10.	Capital expenditure on security	20.00
11.	Total of all items except Land	4391.90
12.	General Charges incl. Design charges @ 5 % on all items except land	219.60
13.	Total of all items including G. Charges except land	4611.50
14.	Contingencies @ 3 %	138.34
15.	Gross Total	4749.84
Cost without land = Rs. 4750 Crore		
Cost with land = Rs. 5333 Crore		

Source: DPR, Nov 2015

3.3.2. Capital Cost Estimate: Vanaz - Ramwadi

The overall capital cost for Vanaz - Ramwadi Corridor at November 2015price level, works out to Rs. 2794 crores, excluding taxes and duties, but including general charges & design charges @ 5% on all items except land and 3% contingencies on all items. The abstract capital cost estimates are shown at Table 3.5.

Table 3.5: Capital Cost Estimate: Vanaz - Ramwadi

Total length = 14.665 km, UG= 0 km and Elv = 14.665 km Total Station = 16 nos, UG = 0 and Elv =15		
S. No	**Item**	**Amount in Rs. Crore**
1.	Land	338.35
2.	Alignment and Formation	503.77
3.	Station Buildings	610.76
4.	Depot	150.00
5.	P-Way	134.79
6.	Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators	161.99
7.	Signalling and Telecom.	327.49
8.	Misc. Utilities, roadworks, other civil works such as median stn.signages Environmental protection	55.57
9.	Rolling Stock	296.81
10.	Capital expenditure on security	20.00
11.	Total of all items except Land	2261.18

Total length = 14.665 km, UG= 0 km and Elv = 14.665 km Total Station = 16 nos, UG = 0 and Elv =15		
S. No	**Item**	**Amount in Rs. Crore**
12.	General Charges incl. Design charges @ 5 % on all items except land	113.06
13.	Total of all items including G. Charges except land	2374.23
14.	Contingencies @ 3 %	71.23
15.	Gross Total	2445.46
16.		
Cost without land = Rs. 2445 Crore		
Cost with land = Rs. 2794 Crore		

Source: DPR, Nov 2015

3.4. ANALYSIS OF ALTERNATIVES

Due to the growing population and economic activities, traffic congestion in Pune has been increasing. A number of Reports have been prepared seeking to recommend solutions. Some of them are as follows:

- Mass Rapid Transit System for Pune Metropolitan Area, RITES LTD,
- January 2001: MRTS network of 91 km including Phase I corridors totalling 22 km was recommended.
- Comprehensive Traffic & Transportation Study, Span Consultants,2003: Complete links in circular roads, flyovers, truck terminals, and improvements to bus terminals, traffic engineering and management measures were recommended.
- Comprehensive Study of Integrated Traffic Dispersal System for PCMC & PMC by CES, July 2004: Master Plan for road network improvement and road linkages to rail stations in the study area comprising widening of existing roads, elevated roads, missing links were recommended.
- DPR on Tramways, Consult Team Bremen, 2007: Tramway Network of 92 km in two Phases was recommended.
- Master Plan for Bus Rapid Transit System, CIRT, March 2008: BRT master plan about 21 corridors was recommended.
- DPR for Metro Rail in Pune Metropolitan Area, DMRC, February 2008: Six lines of High Capacity Rapid Transit of total length 86.2 km was recommended.
- Bus-based Rapid Transport System, PCMC, March 2008.

Average speed on major arterials varied from 16 kph to 29 kph in peak hour; modal share of public transport was 13% (*CMP Pune 2008*). Now particulate matter is beyond acceptable limit along roads.

The need was to meet traffic demand on arterial corridors while reducing congestion and ensuring minimal adverse impact on ecology and involuntary displacement. The corridors and alignments have been identified to address these requirements.

Metro system (i) Requires 1/5th energy per passenger km compared to road-based system (ii) Causes no air pollution in the city (iii) Causes lesser noise level (iv) Occupies no road space if underground and only about 2 metres width of the road if elevated (v) Carries same amount of traffic as 5 lanes of bus traffic or 12 lanes of private motor cars (either way), if it is a medium capacity system. (vi) Is more reliable, comfortable and safer than road based system (vii) Reduces journey time by between 50% and 75% depending on road conditions (*Metro DPR 2008*). The project also provides benefits in terms of savings in road infrastructure.

Under Ground Alignment

In section from Kasba Peth to Swar Gate where road right of way constrains elevated Metro; underground alignment was been proposed: as a corollary the underground section has been commenced at Range Hill Depot. In order to avoid impact on protected monuments Pataleswar cave and Shaniwarwada, the alignment was detoured. On balance sections the alignment is elevated which requires less energy, water and cost.

Vanaz – Ramwadi Corridor

Garvare College to PMC section of Vanaz - Ramwadi corridor has been modified by avoiding Jangli Maharaj Road and run along the left bank of Mutha River between Garware College and Civil Court, which was discussed in the meeting held by the Hon'ble Central Minister, Ministry of RTH&S on 09.09.2015. Due to this modification, one more station near Chhatrapati Sambhaji Udyan has been proposed for facilitating more people to use the Metro system. The revised cost of both the corridors has been arrived at the price level of (November, 2015) and Financial Internal Rate of Return (FIRR) & Economic Internal Rate of Return (EIRR) calculated. Comparative statement of the selected alternatives is given in Table 3.6.

Table 3.6: Comparison of Alternatives for Garvare College to PMC section

S. No	Particulars	Alternative - 01	Alternative - 02	Alternative - 03
1.	Alignments	Deccan – Kalaniketan – Civil Court	Jangali Maharaj Road – Rani Laxmi Bai Putala-Congress Bhawan	Alignment (1.45 Km) Passing through Mutha River (Left Bank)
2.	Length in km	2.65	2.0	1.45
3.	No. of Stations	3	2	2
4.	No. of trees to be affected	155	115	32
5.	Affected Residential / Commercial Buildings	Yes	Yes	No
6.	Technical Remark	Turning at Deccan comer and at Kalaniketan was not suitable. To obtain feasibility various buildings, structures, trees was getting affected	Turning at Deccan Corner and at Rani Laxmi Bai statue was not suitable.	Compare to all the alternatives no structure or building is getting affected except 32 numbers of trees.

Based on the above details, Alternative No. 3i.e. Alignment of 1.45 Km Passing through Mutha River has been finalized. The initial length of the metro alignment along the Mutha river bank was 1.7 Km. Considering the sensitivity of construction along the river bed an effort was made to reduce the environmental impact and reduce the length to 1.45 Km. This was achieved by reducing the 250 metre stretch from Shivaji Bridge to Dengale Bridge. A radius for turning was required and this was achieved by taking additional space at the food grain godown located opposite the civil court.

The stretch of 1.7 Km stretch – The initial alignment involved entry onto the river bed just before the Panchaleshwar temple, exited at Someshwar temple. It again entered the river bed at Shivaji Bridge and exited near Dengale Bridge.

The revised alignment with 1.45 Km length enters the river bed only once at the Panchaleshwar temple and exits at the Vridheshwar /Someshwar temple. Care has been taken that neither of these heritage structures are affected and the alignment stays landward side as far as feasible. This change also reduces number of affected trees from 60 to 32.

The alignment of 1.45 km will reduce the construction along river front by 15%, piers by 10% and, area required for construction by 11%.Comparison of 1.7 km and 1.45 km stretch of alignment passing through Left bank of Mutha River is given in Table 3.7.

Table 3.7: Comparison of 1.7 Km and 1.45 km stretch of Alignment passing through Left Bank of Mutha River

Particulars	Original Alignment (1.7 km)	Updated Alignment (1.45 km)
Alignments length	Alignment (1.7 Km) Passing through Mutha River (Left Bank)	Alignment (1.45 Km) Passing through Mutha River (Left Bank)
Number of Piers	46+20 (viaduct+ stations)	39+20 (viaduct+ stations)
Area required for Construction	1650 sq.m	1475 sq.m
No. of Stations	2	2
Bridges Crossing	1. Sambhaji Bridge (Lakdi Pul) 2. Kakasaheb Gadgil Bridge (Z Birdge) 3. Baba Bhide Bridge - Causeway/Submersible 4. Maharshi Vitthal Ramji Shinde Bridge	1.Sambhaji Bridge (Lakdi Pul) 2.Kakasaheb Gadgil Bridge (Z Birdge) 3. Baba Bhide Bridge - Causeway Submersibble 4. Maharshi Vitthal Ramji Shinde Bridge
No. of trees to be affected	60	32
Affected Residential / Commercial Buildings	Nil	Nil

Changes in the alignment of PCMC – Swargate are given in Table 3.8 and Vanaz – Ramwadi Corridor in Table 3.9. These changes are made in the alignment drawings.

Table 3.8: Details of changes made in the PCMC – Swargate Alignment

S. No	Details as per Tender Alignment Drawing	Modification to Tender Alignment Drawing (Revised alignment)	Reason
1.	PCMC Station ch (-) 0/200	PCMC station has been shifted longitudinally by 140m towards north from ch (-) 0/200 and revised to Ch: -340.	To keep frontage clearance of PCMC building.
2.	Alignment from Dead End (POB- Point of Begging) PCMC side to Ch: +400m	Alignment has been shifted 5.3m laterally towards PCMC footpath side	To keep service road unaffected by maintaining at least 7.5m clear carriageway. The adjoining alignment on median of NH was also slightly modified.
3.	Tender Alignment between Harris bridge to Khadki Station	The horizontal alignment as been modified between Harris Bridge to Khadki Station	To follow the proposed median of BRTS corridor
4.	Alignment Crossing at KhadkiRailway was close to existing crossing.	Alignment at Khadki Railway crossing has been modified to keep ~100m away from previously planned crossing.	To keep provision of future Railway yard expansion towards south side.
5.	Tender alignment	Alignment after Railway crossing on Khadki Bazar road has been modified.	To take the alignment out of defence boundary.
6.	The part of Kadaki station in Transition Curve which is not permissible as per SOD.	Khadki station has been shifted 45m towards north. Due to the above changes, the curvature has been modified from radius 1100m to radius 800m.	To keep station in a straight line portion as described in SOD.
7.	Short of vertical clearance (13.10m) at Tukaram Station & Kasarwadi.	The vertical clearance has been improved at Sant Tukaram Station and Kasarawadi. In these connections the gradients of either side of the station has been revised accordingly	The minimum vertical clearance is required at Station location is.13.750m (Rail lvl to Ground/Road lvl)
8.	Tender Alignment from CH.3000 to 3725	The alignment has been modified between Bhosari Station and Kasarawadi station at Nashik Phata Subway location	To avoid large portal frames along Highway at various locations and simultaneously, re-grading is done at realigned alignment.
9.	This was due to change in Vertical Clearance as mentioned in s.no 7	After re-grading of vertical alignment at Sant tukaram station, the new grade is introduced before Pier no.298.	To maintain the same grade of previous tender alignment because the pier was already casted at site as per previous grade.
10.	The width of station box was 18.0m	As suggested by Architecture team the width of station box has been increased from 18.0m to 20.5m	Due to increase in station box width.
11.	Tender alignment	All the stations chainage has been updated as per revised alignment time to time	As per revised alignment.

Table 3.9: Details of changes made in the Vanaz - Ramwadi Alignment

S. No	Modifications suggested by Metro Expert Committee and Maha Metro.	Modifications carryout by GC	Reason
1	Vanaz station: The station need to be shifted by 50 m towards Vanaz side with entry exit	The Vanaz station has been shifted 50m longitudinally towards Vanaz Depot (from Ch. 84.500m to Ch.34.500m) to avoid the existing road junction. There is no lateral shift. There is no any effect on existing structures.	To avoid station coming over a Tee Junction on Paud Road
2	Anand Nagar: The station need to be shifted by 70 m towards Vanaz side with entry exit	The Ananad Nagar station location has been shifted 180m towords Vanaz station (From Ch. 1223.361m to 1043.361m) longitudinally instead of 70m to avoid the station location on transition curve. After shifting 180m, this station shall be in curvature of 1050m radius with zero cant which is within SOD norms. Previously the station was proposed on straight alignment. There is no lateral shift. There is no any effect on existing structures.	To avoid the station coming over Y Junction on Paud Road
3	Ideal Colony: The station may not be required to be shifted and entry exit.	There is no change in station location	No modification needed
4	Nal Stop: Feasibility for shifting of station toward Vanaz by 20 to 25 m need to be examined with entry exit as below.	The station has been shifted 29.62m towards Vanaz(from Ch. 2719.62m to Ch. 2690.00m) in order to abut the existing SNDT FOB. In order to avoid the shifted station location on transition portion, the curve radius has been modified from 1100m to 600m. The entire station is over straight alignment.	(In order to bring the station abutting the present FOB and facilitate dispersal structures in vacant plots of land viz. SNDT Triangular Plot and Rescon Industries Plot)
5	Garware College: The station may not be required to be shifted and entry exit.	There is no change in station location.	No modification needed
6&8	Deccan Gymkhana: The station may not be required to be shifted and entry exit, Sky walk need to be plan for crossing of river and smooth dispersal from the station as shown below. The Feasibility of the tweaking the alignment in between Lakdi bridge to Deccan Gymkhana station need to be examined	In order to avoid the temple and trees, the station alignment has been shifted 3m laterally towards River bank at Ch:4725.00m. The distance between temple corner and the alignment at Ch.4360.00m has been improved from 2.19m to 4.91m. The alignment is running along the road median up to Ch 4180.00m. Thereafter, the	To save the trees, temple corner and sewerage line of about 2 m dia. If the alignment could be brought in line with first pier of Lakdi Bridge instead of along the abutment, with

S. No	Modifications suggested by Metro Expert Committee and Maha Metro.	Modifications carryout by GC	Reason
		alignment is diverted towards the river bank. It is tried to get minimum ROW at temple location.. However, this will be discussed further for improvements, speed and other issue if any.	perhaps a reverse curve towards Deccan Gymkhana will be desirable.
7	Sambhaji Garden: The station may not be required to be shifted longitudinally. However, the feasibility to shifting the station laterally towards the left bank of Mutha River by about 20 m needs to be examined. This will bring the alignment in line with the Stone Road behind the retaining wall. Sky walk need to be planned for crossing of river preferably at the Ramwadi end of the station. Skywalks leading towards JM Road and Balgandharva Parking lot to be planned at Vanaz & Ramwadi ends of this station respectively to ensure smooth dispersal from the station towards. Following sketch brings out the details schematically.	The Sambaji Garden station at Ch.5250.00m has been shifted 20.0m laterally and 3.08m longitudinally towards Sambaji Garden.	In order to address the point S.no. 6,7 and 8, the alignment has been modified for a length of 1580m (from Ch.4180.00m To 5760.00m).
8	Reduce the height of pier at Vanaz Station from 21.63m to 18.951m	The vertical alignment has been modified.	To reduce the height of pier and avoid heavy design of pier.
9	Revise the Alignment between Vanaz Station to Anand Nagar Station (the tender alignment was not follow the central median)	The horizontal alignment has been modified. The radius of alignment for curve no.2,3,4 and 5 has been changed from 250m,250m,155m and 220m to 300m, 195m,195m,195m and 218m.	To follow the central median portal pier and check rail.

Chapter 4 : Environmental Baseline Data

4.1. GENERAL

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

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

Environmental baseline data includes the physical, biological and socio-economic data. The data collection was carried out in the months fromOctober 2017 to December 2017. A scoping matrix along with the frequency adopted for data collection for environmental attributes is summarized inTable 4.1. Based on environmental scoping matrix and project settings the attributes likely to be affected were identified for baseline data generation.

Table 4.1: Environmental Attributes and Frequency of Monitoring

S. No	Attribute	Parameter	Frequency	Source
LAND ENVIRONMENT				
1.	Soil	Soil Characteristics	One Season	Field studies and Detailed project report
2.	Geology	Geological Status	---	Secondary Data
3.	Seismology	Seismic Hazard	---	Secondary Data
WATER ENVIRONMENT				
4.	Water Quality	Physical, Chemical and Biological parameters	One Season	Field studies
AIR, NOISE AND METEOROLOGY				
5.	Ambient Air Quality	PM2.5 , PM10, $SO_{2,}$,$NO_{2,}$ and CO	One Season	Field Studies
6.	Meteorology	Temperature, Relative humidity, Rainfall, wind direction and speed	Data	India Meteorological Department
7.	Vibration	Peak Particle Velocity	One season	Field Studies
8.	Noise	Noise levels in dB (A)	One Season	Field Studies
ECOLOGY				
9.	Trees	Number/species	Once	Filed Studies
SCIO-ECONOMIC				
10.	Socio-economic aspects	Socio-economic characteristic	Once	Field Studies, Literature review.

4.2. LAND ENVIRONMENT

Field studies were carried out towards collection of baseline data with respect to physical environment viz. physiography, geology, soils, minerals, drainage, land use pattern and seismicity. The data on physical environment was collected from existing literature and from field observations.

4.2.1. Physiography

The proposed metro is located in Pune City. The city is situated at the confluence of the rivers Mula and Mutha; and falls in Haveli Sub Division of Pune District. The city is located at the geographical location of 18.5203° North latitude and 73.8567° East longitude with an average altitude of 560 meters above mean sea level.

The proposed N-S alignment starts at latitude 18.632542° and longitude 73.800611° near PCMC Station and ends at latitude 18.496802° and longitude 73.857350° near Swargate Station with elevation varies from 542m to 580m along the corridor.

The proposed W-E alignment starts at latitude 18.507779° and longitude 73.797138° near Vanaz Station and ends at latitude 18.558429° and longitude 73.910988° near Ramwadi Station with elevation varies from 542m to 605m along the corridor.

4.2.2. Geology and Minerals

The district forms part of Western Ghat and Deccan Plateau. The entire area of the district is underlain by the basaltic lava flows of upper Cretaceous to lower Eocene age. The shallow alluvial formation of recent age also occurs as narrow stretch along the major rivers flowing in the area. The basalt is a predominant rock formation of the district under Deccan Traps. No minerals are available in and around the project area.Geological and Mineral Map of Maharashtra State is shown inFigure 4.1.

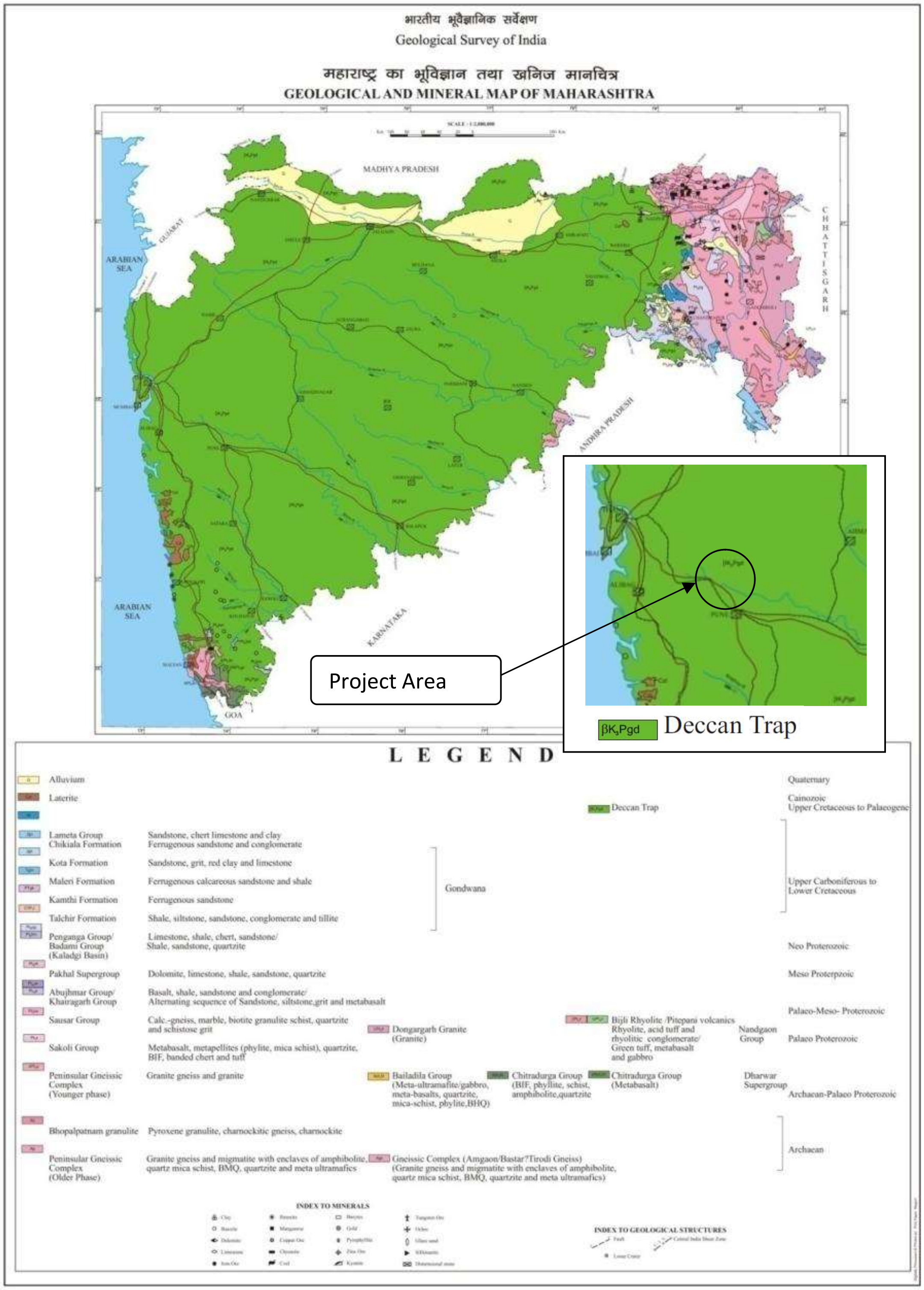
4.2.3. Soils

Soil is the material found on the surface of the earth that is composed of organic and inorganic material. Soil varies due to its structure and composition. The physical and chemical characters of the parent rock, physiography, altitude, climatic condition and plants and animals of the surrounding region influence the process of soil formation.

Pune district possesses mainly two types of soilsie medium black and deep black soils.In western region soil, type has brown and low quality while eastern region having fertile and plain type. The richest alluvial soil track found in the Valley of Bheema River. In the project area black soils are observed.

In the project area, Soil samples from various locations were collected and analyzed to understand the soil characteristics of the area with respect to its productivity potential. The description of Soil quality monitoring locations are given in Table 4.2 and the sample locations are shown in Figure 4.2.

Figure 4.1: Geological and Mineral Map of Maharashtra



Source: Geological Survey of India

These samples were tested in the laboratory to determine the nature and physical characteristics like soil classification, nutrient contents, electrical conductivity, etc. The results of the soil sample analysis are given in Table 4.3. The samples were collected from various locations of the project area in the month of November ie after monsoon season.

Table 4.2: Description of Soil Quality Monitoring Locations

Sample ID	Location	Environmental Setting
SS1.	PCMC	Park
SS2.	Bopodi	Barren
SS3.	Civil Court	Barren
SS4.	KasabaPeth	Residential
SS5.	Swargate	Residential
SS6.	Nal Stop	Residential
SS7.	Bundgarden	Residential
SS8.	Ramwadi	Residential
SS9.	Vanaj Depot	Barren
SS10.	Range Hill Depot	Barren
SS11.	Casting Yard- Phugewadi	Barren
SS12.	Casting Yard- Near Akemi Business School	Barren

- The pH value of study areas varied from 7.25-8.15 with an average 7.7.It was observed that the soil reaction was slightly basic in nature.
- Based on the electrical conductivity, the soils are classified into 4 groups (Normal, Critical for germination, Critical for growth of the sensitive crops, Injurious to most Crops).The electrical conductivity in the study area is varying from 340.8 - 589 µS/cm indicating that soils falling under Normal category (non-saline nature).The limit Suggested by Muhar et al. (1963) for judging salt problem in soils samples to be normal if EC < 1000 µS/cm.
- Available nitrogen status in soils of study area varied from 176-276 kg N /ha.On the basis of the ratings suggested by Subbiah and Ashija (1956) 50 percent samples were rated in medium range (280-560 N kg ha-1) remaining 50percent samples were in the low range (< 280 kg/ha).
- Phosphorus exists in soils in the both form i.e. inorganic and organic. A small portion of the total P is present in plant available form. Plant available phosphorus contents in soils of study areas varied from 5.67-9.80 kg/ ha According to soil fertility index suggested by Muhar et al. (1963), all the soil samples were rated in low range.
- The available sulphur status varied from 3.65 - 6.39 with an average value 5.0 mg/kg. Plant root absorb sulphur in the form of SO4-2 from the soil solution. The soils are deficient in sulphur content.

Figure 4.2: Soil Quality Monitoring Locations

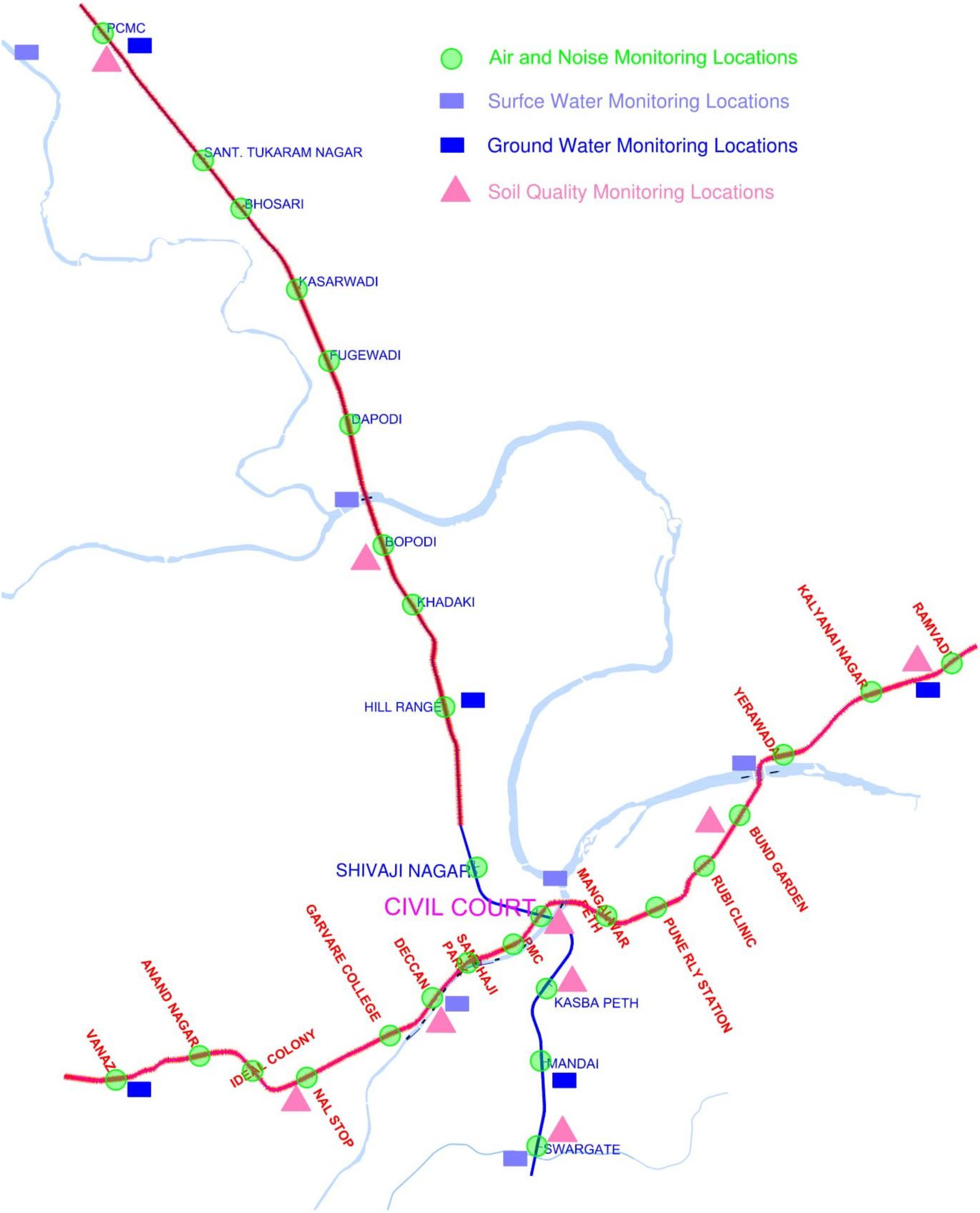


Table 4.3: Soil Quality Data

S. No	PARAMETER	UNIT	SAMPLE NO											
			SS 1	SS 2	SS 3	SS 4	SS 5	SS 6	SS 7	SS 8	SS 9	SS 10	SS 11	SS12
1.	Conductivity	µS/cm	376.5	412	421.5	512.6	456	589	450.6	345	340.8	486	520.3	568.1
2.	Available Phosphorous (as P)	kg/ha	8.77	6.19	6.19	5.67	8.52	7.22	8.51	9.80	8.0	9.03	7.74	6.71
3.	Manganese (as Mn)	mg/kg	2.11	3.07	1.74	1.97	2.14	2.78	1.15	1.42	3.42	3.48	2.53	2.80
4.	Boron	mg/kg	0.60	0.85	0.72	0.80	0.61	0.72	0.88	0.75	0.71	0.67	0.72	0.85
5.	Iron (as Fe)	mg/kg	4.02	2.98	3.18	3.44	3.02	3.92	2.08	2.94	3.46	4.02	2.6	3.96
6.	Magnesium (as Mg)	mg/kg	124	134	278	224	92	108	160	260	126	84	158	112
7.	Texture	--	Clay loam	Clay loam	Clay loam	Clay loam	Clay loam	Clay loam	Clay Loam	Clay Loam	Clay loam	Clay loam	Clay loam	Clay Loam
8.	Sodium	mg/kg	65	84	74	71	54	68	54	84	70	68	65	62
9.	Total Sulfur	mg/kg	3.68	5.5	4.66	5.08	5.01	3.65	3.68	3.68	4.91	5.33	6.86	6.39
10.	Carbonate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
11.	Available Nitrogen	kg/ha	251	238	276	256	186	213	213	213	238	176	213	213
12.	Bicarbonate	mg/kg	<0.1	412	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
13.	Calcium	mg/kg	354	6.19	372	428	215	345	320	420	384	228	375	320
14.	pH		7.84	8.15	7.6	7.25	7.86	7.55	7.95	7.23	7.8	7.98	7.38	7.99
15.	Chlorides	mg/kg	42	26	24	166	52	10	26	57	52	37	34	42
16.	Zinc	mg/kg	74	48	232	418	129	64	111	461	124	84	83	71
17.	Lead	mg/kg	<2	<2	40.4	45.92	<2	<2	<2	<2	<2	<2	<2	<2
18.	Copper	mg/kg	85.77	67.05	201.98	175.72	177.89	129.33	124.3	203.84	137.84	117.24	150.92	84.47
19.	Total Organic Carbon	mg/kg	9242	7544	9573	39895	10209	3980	8476	22988	16712	11460	7798	4678
20.	Sulphates	mg/kg	1536	4509	4716	2833	2856	1406	4549	2191	1462	2698	2770	4786

S. No	PARAMETER	UNIT	SAMPLE NO											
			SS 1	SS 2	SS 3	SS 4	SS 5	SS 6	SS 7	SS 8	SS 9	SS 10	SS 11	SS12
21.	Nickel	mg/kg	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
22.	Potassium	mg/kg	973	724	1040	1523	498	868	975	646	700	963	514	1053
23.	Organic Matter at $600^{O}C$	%	8.51	2.74	12.83	7.63	3.1	4.24	5.26	12.41	5.29	5.4	9.96	0.339
24.	Arsenic	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
25.	Mercury	mg/kg	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
26.	Cadmium	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

SS1: PCMC SS2: Bopodi SS3: Civil Court SS4: KasabaPeth SS5: Swargate SS6: Nal Stop
SS7: Bundgarden SS8: Ramwadi SS9: Vanaj Depot SS10: Range Hill Depot SS11: Casting Yard - Phugewadi SS12: Casting Yard - Near Akemi Business School

- Available Fe content in the soil ranged from 2.08 – 4.02 mg/kg. All the soil samples were found in sufficient amount of available iron considering 4.5 mg/ kg as a critical limit suggested by Lindsay and Norvell (1978).

Over all soil quality data reveal that soil is deficient in Nitrogen, Phosphorous and sulphur; natural soil amendment with Farm Yard manure and vermicompost is may be used for improving these parameters. Growing of local (native) plant species is required for greenbelt development to improve the soil quality.

4.2.4. Land Use Pattern

Land use patterns are important in Environmental Impact Assessment study as it describes its use such as agriculture, settlement, forest, vegetation, etc. Land use pattern of Pune district have been presented in Table 4.4.Land use / Land cover (Built-up Land, Agricultural Land, Forest, Barren Lands, Water Bodies, Roads, and Others) for study area of 5 km on either side from proposed centreline of Metro Corridors has been derived from latest satellite imagery**.**

Table 4.4: Land Use Distribution of the Pune District

S. No	Land Use Pattern	Total Area in Sq. Km	Percentage
1.	Built-Up Land	401.63	2.57
2.	Forest	3647.99	23.32
3.	Double crop	1422.57	9.10
4.	Single Crop	3092.20	19.77
5.	Agricultural Plantation	264.59	1.69
6.	Scrub/ Waste land	5995.39	38.33
7.	Water bodies/ Tanks/ River	815.63	5.22
	Total	15640.00	100

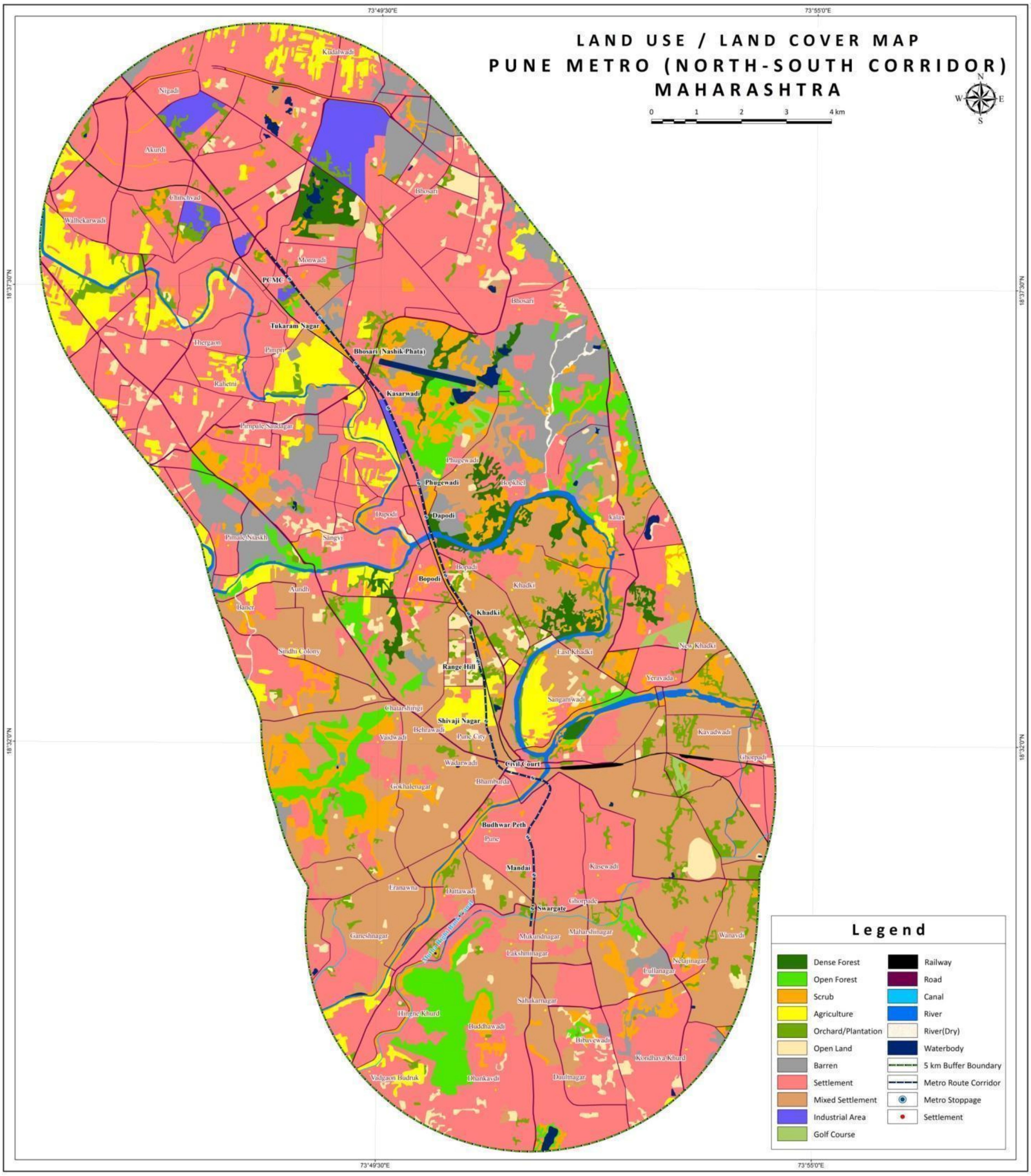
Source: Pune DEA report 2008, MPCB

Satellite Imagery: The satellite image used in the current study includes LISS-IV data of Resourcesat-2 having Row 059 and Path 095 and date of pass as 10-04-2017. The entire data is in Universal Transverse Mercator projection system with spheroid and datum as WGS84 and Zone as 43.

Land use Map: The land use map was prepared using on-screen visual interpretation technique using ERDAS Imagine and Arc GIS software. The land use classes that has been identified includes Agriculture, Airport, Barren, Canal, Dense Forest, Golf Course, Industrial Area, Mixed Settlement, Open Forest, Open Land, Orchard/Plantation, Railway, River, River(Dry), Road, Scrub, Settlement, Water body covering an area of 5 km on either side from proposed centerline of Metro Corridors. The land use classification data of each corridor is given in Table 4.5 and land use map is as shown in Figure 4.3.

Figure 4.3: Land use Map 5 Km on Either Side of Metro Corridors

PCMC – RANGE HILL CORRIDOR



VANAZ – RAMWADI CORRIDOR

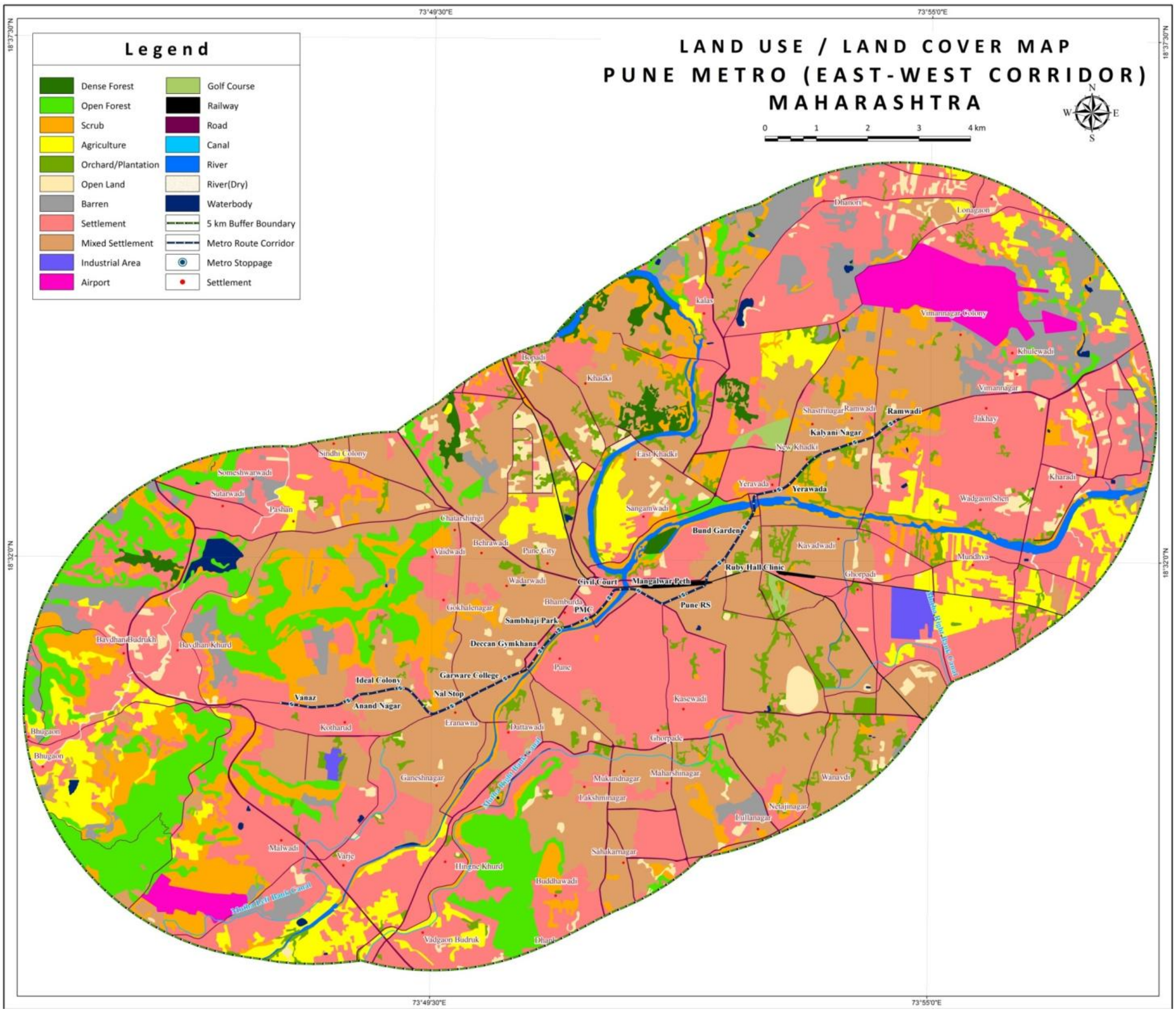


Table 4.5: Land Use Classification on 5 kmon either side of Metro Corridor

S. No	Description	PCMC-Range Hill Corridor			Vanaz-Ramwadi Corridor	
		Area in Sq.Km	Percentage		Area in Sq.Km	Percentage
1.	Agriculture	12.92	5.2		13.36	6.1
2.	Airport	-	0.0		4.85	2.2
3.	Barren	14.91	6.0		11.27	5.1
4.	Canal	0.17	0.1		0.22	0.1
5.	Dense Forest	4.33	1.7		1.98	0.9
6.	Golf Course	0.72	0.3		0.51	0.2
7.	Industrial Area	3.63	1.5		0.91	0.4
8.	Mixed Settlement	55.74	22.5		59.7	27.1
9.	Open Forest	9.68	3.9		17.17	7.8
10.	Open Land	7.17	2.9		5.25	2.4
11.	Orchard/Plantation	7.98	3.2		6.73	3.1
12.	Railway	0.66	0.3		0.47	0.2
13.	River	3.44	1.4		2.72	1.2
14.	River(Dry)	0.31	0.1		0.21	0.1
15.	Road	6.73	2.7		4.64	2.1
16.	Scrub	17.12	6.9		21.03	9.5
17.	Settlement	100.89	40.7		68.36	31.0
18.	Water body	1.24	0.5		0.83	0.4
	Grand Total	247.64	100		220.21	100

Graphical presentation of the Land use classification of the proposedproject corridors is given in Figure 4.4.

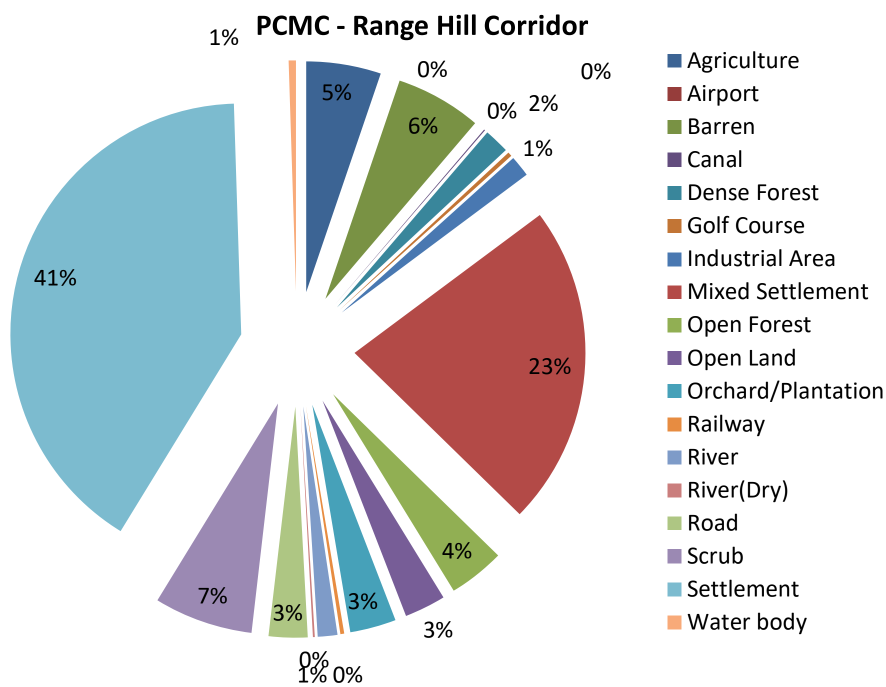
PCMC – Range Hill Corridor

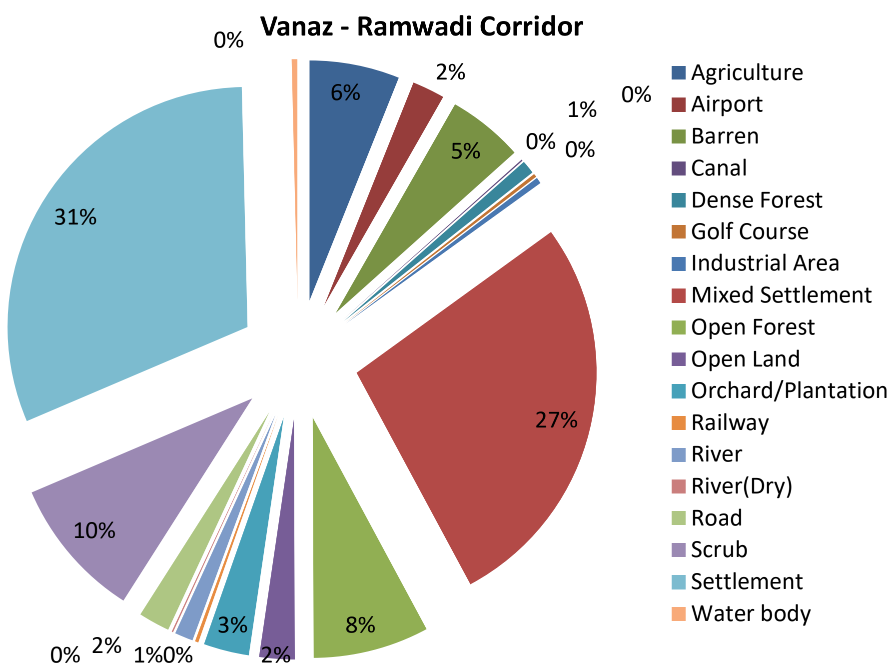
- Agricultural land and Plantation together contributes to about 8.4% of the study area.
- Settlements, Mixed settlements, and Industrial area cover about 40.7%, 22.5% and 1.5% respectively. The surrounding villages around the project site are well developed with road, electricity and water connectivity.
- Scrub covers about 6.9% of the study area.
- Out of the total study area, 6% is barren land.
- Forest area covers about 4.6% of total study area.
- The water bodies contribute about 2.1% of the total study area.

Vanaz – Ramwadi Corridor

- Agricultural land and Plantation together contributes to about 9.1% of the study area.
- Settlements, Mixed settlements, and Industrial area cover about 31.0%, 27.1% and 0.4% respectively.
- Scrub covers about 9.5% of the study area.
- Out of the total study area, 5.1% is barren land.
- Forest area covers about 8.7% of total study area.
- The water bodies contribute about 1.8% of the total study area.

Figure 4.4: Land Use Classification of the Proposed Project Corridors

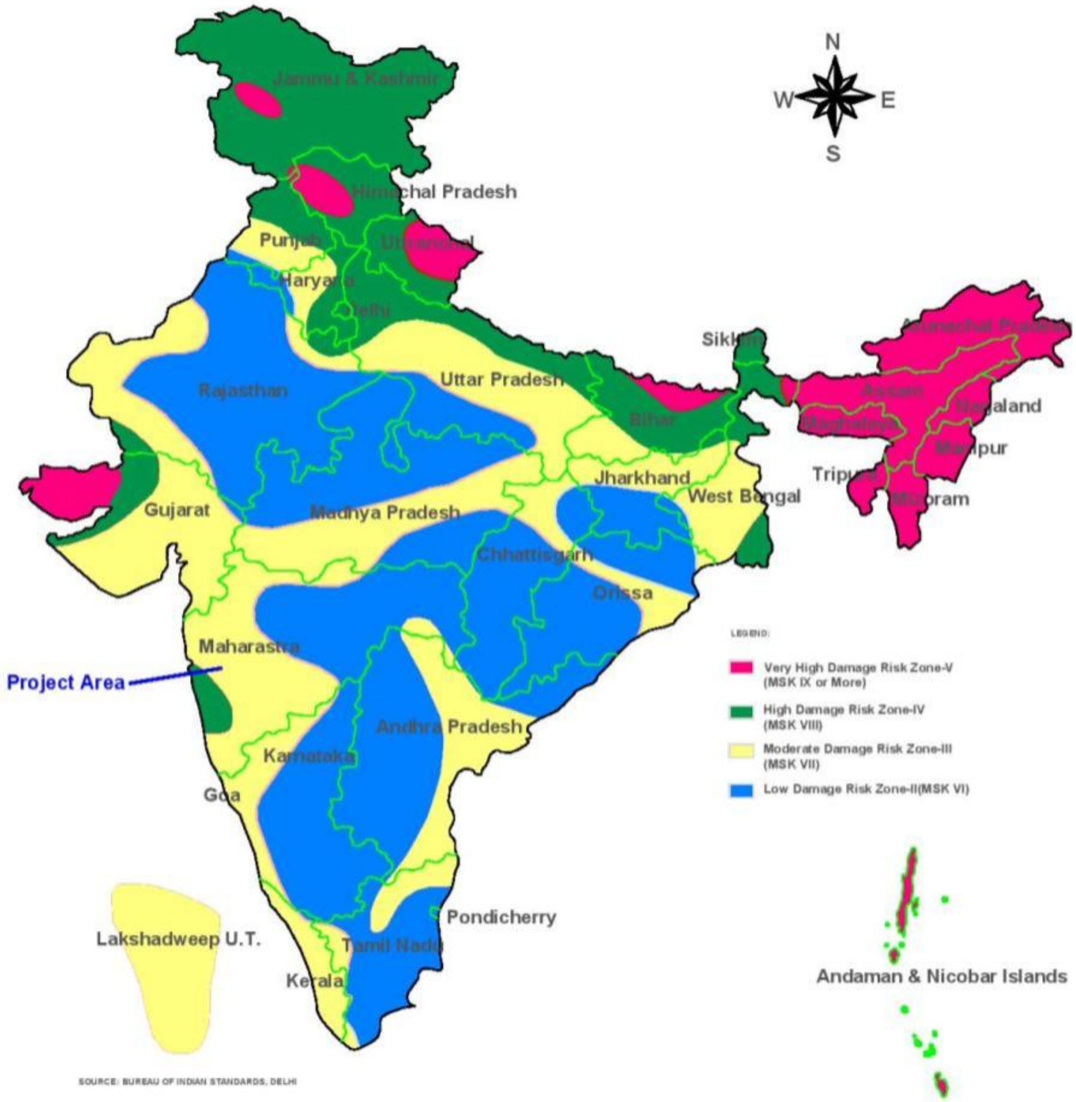




4.2.5. Seismicity

The state of Maharashtra falls in a region of Low Damage Risk Zone (Zone II), Moderate Damage Risk Zone (Zone III) & High Damage Risk Zone (Zone IV) as per revised seismic zoning map of India. The proposed project corridors in Pune City are falls in Zone III as shown in Figure 4.5.

Figure 4.5: Seismic Zoning Map of India



4.3. 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 needs of the project in its various stages and the impact of the project on water environment.

4.3.1. Water Resources of the District

All the Rivers in Pune District originate from the Western part of Sahyadri Hill ranges and flow from west to south. River Bhima is the main river flowing through the district. The Ghod, Mula-Mutha and Nira are tributaries of river Bhima.Mula-Mutha River is formed by the confluence of the Mula and Mutha Rivers in the city of Pune.Surface water throughout the district is used for drinking, irrigation and bathing purpose.Some villages use the surface water for fishing purpose. Industrial water requirement isprimarily surface water dependent.

The water of the Mutha River from the Khadakwasla reservoir is used by PMC for water supply in Pune City. Dams at Panshet, Varasgaon and Temgharsupplement the storage capacity of Khadakwasla. The Total live storage of all the 4 Dams is around 30 TMC. Water is supplied to different parts of the city through a network of pumping stations and pipelines.

Water requirement for Pune city is about 671 MLD, 960 MLD and 1324 MLD for the years 2011, 2021 and 2031 respectively. Existing installed water treatment plants is 1318 MLD which are sufficient till Year 2031[1]. Pune Municipal Corporationsupplies water supply of 1123 MLD to the city. As per City Sanitation Plan of Pune, total Sewage generation in the city is about 744 MLD as per City, while the treatment capacity is 527 MLD.

The ground water in the district occurs under phreatic, semi – confined and confined conditions. Generally the shallower zones down to the depth of 20 to 22 m bgl form the phreatic aquifer. The water bearing zones occurring between the depth 20 and 40 m bgl when weathered or having shear zones yield water under semi-confined condition. The deep confined aquifers generally occur below the depth of 40 m bgl. As per CGWB 2011 data, Pre-monsoon depth to water level was varied between 5 to 10 m bgl, where as post monsoon depth to water level was less than 5 m bgl in Pune City. The Pune city falls in Basaltic rock aquifer where the yield potential is medium.Pune city in Haveli Subdivision is categorised as safe as per CGWB data.

4.3.2. Drainage

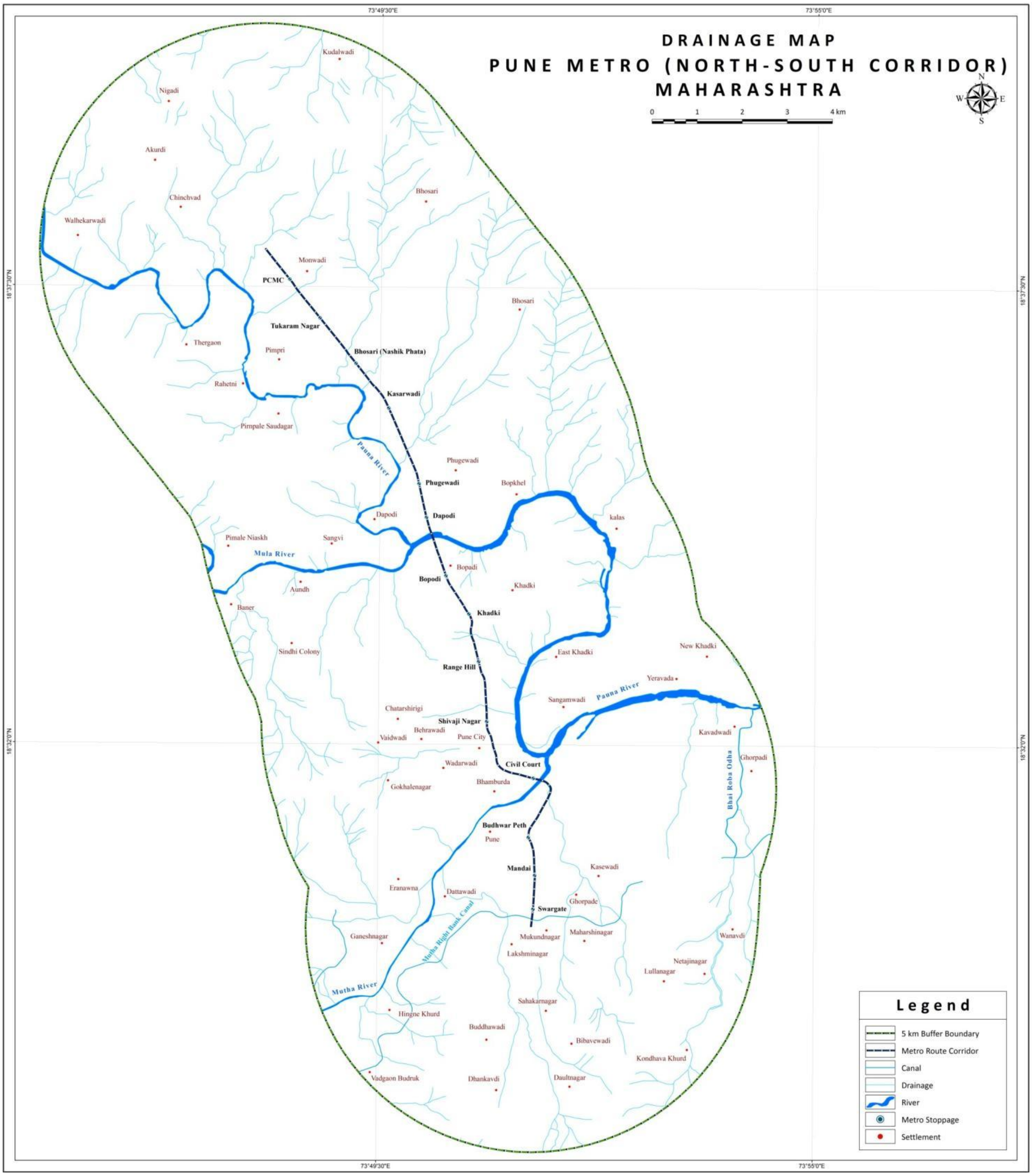
The district has three major drainage systems namely the Bhima-Ghod River System in northern, north-eastern and eastern part;Mula-Mutha River System covering the central part of the district; andNira River system covers south, south-east and eastern part of the district. During rainy season, these rivers flow with ample water and shrinks to narrow channel after monsoon. Pune city is drained from west to east by Rivers Mula and Mutha. Mula River, which is coming from Western side of Pune City, meets the Mutha River near Sangamwadi and then the combined rivers flow towards eastern side.

The drainage map of the study area was mapped using the field data and Topographical map. The drainage map shows that there are rivers, small stream and water bodies in the study area and water flow is from the North-West direction to South East Direction of the study area. Drainage map of project corridors is shown in Figure 4.6. MulaMuthaRiver system is major source of drainage system along the project corridors.

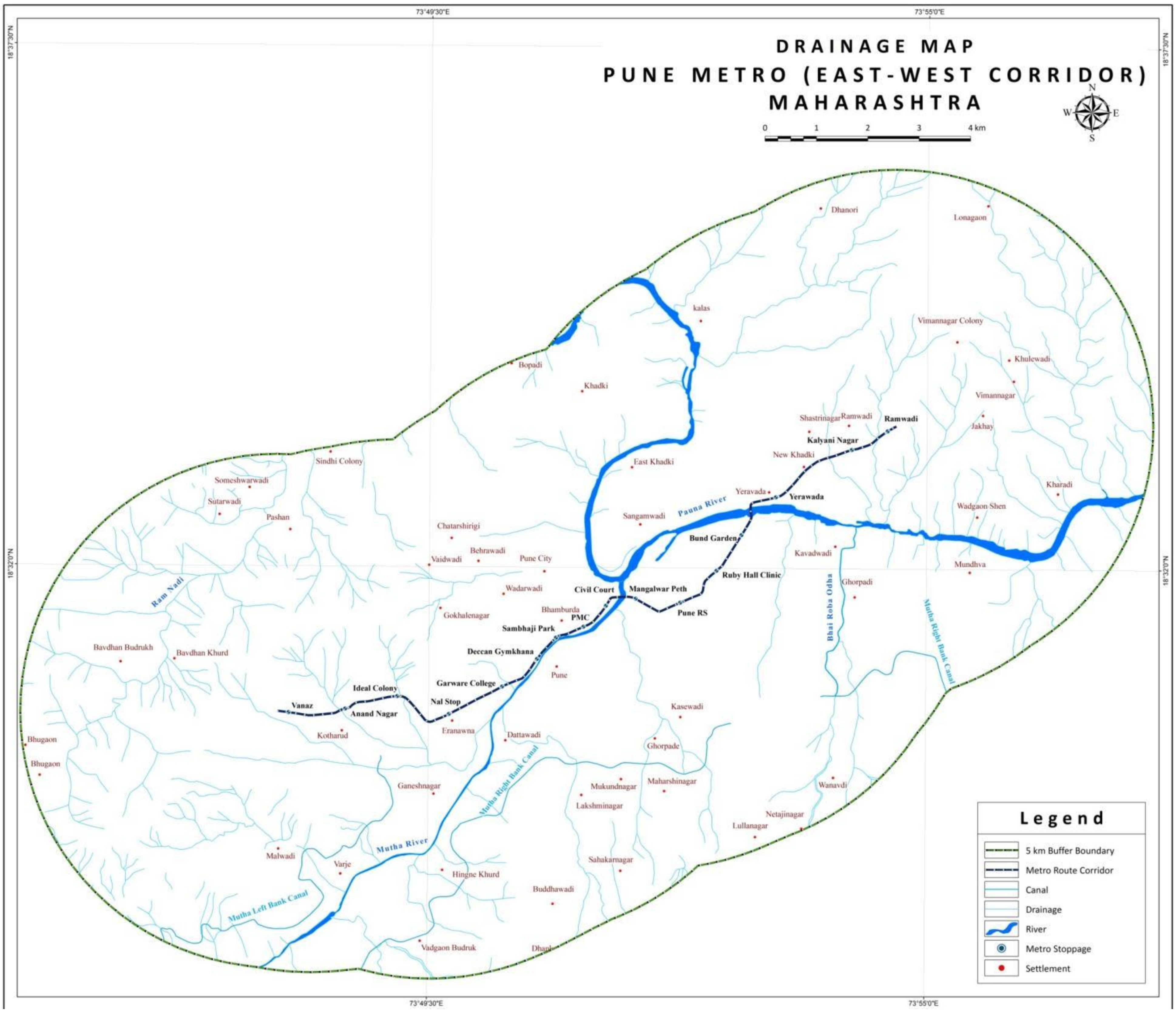
[1]City Development Plan for Pune City 2041, Pune Municipal Corporation, Year 2012

Figure 4.6: Drainage Map 5 Km on Either Side of Metro Corridors

PCMC – RANGE HILL CORRIDOR



VANAZ – RAMWADI CORRIDOR



4.3.3. Water Quality of the Project Area

In order to assess the baseline water quality status of the study area, eleven (11) samples were collected in the project area, which includes six (6) samples of surface water and five (5) ground water samples. The sample locations are shown in Figure 4.2 and description of water quality monitoring locations are given in Table 4.6.

Table 4.6: Description of Water Quality Monitoring Locations

Id	Location	Environmental Setting
Surface Water		
SW 1	Pawana River near PCMC	River
SW 2	Mula River near Bopodi	River
SW 3	Mula-Mutha River Near Bund Garden	River
SW 4	Mula-Mutha River Near Civil Court	River
SW 5	Mula-Mutha River Near Gymkhana	River
SW 6	Mutha Right Bank Canal Near Swargate	River
Ground Water		
GW 1	Near PCMC	Open well
GW 2	Near Range Hill	Bore Well
GW 3	Near Mandai	Open well
GW 4	Near Vanaz	Open well
GW 5	Near Ramwadi	Bore Well

The samples were analyzed for physical and chemical constituents for the purpose ofdomestic and irrigation use. The results of Surface water parameters are compared with Tolerance Limits for Inland Surface Waters subject to Pollution (IS: 2296 – 1982) and the results of Ground water analysis are compared with CPHEEO manual for Drinking Water Specifications. The results of sample testing are presented in Table 4.7.The analysis for various parameters indicates the following:

- Parameters like pH, TDS and Total alkalinity are found within permissible limits in both surface and ground water samples.
- Coliform count is present in the samples of surface water is very high indicates sewage contamination in both Pawana & Mula-Mutha river. Presence of coliform count in ground water samples indicates contamination.
- The DO ranges from 4.2 to 7.2 mg/l in six surface water samples. In five samples, the DO crosses the tolerance limit of 5 mg/l; which signifies that the aquatic organisms are more and water shows eutrophic conditions.
- BOD ranges from <1 to 52. In five samples, Biochemical oxygen demand is more than tolerance limit
- Total Hardness and calcium is within the tolerance limits in all the samples
- Magnesium exceeds permissible limit for Surface water samples and within permissible limits in Ground water samples
- Chloride, Nitrate, Sulphates, Fluoride, Sodium, Potassium, Iron, Copper, Manganese,Zinc, Chromium, and Mercury are within the permissible limits in all the samples
- Aluminium is within the limits in all the samples of Surface but it is exceeding in Ground water samples.

Table 4.7: Results of Water Quality Monitoring

S. No.	Parameters	Unit	Surface Water Samples							Ground Water Samples					
			SW- 1	SW- 2	SW- 3	SW- 4	SW- 5	SW- 6	Tolerance Limits For Inland Surface Waters	GW- 1	GW- 2	GW- 3	GW- 4	GW- 5	Standards as per IS:10500:2012
1.	pH at 25 ^{o}C	-	6.95	7.07	7.30	7.35	7.65	7.88	6.5 to 8.5	7.61	7.83	7.82	7.65	7.63	6.50 to 8.50
2.	Total Dissolved Solids	mg/l	239	404	410	394	312	137	1500	144	165	125	492	356	≤ 500
3.	Total Alkalinity as $CaCO_3$	mg/l	104	189	210	193.2	170	52.5	N.S.	62	53	45	216	151.2	≤ 200
4.	Chemical Oxygen Demand	mg/l	17	43	52	200	78	<5	N.S.	<5	<5	<5	8	8	N.S.
5.	Biochemical Oxygen Demand at 27^{0}C for 3 days	mg/l	4	12	15	52	22	<1	3.0						
6.	Dissolved Oxygen	mg/l	6.9	7.2	6.6	4.2	6.9	7.0	4.0						
7.	Total Hardness as $CaCO_3$	mg/l	140.11	192.15	200.16	176.14	189	56.04	N.S.	60.04	58.04	55.04	300.24	184.14	≤ 200
8.	Calcium as Ca	mg/l	32.06	18.09	54.50	44.88	41.68	13.22	N.S.	14.42	14.42	8.0	62.52	56.11	≤ 75
9.	Magnesium as Mg	mg/l	14.58	17.5	15.55	15.55	13.61	5.59	N.S.	5.83	5.34	6.0	35	10.69	≤ 30
10.	Chloride as Cl^-	mg/l	37	35	45.33	39.42	31.54	22	600	20.5	29	19	62	42	≤ 250
11.	Sulphates as SO_4	mg/l	28	27.91	30.33	22.09	20	18.6	400	18	28	22.5	67	34	≤ 200
12.	Fluoride as F	mg/l	0.13	0.21	0.32	0.30	0.48	<0.1	N.S.	<0.1	0.19	<0.1	0.42	0.14	≤ 1.0
13.	Sodium as Na	mg/l	12	47.13	28.2	24.2	18.19	15	N.S.	16	21.6	19	26	18	N.S.
14.	Potassium as K	mg/l	4.89	8.0	4.8	5.9	6.19	4	N.S.	3.0	6.5	1.18	2.18	4	N.S.
15.	Cadmium	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.01	<0.05	<0.05	<0.05	<0.05	<0.05	N.S.
16.	Iron (as Fe)	mg/l	0.062	0.09	<0.05	<0.05	<0.05	<0.05	50	<0.05	<0.05	<0.05	<0.05	<0.05	≤ 0.3
17.	Copper (as Cu)	mg/l	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	1.5	<0.04	<0.04	<0.04	<0.04	<0.04	≤ 0.05
18.	Manganese as Mn	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	N.S.	<0.05	<0.05	<0.05	<0.05	<0.05	≤ 0.1

S. No.	Parameters	Unit	Surface Water Samples							Ground Water Samples					
			SW- 1	SW- 2	SW- 3	SW- 4	SW- 5	SW- 6	Tolerance Limits For Inland Surface Waters	GW- 1	GW- 2	GW- 3	GW- 4	GW- 5	Standards as per IS:10500:2012
19.	Lead as Pb	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	≤ 0.01
20.	Zinc as Zn	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	15	<0.05	<0.05	<0.05	<0.05	<0.05	≤ 5
21.	Chromium as Cr	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	≤ 0.05
22.	Nickel as Ni	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	N.S.	<0.02	<0.02	<0.02	<0.02	<0.02	≤ 0.02
23.	Nitrate	mg/l	2.488	1.285	0.942	1.692	1.8	0.069	≤ 45	0.438	0.262	0.112	4.76	3.742	≤ 45
24.	Mercury	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	≤ 0.001	<0.001	<0.001	<0.001	<0.001	<0.001	≤ 0.001
25.	Aluminium	mg/l	0.1431	0.2520	0.633	1.696	1.069	0.1703	≤ 0.03	0.2207	0.1158	0.2376	0.2520	0.09	≤ 0.03
26.	Arsenic	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	≤ 0.01	<0.001	<0.001	<0.001	<0.001	<0.001	≤ 0.01
27.	Phenolic Compound	mg/l	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	≤ 0.001	<0.001	<0.001	<0.001	<0.001	<0.001	≤ 0.001
28.	Total Phosphate	mg/l	0.31	1.172	1.736	0.928	1.698	<0.01	N.S.	0.03	0.046	<0.01	<0.01	0.096	N.S.
29.	Total Suspended Solids	mg/l	8	8	10	12	14	<5	N.S.	<5	<5	<5	<5	<5	N.S.
30.	Total Coliforms	No/100 ml	1600	1600	1600	1600	1600	1600	Absent	30	23	130	1600	500	Absent

SW 1: Pawana River near PCMC SW2: Mula River near Bopodi SW3: Mula-Mutha River Near Bund Garden
SW4: Mula-Mutha River Near Civil Court SW5: Mula-Mutha River Near Gymkhana SW6: Mutha Right Bank Canal Near Swargate

GW1: Near PCMC GW2: Near Range Hill GW1: Near Mandai
GW1: Near Vanaz GW1: Near Ramwadi

4.4. AMBIENT ENVIRONMENT

All air pollutants emitted by point and non-point sources are transported, dispersed or concentrated by meteorological and topographical conditions. The meteorological parameters regulate the transport and diffusion of pollutants into the atmosphere. Meteorological data on rainfall, wind, humidity, and temperature was collected from secondary sources. The ambient environmental status existing in the project area is discussed in different paragraphs as under.

4.4.1. Climate

Pune experiences three distinct seasons: summer, monsoon and winter. Typical summer months are from March to May. Pune receives moderate rainfall and June to September is the south-west monsoon season, whereas October and November constitute the post-monsoon season. The winter season is from December to February. The city receives an annual rainfall of 722 mm, mainly between June and September as a result of the southwest monsoon. July is the wettest month of the year. Meteorological data for the period of 2007 to 2015 was collected from Indian Meteorological Data (IMD), Pune and presented in Table 4.8.Analysis of data reveals that the minimum temperature is 4.6°C (in February 2012) and maximum temperature is about 42.1°C (in April 2008). Total rainfall in year 2013 was 455.5 mm and in year 2010 was 1177.8 mm.

Table 4.8: Meteorological Data from 2007 to 2015

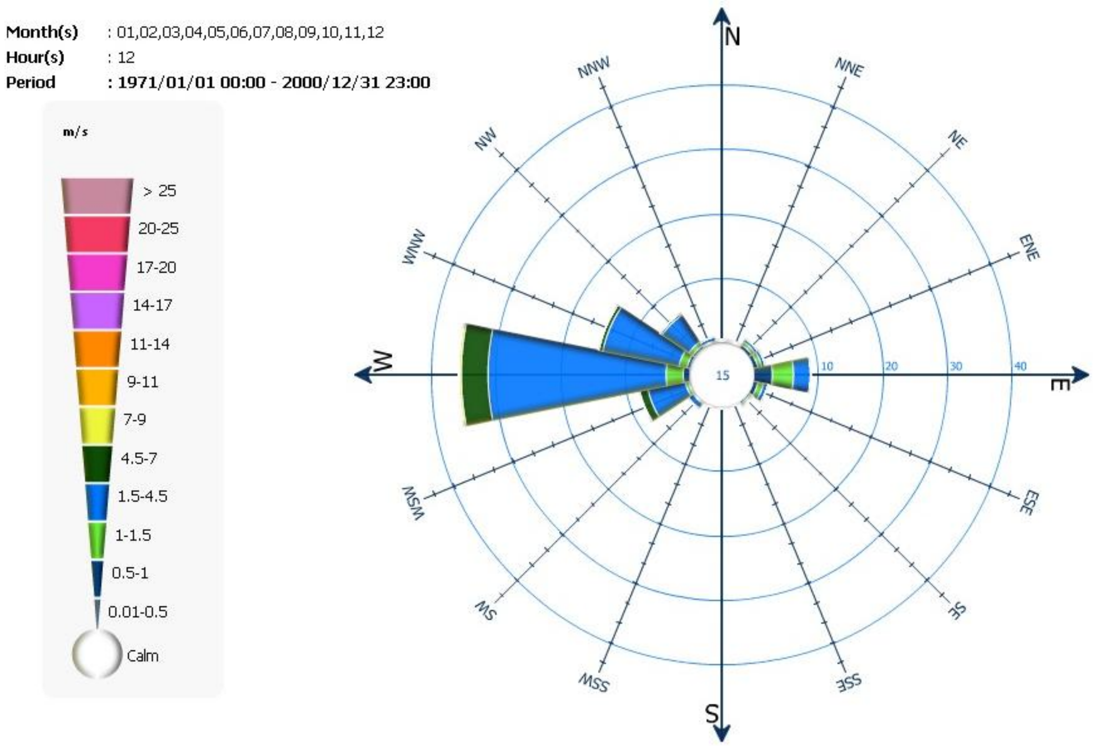
Month	Year								
	2007	2008	2009	2010	2011	2012	2013	2014	2015
A.	**Maximum Temperature in ^{O}C**								
Jan	33.1	33.3	35.3	30.4	32.9	32.5	34.2	31.3	30.1
Feb	35.3	35.1	37.4	36.3	32.8	36.7	35	34	35.1
Mar	39.6	38.6	39	39	38.1	39.1	36.9	38.4	38
Apr	41.4	42.1	41.7	41.5	39.7	39.9	40.8	40.6	40
May	41.9	38.6	40.3	41.9	40.4	39.4	41.3	40.7	40.8
Jun	38.6	37.6	37.1	37.5	36.9	37.8	36.6	40.4	38.6
Jul	33	32	33	31.8	31.4	33.4	30.1	34.4	32.2
Aug	31.4	32	33	31.9	30.9	31.1	NA	32.9	31.3
Sep	31.8	33.2	34.1	33.5	31.3	31.9	NA	33.4	35.4
Oct	34.3	34.1	34.3	33.7	34	33.1	NA	34.7	34.4
Nov	34.2	33.9	33.2	32.2	33.3	32.7	NA	33.3	34
Dec	33.5	32.4	31.5	30.6	33.1	37.1	NA	31.8	33.8
B.	**Minimum Temperature in ^{O}C**								
Jan	10.4	5.8	9.4	9.1	5.3	6.6	7.5	7.1	7
Feb	11.3	6.4	9.4	10.4	9.8	4.6	9.4	7.8	9.8
Mar	11.5	12.7	14.2	13.8	10.6	8.8	9.9	8.6	10.4
Apr	13.1	14.8	15.1	16.2	11.2	17.3	15.1	14.7	14.3
May	21.1	20.6	18	20.2	19.6	16.3	20.8	18.7	18.3
Jun	22.3	20.4	20.4	17.6	20.5	21.1	20.8	21.4	20.8
Jul	20.2	21.3	21.7	21.6	21	21.2	21	21.1	20.3

Month	Year								
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Aug	20.5	19	21.6	21.3	20.5	19.2	NA	20.8	20.2
Sep	20.3	14.9	19.6	19.2	18.3	18.5	NA	18.9	17.7
Oct	13.4	11.6	12.6	15.9	12.6	12.7	NA	13.9	17.6
Nov	8.2	9.9	11.4	13.8	10.7	7.9	NA	11.2	12.9
Dec	10.9	8.6	8.5	6.5	7.6	10	NA	7.8	6.6
C.	**Average wind speed in Km/hr**								
Jan	4	6	4	4	3	6	4	3	4
Feb	9	7	4	5	7	5	8	8	4
Mar	6	9	4	7	5	7	50	6	7
Apr	8	8	9	10	9	7	10	8	8
May	12	13	12	18	14	12	13	11	12
Jun	13	16	12	12	15	17	10	19	16
Jul	15	14	13	10	13	14	11	13	15
Aug	15	13	13	11	12	14	NA	10	15
Sep	12	10	7	10	10	8	NA	10	9
Oct	7	4	8	7	5	4	NA	4	5
Nov	5	11	11	7	5	3	NA	8	4
Dec	5	4	4	7	3	4	NA	9	4
D.	**Total Rainfall in mm**								
Jan	0	0	0	0	0	0	0	0.1	0
Feb	0	0	0	0	0	0	0	0	0
Mar	0	25	2.9	23.1	0.4	0	2.8	3.6	59.1
Apr	8.1	0	0.4	0.3	25.6	7	0	6	0
May	3.8	1.7	0.7	5.9	4.8	0	0	9.4	112.7
Jun	232.2	128	117.5	338.2	256.9	29.8	260.8	13	211.2
Jul	297.6	87.7	272.1	206.5	212.3	66.8	191.9	288.2	62.5
Aug	159.9	168.3	245	172.3	117.9	205	NA	269.4	24.7
Sep	149.2	293.4	77.9	117.4	220.6	54.9	NA	128.3	173.6
Oct	3.2	30	104.7	263.5	203	144.5	NA	25.8	76.7
Nov	10.5	0.5	176.8	50.6	0	1.2	NA	25.6	109.1
Dec	0	24.3	0.3	0	0	0	NA	53.1	0
E.	**Total Evaporation in mm**								
Jan	110	135.5	111.2	97.1	105.5	111.7	121.7	116.7	102
Feb	139.6	154.4	138.9	125.1	138.4	137.4	135.2	131.4	123.4
Mar	209.7	213.8	210.7	216.3	208.2	215.5	236.8	210.5	178.7
Apr	241.4	266.3	288.7	269.1	256.4	298.5	308.3	293	242.9
May	275.4	308.5	315	316	309.5	312.6	335.6	285.7	248.5
Jun	148.6	141.6	229.9	171	141	237.8	127	271.7	156.5
Jul	107.6	105.3	87	130.6	97.4	146.2	81.9	146.8	156.4
Aug	93.6	88.1	85.2	113.5	97.6	129.5	NA	104.9	141.3
Sep	84.2	84.7	107.7	122.2	115.3	113.4	NA	125.4	140.9
Oct	145.1	135.2	120	129.5	108.7	132.6	NA	150.8	131.7
Nov	124.2	128.9	92.7	100	135.3	128.2	NA	138	121
Dec	143	105.3	90.6	90.1	112.1	83.9	NA	115.1	111.4

Source: IMD, Pune

The wind rose diagram of Pune for the period of Jan1970 to Dec 2010 developed Indian Meteorological Department (IMD) is shown in Figure 4.7.From the Figure, the predominant direction is from West direction with 35.9% of the Year; out of which 77% of time the wind speed varies between 1.5-4.5 m/s.

Figure 4.7: Wind Rose Diagram for Pune City



4.4.2. Air Quality

The prime objective of baseline air quality survey was to assess conformity to standards of ambient air quality.

Air quality monitoring was carried out at 29 proposed station locations of the proposed project on two working days in the months of November and December 2017. The sample locations are shown in Figure 4.2.

Five major air pollutants viz. particulate matter (PM_{10}& $PM_{2.5}$), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and Carbon Monoxide (CO) representing the air quality was monitored. Air quality monitoring was carried out by collecting 24 hourly samples continuously for 2 days. Results of the monitoring are tabulated in Table 4.9. The air quality monitoring results indicate that PM_{10}& $PM_{2.5}$ exceeding the permissible limits for residential, Industrial and Sensitive areas at all locations and CO is exceeding the permissible limits at some locations.Parameters SO_2 and NO_2 were noted within the permissible limits. Road suspended dust and vehicle emissions are the major sources of pollution.

Table 4.9: Ambient Air Quality Monitoring Results

Station ID	Location	Date	Concentration				
			SO_2	NO_2	PM_{10}	$PM_{2.5}$	CO
		Permissible Limit	**80**	**80**	**100**	**60**	**2**
		Unit	**µg/m^3**	**µg/m^3**	**µg/m^3**	**µg/m^3**	**mg/m^3**
PCMC – Range Hill Corridor							
1.	PCMC	31/10/17 to 01/11/17	5.47	7.8	198	49	1.84
		01/11/17 to 02/11/17	5.39	5.47	306	78	1.84
2.	Tukaram Nagar	18/12/17 to 19/12/17	6.06	6.68	348	90	1.2
		19/12/17 to 20/12/17	5.21	6.05	393	96	1.2
3.	Nashik phata	31/10/17 to 01/11/17	4.71	5.85	213	53	1.83
		01/11/17 to 02/11/17	5.38	4.98	434	108	1.83
4.	Kasarwadi	05/10/17 to 06/10/17	4	5.9	151	32	1.33
		06/10/17 to 07/10/17	<4	15.7	181	42	1.25
5.	Phugewadi	31/10/17 to 01/11/17	5.55	5.74	218	54	1.03
		01/11/17 to 02/11/17	4.88	5.42	159	38	1.03
6.	Dapodi	05/10/17 to 06/10/17	<4	12.9	370	78	1.38
		06/10/17 to 07/10/17	<4.0	14.4	172	37	1.88
7.	Bopadi	31/10/17 to 01/11/17	5.63	5.30	381	95	1.59
		01/11/17 to 02/11/17	4.63	5.52	415	103	1.59
8.	Khadki	31/10/17 to 01/11/17	5.30	5.85	250	64	2.56
		01/11/17 to 02/11/17	5.05	5.63	267	66	2.56
9.	Range Hill	21/12/17 to 22/12/17	5.3	5	171	45	1.04
		22/12/17 to 23/12/17	6.73	5	175	46	<0.5
10.	Shivajinagar	20/11/17 to 21/11/17	5.13	5.78	189	50	1.33
		21/11/17 to 22/11/17	5.63	5.89	278	65	0.65
11.	Civil court	12/12/17 to 13/12/17	4.96	5.78	146	35	0.71
		13/12/17 to 14/12/17	6.05	5.45	186	43	0.71
12.	Kasba peth	12/12/17 to 13/12/17	4.96	5.34	166	40	0.84
		14/12/17 to 15/12/17	5.38	6.01	149	35	0.84
13.	Mandai	14/12/17 to 15/12/17	4.96	5.11	118	25	0.88
		15/12/17 to 16/12/17	5.04	5.34	135	32	0.88
14.	Swargate	16/11/17 to 17/11/17	5.05	6.24	388	94	0.83
		17/11/17 to 18/11/17	4.96	6.01	324	79	2
Vanaz-Ramwadi Corridor							
15.	Vanaz	06/11/17 to 07/11/17	5.97	5.67	168	40	3.49
		07/11/17 to 08/11/17	5.55	6.34	192	47	3.49
16.	Anand nagar	06/11/17 to 07/11/17	5.46	5.22	286	73	2.94
		07/11/17 to 08/11/17	6.14	6.23	190	47	2.94
17.	Ideal colony	06/11/17 to 07/11/17	5.38	6.34	237	59	4.44
		07/11/17 to 08/11/17	5.80	5.11	249	62	4.44
18.	Nal stop	06/11/17 to 07/11/17	6.39	6.14	180	45	2.84
		07/11/17 to 08/11/17	6.39	6.14	180	45	2.84
19.	Garware college	06/11/17 to 07/11/17	5.38	5.34	189	48	6.15
		07/11/17 to 08/11/17	5.72	7.01	200	49	6.15
20.	Deccan Gymkhana	02/11/17 to 03/11/17	4.81	5.63	306	76	2.04
		03/11/17 to 04/11/17	5.46	4.98	253	63	2.04
21.	Sambhaji Park	02/11/17 to 03/11/17	5.55	5.53	343	114	2.38
		03/11/17 to 04/11/17	5.48	5.96	368	96	2.38
22.	PMC	02/11/17 to 03/11/17	6.05	5.09	319	79	2.6
		03/11/17 to 04/11/17	5.3	5.30	325	81	2.6

Station ID	Location	Date	Concentration				
			SO_2	NO_2	PM_{10}	$PM_{2.5}$	CO
		Permissible Limit	**80**	**80**	**100**	**60**	**2**
		Unit	**µg/m³**	**µg/m³**	**µg/m³**	**µg/m³**	**mg/m³**
23.	Mangalwar peth	14/12/17 to 15/12/17	5.55	5.78	396	95	0.73
		15/12/17 to 16/12/17	5.55	6.12	457	115	0.78
24.	Pune railway station	12/12/17 to 13/12/17	6.15	6.11	191	50	1.2
		13/12/17 to 14/12/17	5.46	5.11	174	42	0.73
25.	Ruby Hall	21/12/17 to 22/12/17	5.04	4.67	166	40	<0.5
		22/12/17 to 23/12/17	6.73	5	175	46	<0.5
26.	Bund garden	08/11/17 to 09/11/17	5.13	5.22	350	82	0.95
		09/11/17 to 10/11/17	4.96	5.34	208	50	1.96
27.	Yerwada	14/11/17 to 15/11/17	4.96	5	346	83	2.05
		15/11/17 to 16/11/17	5.38	5.34	458	112	0.78
28.	Kalyaninagar	08/11/17 to 09/11/17	5.55	5.22	423	101	1.28
		09/11/17 to 10/11/17	4.87	5	542	132	1.25
29.	Ramavadi	08/11/17 to 09/11/17	5.38	5	295	70	2.11
		09/11/17 to 10/11/17	4.96	4.78	413	100	1.94
Depots and Casting Yards							
30.	Range hill depot	18/12/17 to 19/12/17	5.3	6.01	606	150	1.55
		19/12/17 to 20/12/17	6.12	5.45	377	96	1.55
31.	Vanaz depot	14/12/17 to 15/12/17	5.55	5.56	182	45	1.45
		15/12/17 to 16/12/17	6.06	5.84	219	56	1.45
32.	Metro yard Marunji	18/12/17 to 19/12/17	5.63	5.89	193	44	1.38
		19/12/17 to 20/12/17	5.81	5.90	127	34	1.38
33.	Metro yard pimple Gurav	18/12/17 to 19/12/17	5.63	5.0	269	70	1.51
		19/12/17 to 20/12/17	5.73	5.79	594	146	1.51

4.4.3. Noise Environment

Noise exposure can lead to adverse effects on health. The impacts of noise sources on surrounding community depend upon:

- Characteristics of noise sources (instantaneous, intermittent or continuous in nature). It can be observed that steady noise is not as annoying as one, which is continuously varying in loudness.
- Time of day at which noise occurs, for example high noise levels at night in residential areas are not acceptable because of sleep disturbance.
- Location of noise source, with respect to noise sensitive land use, which determines the loudness and period of exposure.

Noise level survey was conducted at 33 locations in the project area with an objective to establish the baseline noise levels and assess the impacts of the noise expected due to the proposed development. Noise levels were recorded on hourly basis for 24 hours continuously for two working days in order to have an assessment of the Day and Night time noise levels. The sample locations are shown inFigure 4.2and the noise levels so obtained are summarized in Table 4.10.

Table 4.10: Noise Levels in the Project Area

S. No	Corridor	Day 1 - Day						Day 1 - Night						Day 2 - Day						Day 2 - Night					
		L_{eq}	L_{max}	L_{min}	L_{10}	L_{50}	L_{90}	L_{eq}	L_{max}	L_{min}	L_{10}	L_{50}	L_{90}	L_{eq}	L_{max}	L_{min}	L_{10}	L_{50}	L_{90}	L_{eq}	L_{max}	L_{min}	L_{10}	L_{50}	L_{90}
PCMC - Swargate																									
1	PCMC	74.9	80.1	54.1	79.1	73.0	61.2	61.5	69.3	42.4	65.2	47.5	43.0	73.8	79.1	55.0	76.8	73.4	61.4	61.1	68.4	43.7	65.5	50.7	44.3
2	Tukaram Nagar	63.0	65.6	54.6	65.0	62.1	59.5	57.5	61.6	52.8	60.3	55.9	52.8	65.7	57.4	69.4	68.6	65.3	59.9	57.8	61.0	50.0	60.9	56.2	50.7
3	Nashik Phata	75.2	82.7	54.0	77.9	73.1	59.7	60.3	67.0	43.6	65.5	46.8	43.6	73.2	77.6	53.9	75.7	73.6	60.8	60.2	67.5	43.8	64.1	53.4	43.8
4	Kasarwadi	74.0	79.5	54.6	76.7	73.7	62.7	61.0	68.2	43.5	65.5	50.3	43.6	74.9	80.1	54.3	79.0	73.1	62.3	59.5	66.7	41.9	64.3	46.1	42.8
5	Phugewadi	77.1	81.9	56.9	80.2	76.9	64.1	67.7	76.2	46.3	69.0	54.6	48.6	74.2	79.6	54.8	76.8	73.7	64.0	61.1	68.1	43.6	65.8	50.5	43.8
6	Dapodi	73.3	78.0	53.7	76.8	71.8	62.6	56.1	63.8	44.9	58.1	49.2	45.0	73.6	77.8	55.7	76.4	73.9	57.3	62.3	70.4	44.1	65.0	49.9	45.2
7	Bopodi	73.1	78.3	54.9	77.0	71.7	63.8	58.0	65.9	44.5	59.8	50.6	45.4	73.7	79.7	55.6	76.9	72.4	59.5	65.7	74.2	43.4	67.3	51.3	43.9
8	Khadki	72.9	77.9	52.2	76.0	72.6	57.8	60.3	68.6	40.6	61.5	48.7	42.6	73.5	78.2	50.2	77.1	72.3	55.0	58.2	66.0	42.4	61.9	47.9	42.7
9	Range Hill	55.9	58.6	49.8	58.5	55.8	51.1	48.9	51.6	43.8	50.9	48.7	45.8	55.7	49.4	58.2	57.6	55.8	51.3	48.4	50.9	43.0	50.3	48.1	44.3
10	Shivaji Nagar	71.7	75.3	53.6	74.6	71.6	61.5	70.5	71.6	45.5	67.8	55.2	51.4	74.0	79.3	53.3	76.5	73.6	64.0	65.4	73.6	46.1	67.8	56.0	46.5
11	Civil Court	71.4	79.1	51.9	75.3	68.1	57.1	61.6	69.4	44.6	65.1	49.8	47.2	69.6	76.8	51.9	72.5	67.4	57.1	61.5	67.6	44.4	67.2	46.5	45.3
12	Kasaba Peth	78.7	84.3	51.8	83.8	72.7	57.4	68.8	76.9	50.7	72.1	53.7	51.0	81.9	88.7	53.4	86.3	78.7	58.6	71.2	78.7	49.6	75.8	52.3	50.2
13	Mandai	70.4	75.5	51.8	74.9	68.4	55.4	53.5	59.4	44.6	56.4	49.9	45.7	74.3	79.0	55.3	78.4	72.6	60.6	64.3	72.3	44.5	66.7	49.3	44.8
14	Swargate	74.2	78.5	57.5	77.6	73.8	64.8	72.5	68.5	43.6	65.5	51.3	46.3	74.3	78.9	58.2	77.7	72.7	65.4	55.1	62.4	41.8	58.2	48.9	42.4
Vanaz-Ramwadi																									
1	Vanaz	73.6	80.1	56.5	78.2	70.8	60.1	67.1	74.2	46.7	69.6	59.7	46.8	69.6	76.2	54.8	74.4	64.5	56.9	63.7	70.2	44.0	68.0	54.7	45.8
2	Anand Nagar	72.7	79.8	53.6	75.6	69.0	59.2	58.5	64.7	46.2	62.9	53.2	48.7	69.3	73.7	53.9	72.6	68.2	59.0	55.1	61.3	41.6	59.6	49.3	42.6

S. No	Corridor	Day 1 - Day						Day 1 - Night						Day 2 - Day						Day 2 - Night					
		L_{eq}	L_{max}	L_{min}	L_{10}	L_{50}	L_{90}	L_{eq}	L_{max}	L_{min}	L_{10}	L_{50}	L_{90}	L_{eq}	L_{max}	L_{min}	L_{10}	L_{50}	L_{90}	L_{eq}	L_{max}	L_{min}	L_{10}	L_{50}	L_{90}
3	Ideal Colony	71.2	75.5	53.3	74.0	70.2	59.5	48.9	53.6	44.6	51.2	47.6	45.2	71.6	74.7	53.1	74.4	72.0	58.6	51.1	55.4	45.8	53.7	50.1	46.6
4	Nal Stop	68.7	72.3	54.7	71.7	67.7	61.4	57.1	62.6	43.8	61.3	53.2	44.2	73.1	80.1	57.7	78.3	69.4	58.8	64.9	72.6	44.2	67.3	53.3	44.3
5	Garware College	74.0	79.8	55.2	78.7	69.6	60.6	59.5	66.2	43.8	63.8	54.1	43.9	71.9	79.1	55.4	75.7	68.0	58.5	55.5	63.2	44.0	57.3	49.0	44.4
6	Deccanjimkhana	72.9	77.6	55.7	74.8	71.5	57.8	62.7	70.7	49.4	64.4	55.8	50.0	73.0	77.5	57.3	75.9	72.3	63.3	60.7	68.2	44.0	63.1	55.3	48.6
7	Shambhaji Garden	73.1	78.7	56.4	76.4	72.2	63.2	66.5	75.1	45.2	67.4	49.5	46.0	73.1	76.8	56.5	76.0	72.0	63.6	66.6	75.2	44.3	67.8	51.0	45.1
8	PMC	73.0	77.4	54.9	76.7	72.8	61.3	61.8	69.8	44.6	65.0	49.8	45.2	73.7	79.4	55.2	77.5	72.6	60.8	64.0	72.2	44.4	66.6	49.4	44.8
9	Mangalwar Peth	70.1	75.4	53.3	72.9	69.1	59.0	56.1	63.4	43.8	58.0	51.1	44.4	63.0	72.4	51.9	64.5	57.2	53.6	56.8	61.5	48.4	59.5	55.4	51.5
10	Pune Station	74.4	78.7	56.5	78.3	71.8	59.8	62.2	68.3	57.4	63.7	60.2	57.7	73.0	78.4	58.6	76.7	72.0	61.1	64.0	69.9	52.6	66.3	61.8	57.3
11	Ruby Hall	74.7	80.2	56.6	77.8	73.4	59.6	66.3	74.6	44.5	69.0	49.4	45.4	76.5	81.5	57.4	80.8	73.6	60.2	66.8	75.1	44.2	69.6	50.6	45.6
12	Bund Garden	68.5	79.5	53.8	77.5	68.4	58.4	75.9	86.1	69.8	83.7	73.3	71.1	68.7	77.8	61.0	75.9	66.7	64.2	53.2	63.5	46.7	61.2	51.9	47.4
13	Yerwada	71.3	76.2	56.7	74.7	70.2	60.8	70.3	66.3	45.3	63.6	47.7	45.7	72.0	79.3	55.3	74.1	71.0	61.8	58.7	65.3	44.8	63.8	48.6	45.8
14	Kalyani Nagar	74.6	82.7	67.3	80.2	74.2	69.3	70.9	75.5	61.7	75.3	69.1	67.3	72.4	75.1	66.9	74.6	71.2	69.8	59.9	66.6	52.2	65.8	59.4	53.6
15	Ramwadi	71.1	76.0	52.1	74.8	67.1	54.3	58.0	64.0	41.6	62.5	52.2	42.4	62.4	70.9	51.9	65.3	56.9	53.2	50.6	55.5	43.0	54.2	46.8	43.7
Depots and Casting Yards																									
1	Vanaz Depot	74.8	82.8	54.0	78.6	70.0	57.9	57.3	64.9	46.0	60.8	49.0	46.5	75.2	82.4	52.1	79.0	71.7	57.0	57.2	64.5	44.7	61.0	49.9	45.6
2	Rangehill Depot	55.3	59.8	48.8	57.6	54.9	49.5	47.7	51.0	43.5	50.4	46.5	43.9	55.7	59.4	49.2	59.1	54.5	50.1	47.9	51.8	42.8	51.3	45.9	42.9
3	Marunji Yard	59.5	62.5	53.4	61.7	59.0	55.7	63.1	66.5	59.0	64.5	63.0	59.5	62.8	53.7	67.4	64.4	62.3	58.8	51.9	54.4	47.9	54.2	51.0	48.5
4	Pimple Gurav Yard	73.8	80.3	46.1	78.4	71.2	51.3	69.7	75.6	46.9	75.5	54.3	47.3	73.2	48.5	78.6	77.3	72.2	51.3	67.0	73.5	45.7	72.0	54.5	46.8

It is observed from the table that Leq for day and night at all monitoring locations were exceeding the permissible limits for commercial zone as per National Ambient Noise Standards.The main source of noise in the project area is the traffic movement on the road.

4.4.4. Vibration

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. Rattling of windows, dishes, and similar parts may also result in audible noise which is called ground-borne noise. People may be more annoyed if they are exposed to both noise and vibration compared to when only vibration is felt.

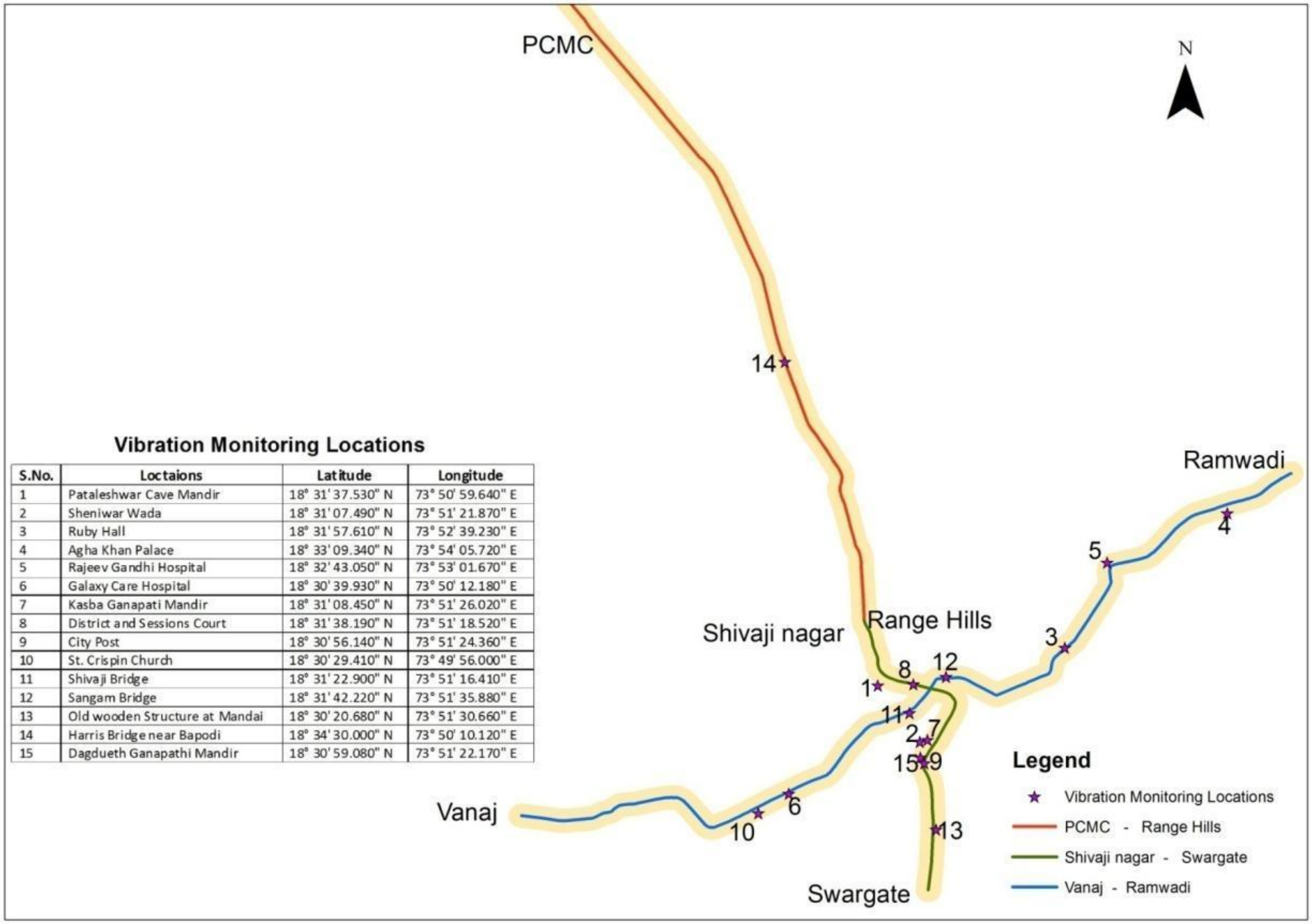
Ground-borne vibration can be a major concern for nearby neighboursof a transit system route or maintenance facility. Some common sources of ground-borne vibration are trains, buses on rough roads, and construction activities such as blasting, pile- driving and operating heavy earth-moving equipment.

Vibration monitoring was carried out at 15 locations (8 locations on PCMC - Swargate alignment and 7 locations on Vanaj - Ramwadi alignment) as indicated in Figure 4.8. Vibration monitoring was conducted for 24 hr at each location. Vibration meter recorded all three direction vibration (Radial, Vertical and Horizontal vibration) per minute in VdB and in mm/s. Peak Particle Vibration was calculated from the recorded vibration. The list of location along with the date of monitoring is given in Table 4.11. Vibration monitoring was carried out using the Nomis Seismograph equipment which can measure the radial, transverse and vertical vibration of ground-borne vibrations.

Table 4.11: Vibration monitoring location with date and time of Monitoring

S. No	Location	From	To
PCMC - Swargate			
1.	Harris Bridge near Bapodi	9th Nov. 17	10th Nov. 17
2.	Pataleshwar Cave Mandir	9th Oct. 17	10th Oct. 17
3.	District and sessions court	31st Oct. 17	1st Nov. 17
4.	Shaniwar Wada	10th Oct. 17	11th Oct. 17
5.	Kasba Ganapati mandir	30th Oct. 17	31st Oct. 17
6.	DagdusethGanapathiMandir	10th Nov. 17	11th Nov. 17
7.	City post	1st Nov. 17	2nd Nov. 17
8.	Old wooden structure at Mandai	8th Nov. 17	9th Nov. 17
Vanaz - Ramwadi			
9.	St. Crispin Church	2nd Nov. 17	3rd Nov. 17
10.	Galaxy Care Hospital	27th Oct. 17	28th Oct. 17
11.	Shivaji Bridge	6th Nov. 17	7th Nov. 17
12.	Sangam Bridge	7th Nov. 17	8th Nov. 17
13.	Ruby Hall	23rd Oct. 17	24th Oct. 17
14.	Rajeev Gandhi Hospital	26h Oct. 17	27th Oct. 17
15.	Agha Khan Palace	24th Oct. 17	25th Oct. 17

Figure 4.8: Vibration Monitoring Locations



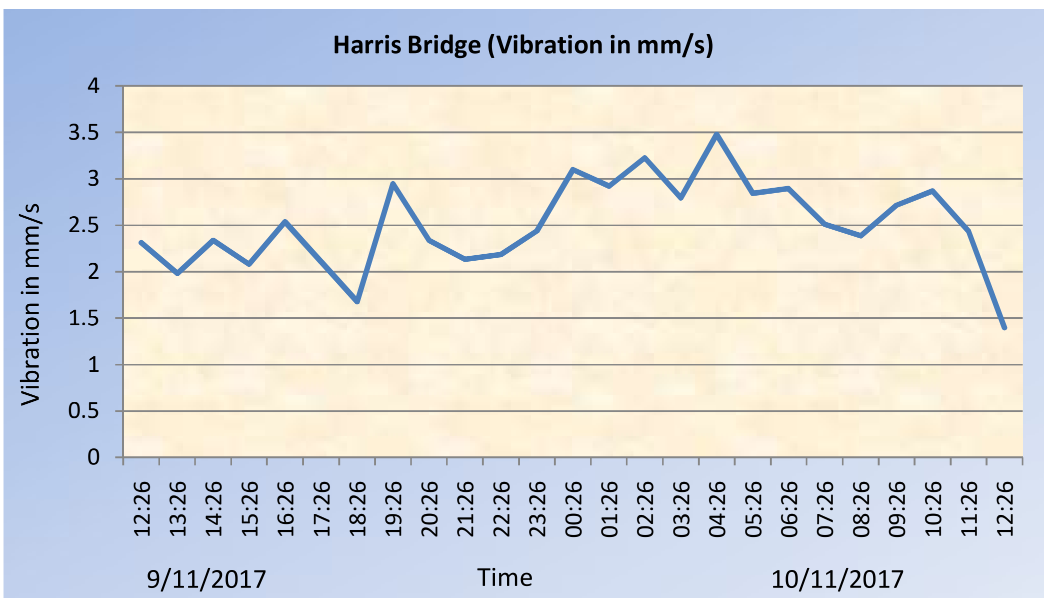
Vibration Monitoring Locations

S.No.	Loctaions	Latitude	Longitude
1	Pataleshwar Cave Mandir	18° 31' 37.530" N	73° 50' 59.640" E
2	Sheniwar Wada	18° 31' 07.490" N	73° 51' 21.870" E
3	Ruby Hall	18° 31' 57.610" N	73° 52' 39.230" E
4	Agha Khan Palace	18° 33' 09.340" N	73° 54' 05.720" E
5	Rajeev Gandhi Hospital	18° 32' 43.050" N	73° 53' 01.670" E
6	Galaxy Care Hospital	18° 30' 39.930" N	73° 50' 12.180" E
7	Kasba Ganapati Mandir	18° 31' 08.450" N	73° 51' 26.020" E
8	District and Sessions Court	18° 31' 38.190" N	73° 51' 18.520" E
9	City Post	18° 30' 56.140" N	73° 51' 24.360" E
10	St. Crispin Church	18° 30' 29.410" N	73° 49' 56.000" E
11	Shivaji Bridge	18° 31' 22.900" N	73° 51' 16.410" E
12	Sangam Bridge	18° 31' 42.220" N	73° 51' 35.880" E
13	Old wooden Structure at Mandai	18° 30' 20.680" N	73° 51' 30.660" E
14	Harris Bridge near Bapodi	18° 34' 30.000" N	73° 50' 10.120" E
15	Dagdueth Ganapathi Mandir	18° 30' 59.080" N	73° 51' 22.170" E

1. Harris Bridge

The Harris Bridge is built between Bopodi and Dapodi on old Pune - Mumbai Highway. The Bridge was built with substantial stone structure of strong, coursed masonry in black basalt, procured from local quarries. The bridge is 280 m long and 14 m wide.The vibration monitoring location and results at Harris Bridgeare shown in Figure 4.9.The peak vibration is about 3.5 mm/sand the minimum vibration is around 0.4 mm/s.

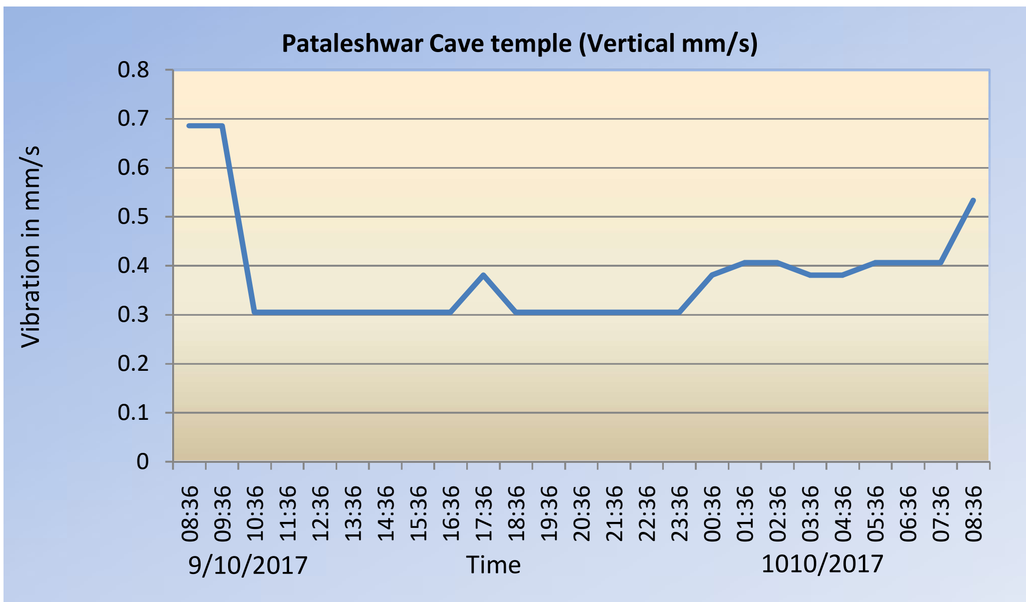
Figure 4.9: Vibration Monitoring Location and Results at Harris Bridge



2. Pataleshwar Cave Temple

The Cave Temple is a rock-cut cave temple, carved out in the 8th century in the Rashtrakuta period. The temple is made of basalt rock and is dedicated to the Hindu god Shiva. The cave is located at a lower level than the present level of the road and the cave complex.The vibration monitoring location and results at Pataleshwar Cave Temple are shown in Figure 4.10.

Figure 4.10: Vibration Monitoring Location and Results at Pataleshwar Cave Temple

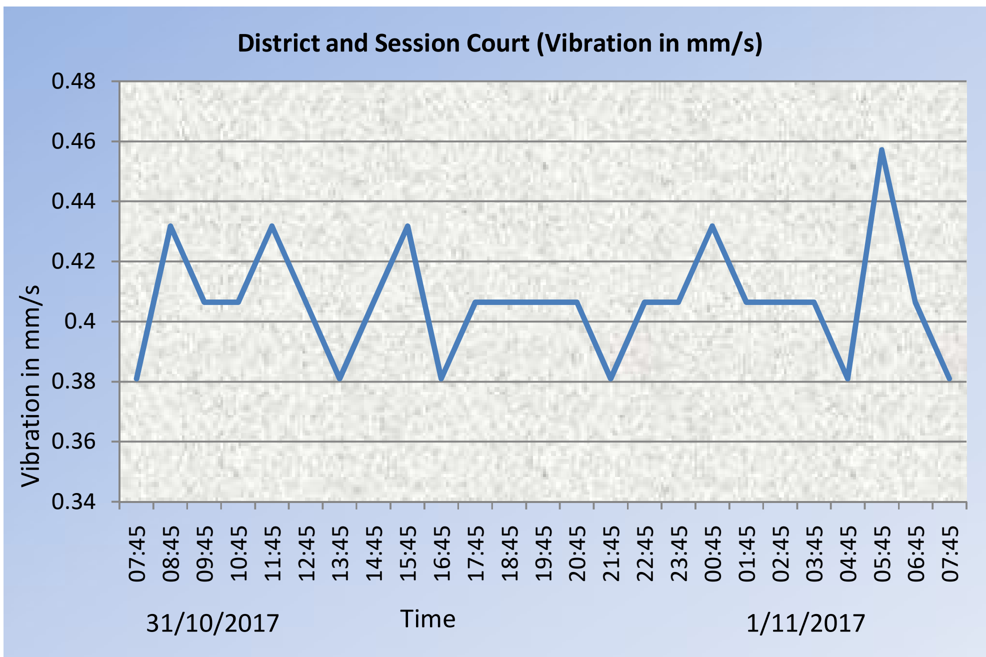


The result of the monitoring shows that, the vector sum vibration is between 0.3 to 0.7 mm/s, which is quite normal with regards to vibration levels due to road traffic. The Peak Vector sum vibration of the study location is found to be below o.69 mm/s.

3. District and Session Court

The District and Session Court Building of Pune were declared open by the Hon'ble sir Charles Gordon hill Fawcett Kt I C S PUISNE Judge of the High court of Judicature Bombay 5th Nov 1928. It is built with hard rock.The vibration monitoring location and results at District and Session Court are shown in Figure 4.11.

Figure 4.11: Vibration Monitoring Location and Results at District and Session Court



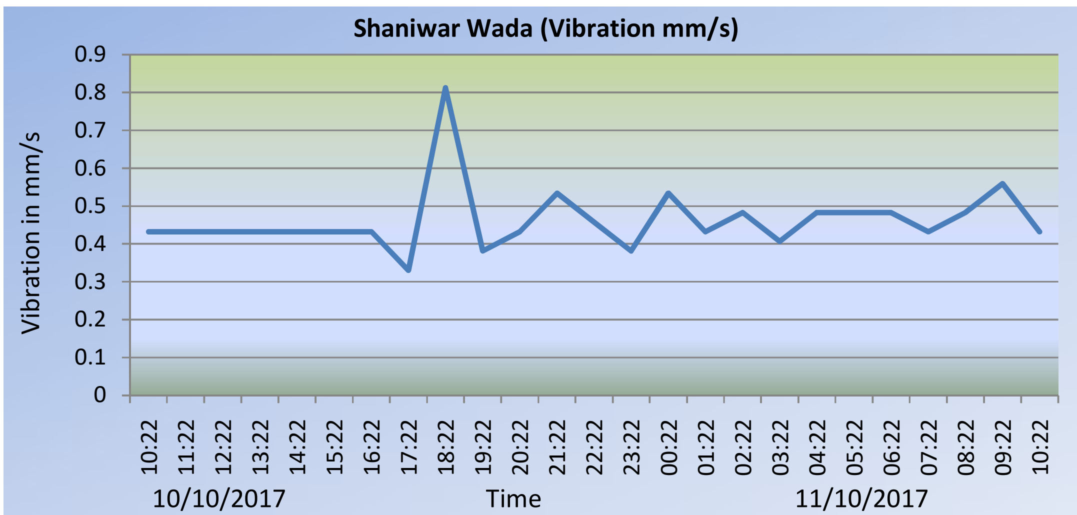
As can be seen from the graph, the peak vibration is about 0.45mm/s and the minimum vibration is around 0.38 mm/s.

4. Shaniwar Wada

Shaniwar Wada was built in 1732 and it was the seat of the Peshwas of the Maratha Empire until 1818. Shaniwar Wada is an Archaeological Monument and it is protected by Archaeological Survey of India.The vibration monitoring location and results at Shaniwar Wada are shown in Figure 4.12.

The result of the monitoring shows that, the vector sum vibration is between 0.35 to 0.8 mm/s, which is quite normal with regards to vibration levels due to road traffic. The peak vector sum vibration of the study location is found to be below 0.8 mm/s.

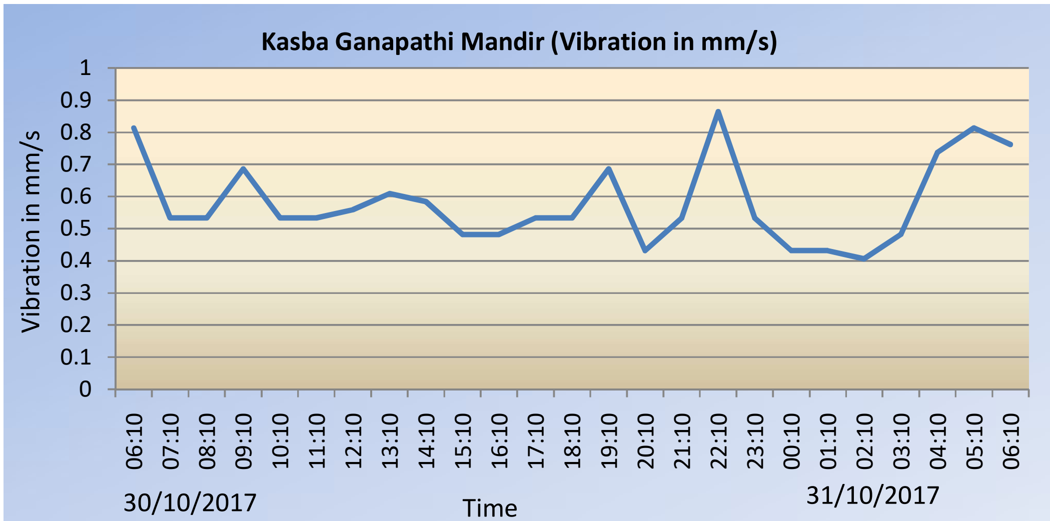
Figure 4.12: Vibration Monitoring Location and Results at Shaniwar Wada



5. Kasba Ganapati Mandir

The Temple was built in year 1630. The main building of "Kasba Ganapati Mandir" complex is about 100m from the proposed metro rail corridor. The structure is built with hard wood.The vibration monitoring location and results at Kasba Ganapati Mandirare shown in Figure4.13.The peak vibration is about 0.82mm/s and the minimum vibration is around 0.25 mm/s.

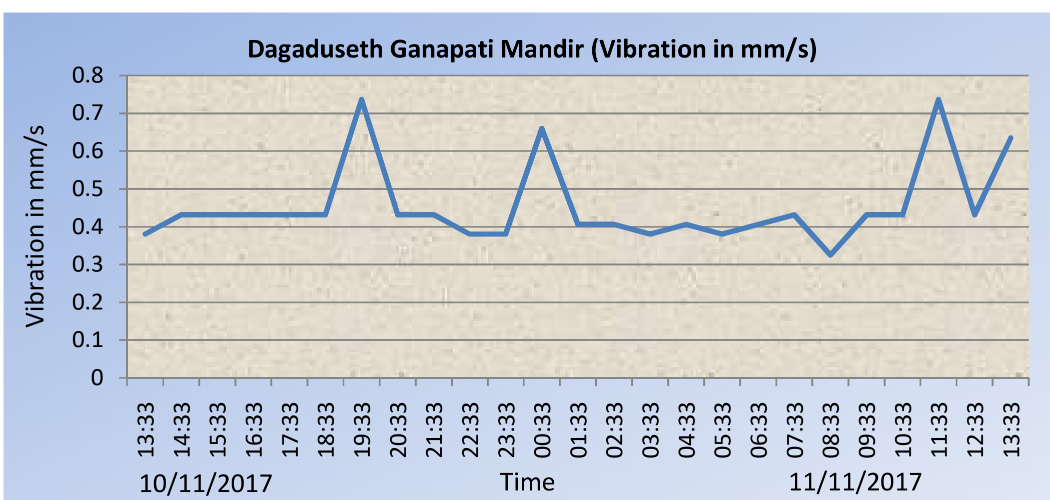
Figure 4.13: Vibration Monitoring Location and Results at Kasba Ganapati Mandir



6. Dagaduseth Ganapati Mandir

The temple is a beautiful construction and boasts a rich history of over 100 years. The temple was built in 1893. The structure is built with marble stone.The vibration monitoring location and results at Dagaduseth GanapatiMandirare shown in Figure 4.14.The peak vibration is about 0.75mm/s and the minimum vibration is around 0.3 mm/s.

Figure 4.14: Vibration Monitoring Location and Results at Dagaduseth GanapatiMandir

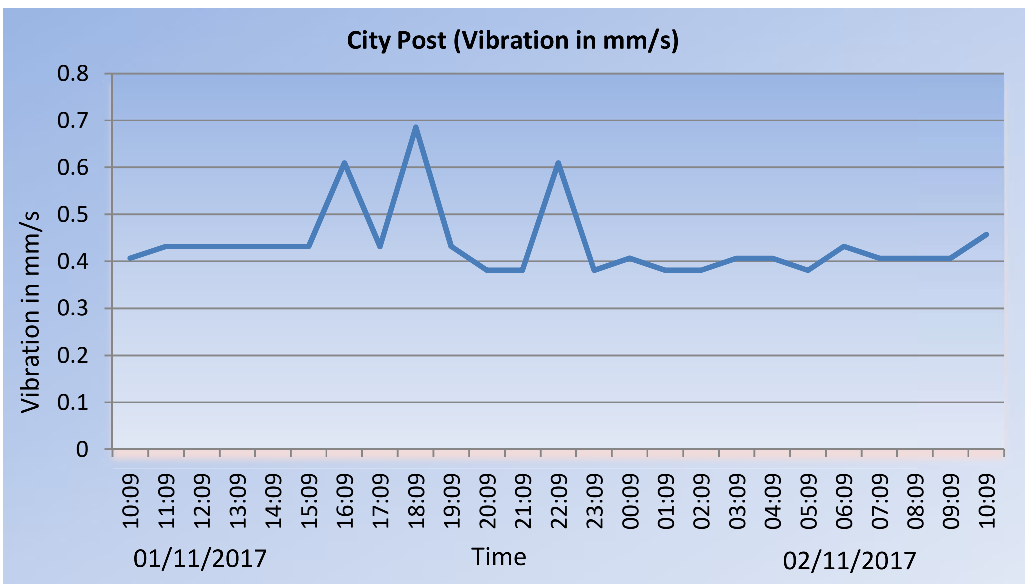


7. City Post

The City Post office of Pune was built by British in 1800s and the building was built with hard rock. Vibration monitoring was carried out at the adjacent to main building.The vibration monitoring location and results at City Post are shown in Figure 4.15.

As can be seen from the graph, the peak vibration is about 0.7mm/sand the minimum vibration is around 0.38 mm/s.

Figure 4.15: Vibration Monitoring Location and Results at City Post

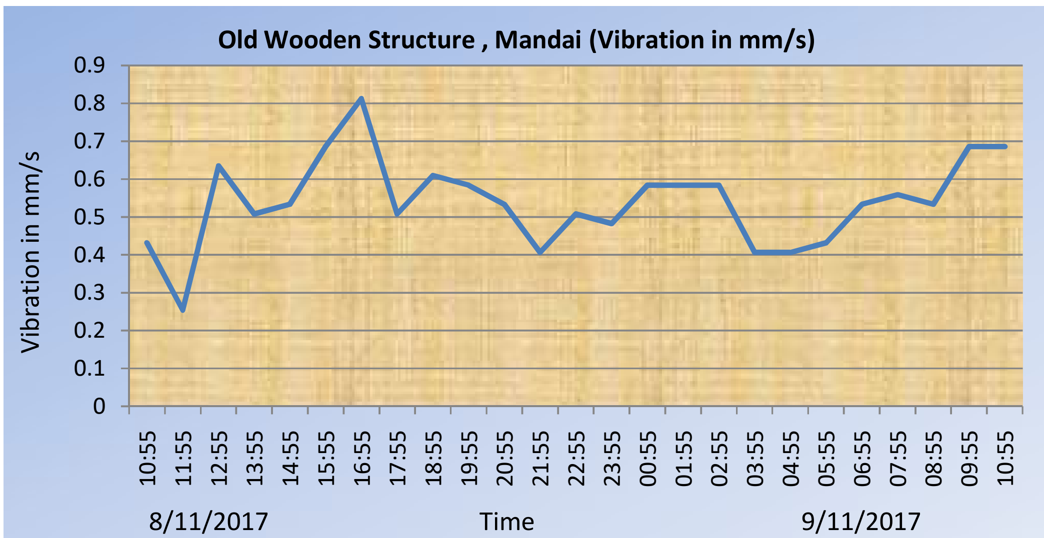


8. Old Wooden Structure at Mandai

The old wooden structure is a private residential house built more than 100 year ago. This house is of three story building supported by wooden frame and slab. There are two families staying in this house.The vibration monitoring location and results at Old Wooden Structure at Mandaiare shown in Figure 4.16.

The peak vibration is about 0.8mm/sand the minimum vibration is around 0.25 mm/s. The vibration is more in this location and the structure is getting damaged with the existing road traffic.

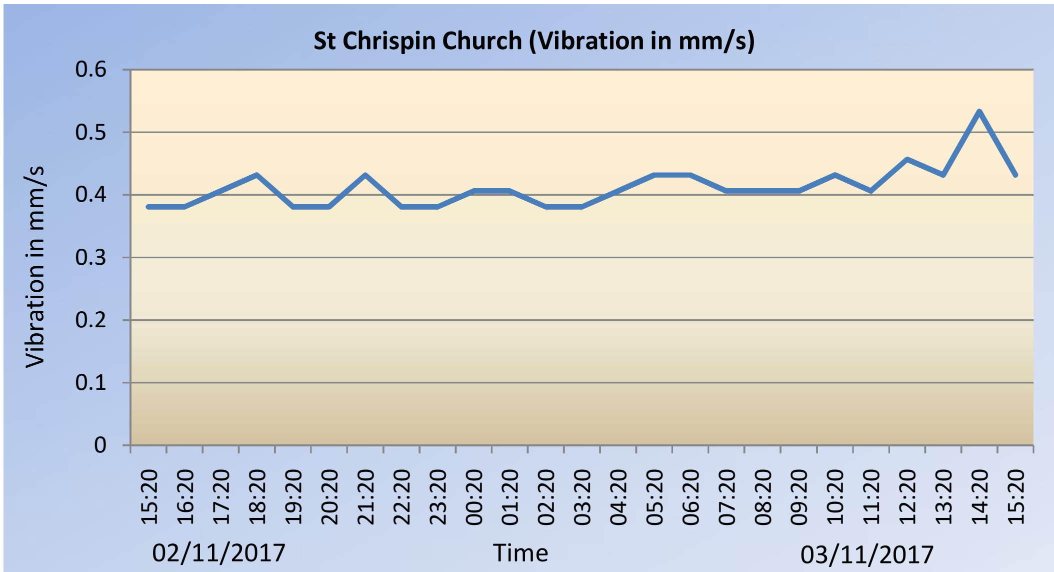
Figure 4.16: Vibration Monitoring Location and Results at Old Wooden Structure at Mandai



9. St. Crispin Church

St. Crispin Church was built in 1900, and it is the only church in western parts of the city having over 100 year's history. Society of St. John the Evangelist Fathers (SSJE) started an orphanage for boys along with a Primary School, the first in the area and built the St. Crispin's Home Church with a bungalow which was used as the Primary School and Fathers residence. The vibration monitoring location and results at St. Crispin Church are shown inFigure 4.17.

Figure 4.17: Vibration Monitoring Location and Results at St. Crispin Church



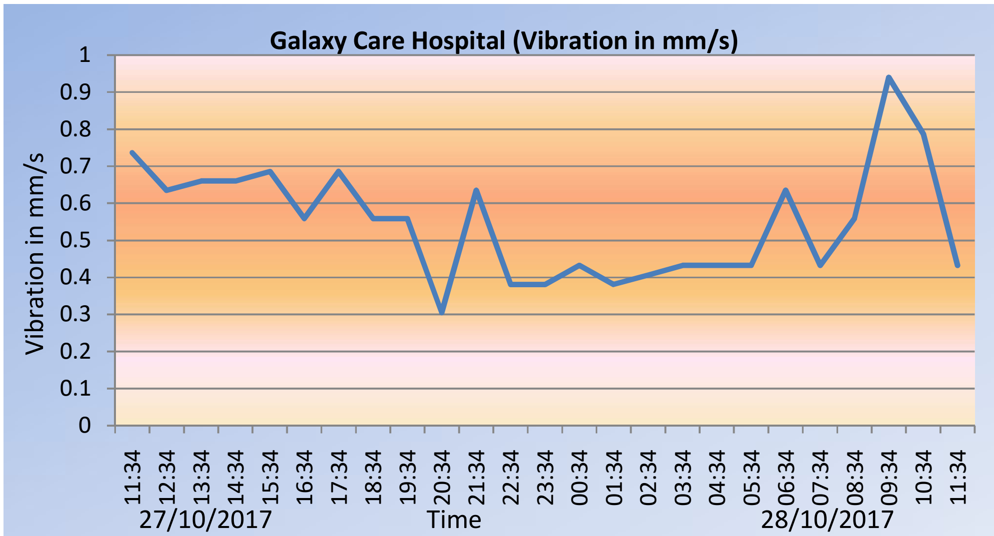
The peak vibration is about 0.54mm/sand the minimum vibration is around 0.25 mm/s.

10. Galaxy Care Hospital

Galaxy Care Hospital is located in Pune, at Karvy road, adjacent to proposed Vanaj – Ramwadi metro rail alignment. It is specialised in laparoscopic surgeries and Robotic cancer surgeries. The vibration monitoring location and results at Galaxy Care Hospital are shown inFigure 4.18.

As can be seen from the graph, the peak vibration is about 0.9mm/s, and the minimum vibration is around 0.3mm/s.

Figure 4.18: Vibration Monitoring Location and Results at Galaxy Care Hospital

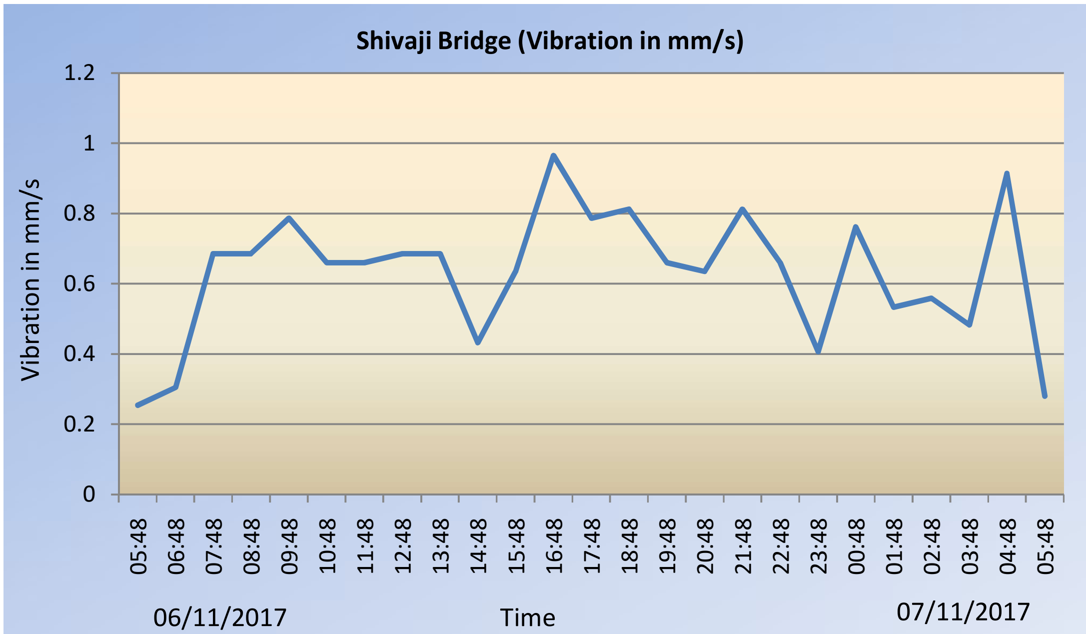


11. Shivaji Bridge

The Shivaji Bridge was built with substantial stone structure of strong, coursed masonry in black basalt, procured from local quarries. The bridge is 370 m long and 11.45 m wide. The Nin-span, buttressed bridge is supported by a pointed arch in the centre and four segmental arches on either side of the central arch.The vibration monitoring location and results at Shivaji Bridge are shown in Figure 4.19.

The peak vibration is about 0.9mm/s and the minimum vibration is around 0.25 mm/s.

Figure 4.19: Vibration Monitoring Location and Results at Shivaji Bridge

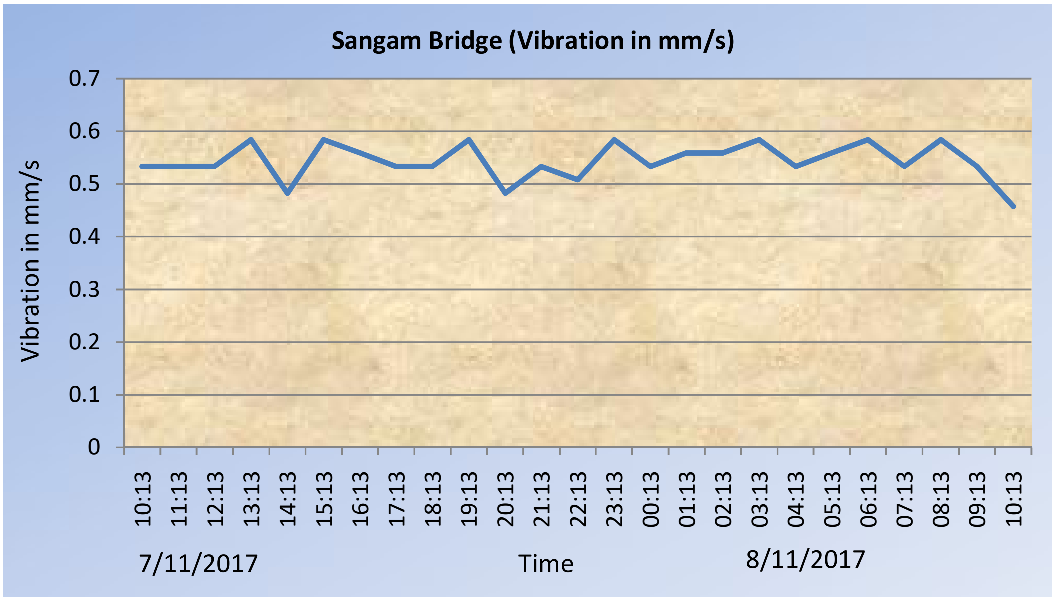


12. Sangam Bridge

The Sangam Bridge that is right next to the railway bridge on Mutha River near Pune station and was built in 1857. In 1928, when the Pune-Mumbai railway line was electrified, the present railway bridge was built right next to the old one. The old railway bridge was converted to a road bridge. The “Sangam Bridge” is about 250m long and 10m width. The bridge is built with cement concrete.The vibration monitoring location and results at Sangam Bridge are shown in Figure 4.20.

The peak vibration is about 0.6mm/sand the minimum vibration is around 0.38 mm/s.

Figure 4.20: Vibration Monitoring Location and Results at Sangam Bridge

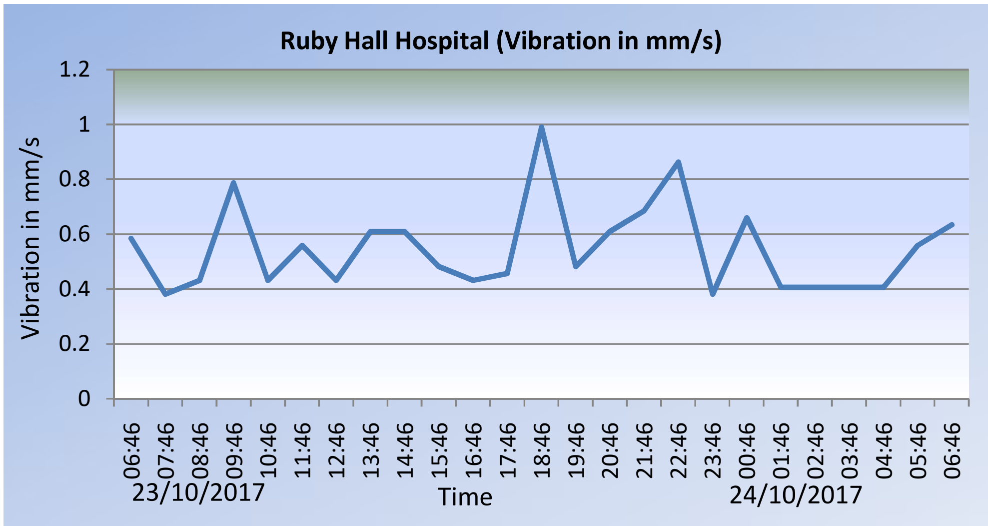


13. Ruby Hall Clinic

Ruby Hall Clinic started in Year 1959 as a small nursing home by Dr K B Grant in the bungalow Ruby Hall. Today Ruby Hall Clinic boasts of 550 inpatient beds including 130 intensive care beds; with staff strength of 150 consultants, 500 panel doctors and 1400 paramedical staff. This hospital is close to proposed metro rail alignment which is about 20m from centreline.The vibration monitoring location and results at Ruby Hall Clinic are shown in Figure 4.21.

The above chart shows the peak vibration level to be around 0.9 mm/s. The vibration is more because the area around “Ruby Hall Hospital” is a very busy traffic area with all types of vehicles (light to heavy) plying by.

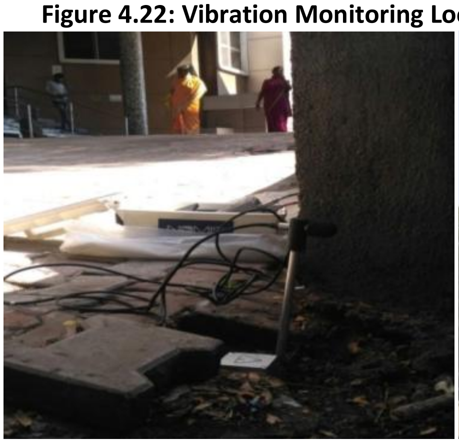
Figure 4.21: Vibration Monitoring Location and Results at Ruby Hall Clinic

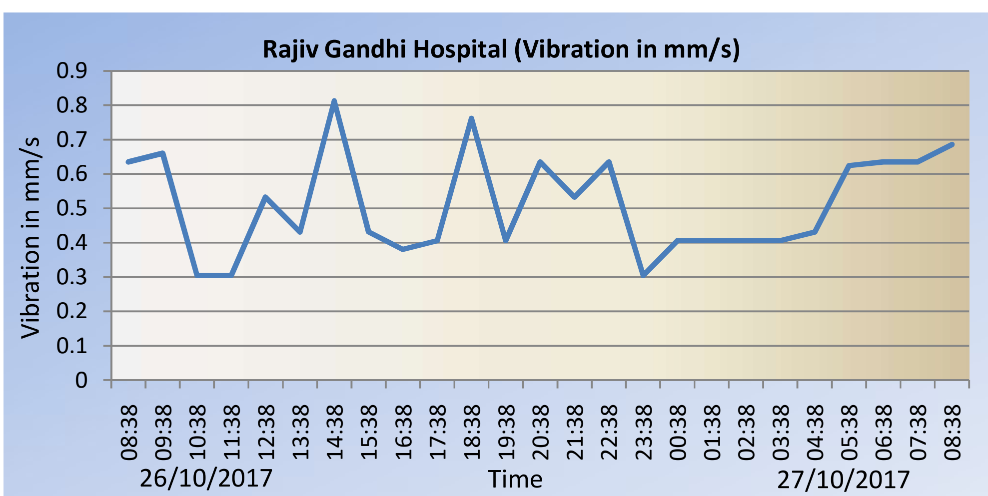


14. Rajiv Gandhi Hospital

The "Rajiv Gandhi Hospital" is government hospital with 650 beds. The hospital is equipped with all the facilities. About 500 out patients come for treatment every day.The vibration monitoring location and results at Rajiv Gandhi Hospitalare shown in Figure 4.22.

Figure 4.22: Vibration Monitoring Location and Results at Rajiv Gandhi Hospital



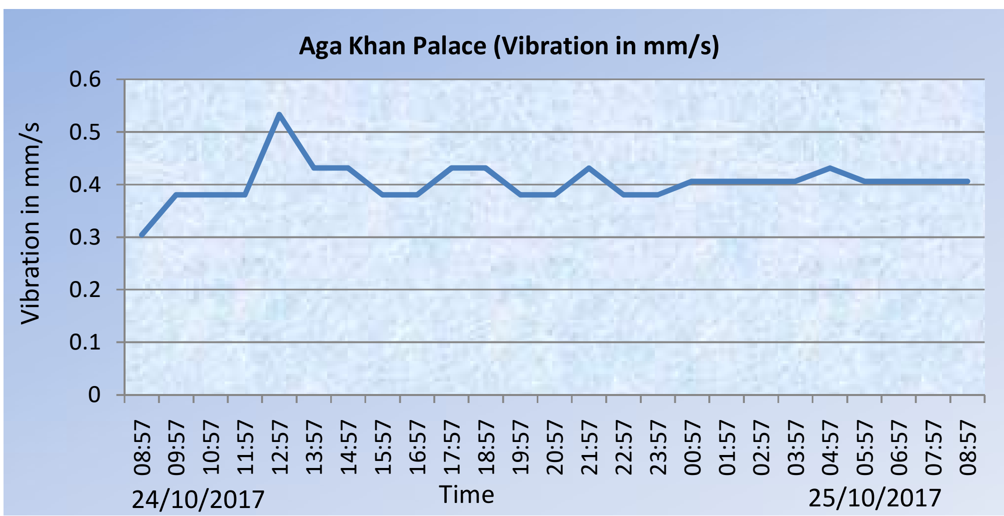


The graph shows that the vibration at Currency Building is 0.3 to 0.8 mm/s. The peak vibration is around 0.8 mm/s.

15. Aga Khan Palace

Built in 1892, it is one of the biggest landmarks in Indian history. The palace was an act of charity by the Sultan who wanted to help the poor in the neighbouring areas of Pune, who were drastically hit by famine.The vibration monitoring location and results at Aga Khan Palaceare shown in Figure 4.23.The vibration is found to be between 0.3 and 0.53mm/s. The maximum vibration is seen to be 0.53mm/s for an event.

Figure 4.23: Vibration Monitoring Location and Results at Aga Khan Palace



4.5. ECOLOGICAL ENVIRONMENT

Ecological studies are one of the important aspects of Environmental Impact Assessment with a view to conserve environmental quality and biodiversity. Ecological systems show complex inter-relationships between biotic and abiotic components including dependence, competition and mutualism. Biotic components comprise of both plant and animal communities, which interact not only within and between themselves but also with the abiotic components viz. physical and chemical components of the environment. To achieve the above objectives a detailed study of the project corridors was undertaken.

4.5.1. Natural Vegetation

The vegetation pattern of the city is conducive almost for all types of tropical species indigenous and exotic both.

4.5.2. Flora and Fauna

The city has a tree cover distributed throughout the urban-scape. Road side vegetation has been observed along the proposed metro corridors. The predominant tree species observed at the site are Indian rain tree, Subabol,Copperpod, Kadam, shubhrachafa, Asoka, Devils tree, Sisham, Neem, Banyan, Peepal, Eucalyptus, Bargad etc.

There has been a change in the native fauna of Pune because of urbanization and *introduction of exotic species.* Development of the city has resulted in the habitat loss and posed a threat on the faunal community.*The predominant faunal species found in the city is common mongoose (Herpestesedwardsii), Squirrel (Funambuluspennati), fruit bat, insectivorous bat (Myotishorsfieldii) & (*Hesperoptenustickelli). The avifauna found in the Pune city is Crows, Mynas, Herons and Egrets, Parakeets and Kites, House Crows, House Sparrows, Common Mynas, Rose ringed Parakeets, Red vented Bulbul, Little Brown Dove, Black winged Stilt, Common Green Pigeon and Cattle Egrets.No threatened or endangered species are found or sited in the Study Area.

4.5.3. Protected Areas in the region

No National Parks, Wildlife Sanctuary and Biosphere reserve etc are found within 5 km on either side of the metro corridors.

4.6. SENSITIVE RECEPTORS

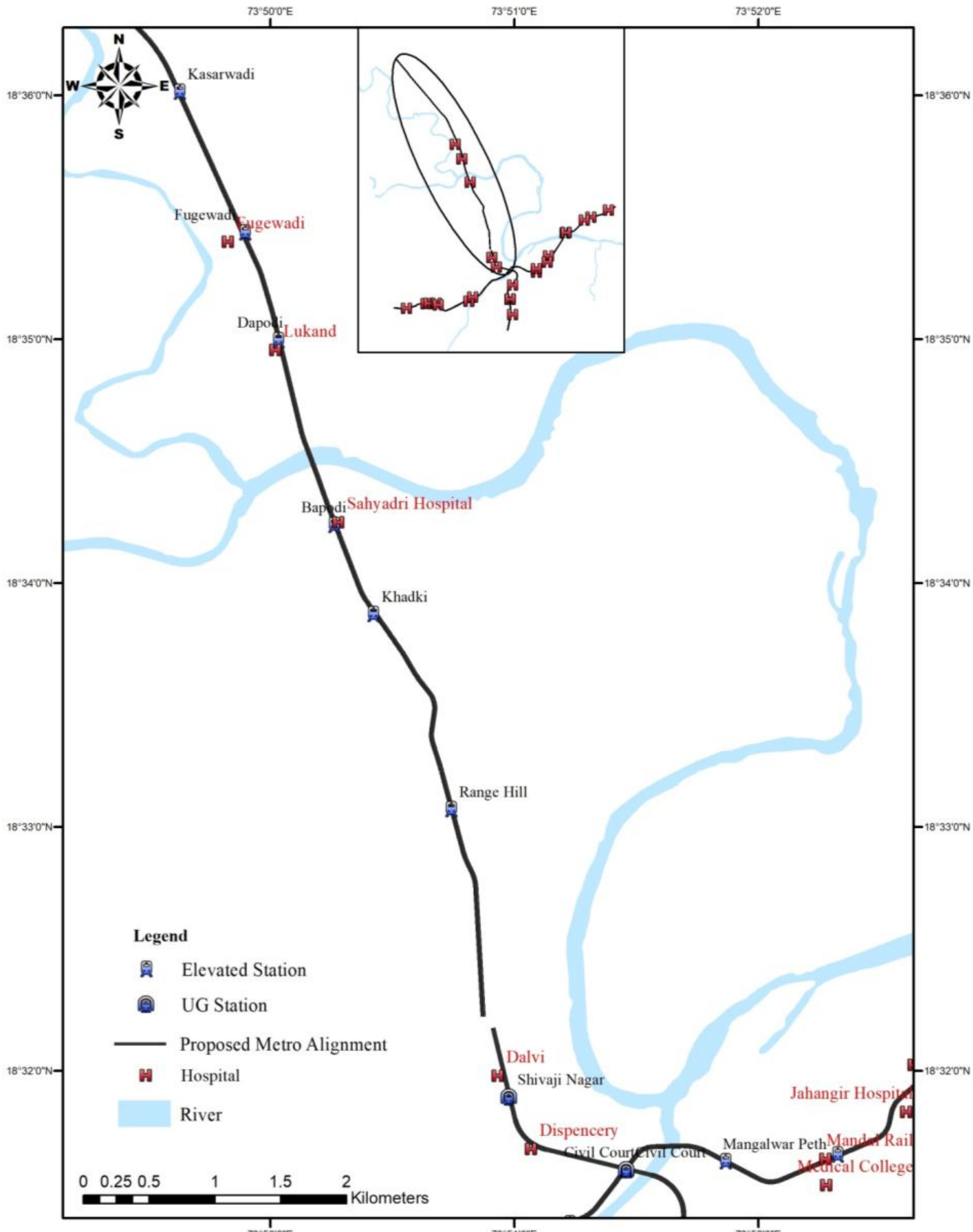
From the alignment drawings made available by Maha-Metro for Pune Metro Rail Project, the sensitive receptors were noted down corridor wise as given in Table 4.12.Details of VECs within ROW are given in Annexure 4.1. Map showing list of Hospitals and Educational Institutes along the proposed corridors are given in Figure 4.24 and Figure 4.25.

Table 4.12: VECs of Metro Corridors

Alignment	VECs within								
	ROW			100 m on either side of CL of alignment					
	Temple	Mosque /Dargah	School/ College	Temple	Mosque /Dargah	Church	School/ College	Hos pital	Grave Yard
PCMC-Range Hill (Elevated Section)	1	1	0	30	0	1	4	4	1
Shivaji Nagar – Swargate (UG Section)	6	0	3	24	0	0	1	7	0
Vanaz – Civil Court (Elevated Section)	5	0	0	40	2	1	12	5	0
Civil Court – Ramwadi (Elevated Section)	2	0	0	21	5	0	4	12	2
Total	**14**	**1**	**3**	**115***	**7**	**2**	**15**	**34**	**3**

* Total is 115; of which 4 temples are common at Civil Court Intersection station between N-S and E-W corridors

Figure 4.24: Hospitals along the Proposed Alignments



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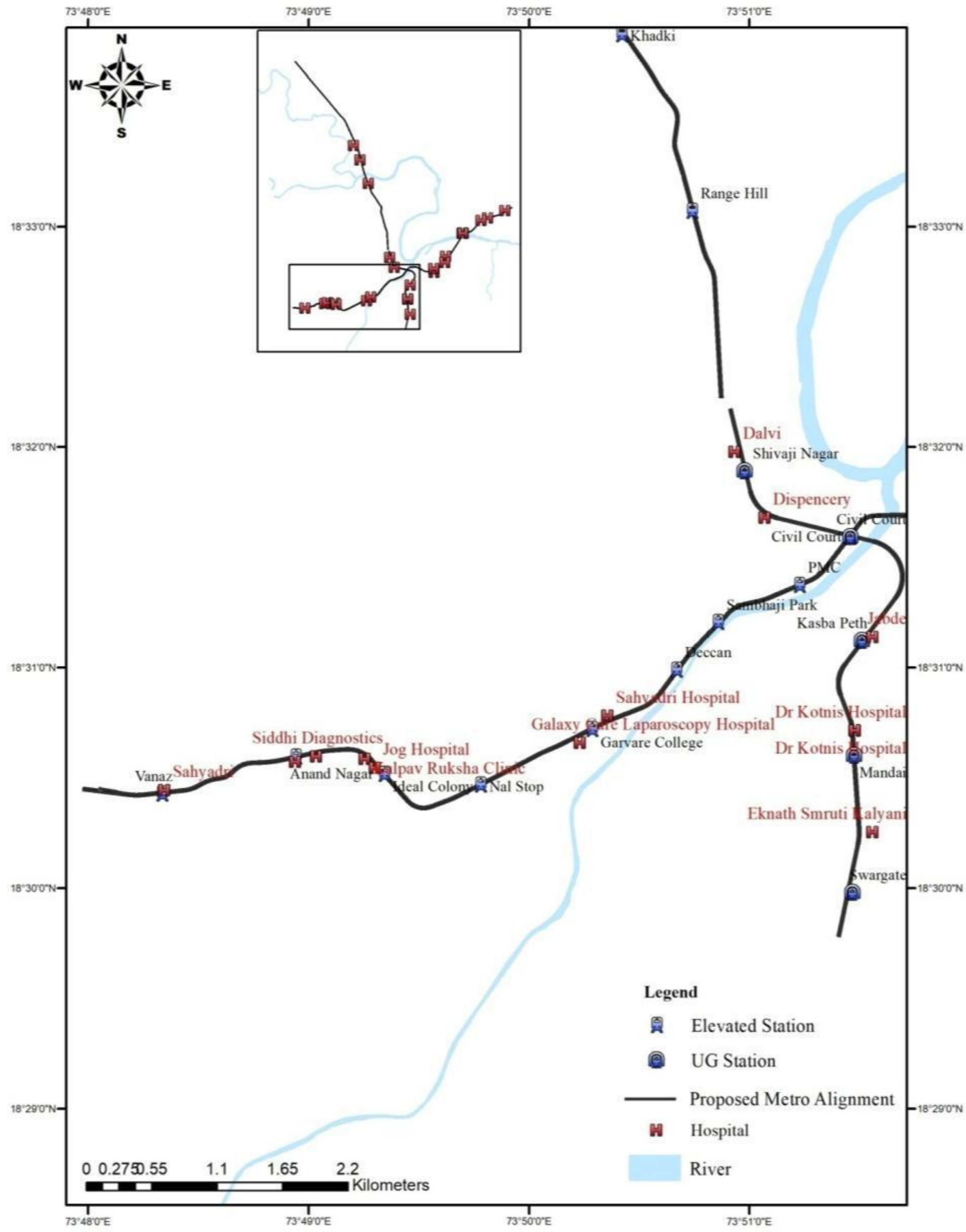

Khadki
Range Hill
Dalvi
Shivaji Nagar
Dispencery
Civil Court
PMC
Kasba Peth
Deccan
Sahyadri Hospital
Galaxy Care Laparoscopy Hospital
Garvare College
Dr Kotnis Hospital
Mandai
Eknath Smruti Kalyani
Swargate
Siddhi Diagnostics
Jog Hospital
Kalpav Ruksha Clinic
Anand Nagar
Ideal Colony
Nal Stop
Vanaz
Sahyadri
Legend
Elevated Station
UG Station
Proposed Metro Alignment
Hospital
River
0 0.275 0.55 1.1 1.65 2.2
Kilometers

Contd. …

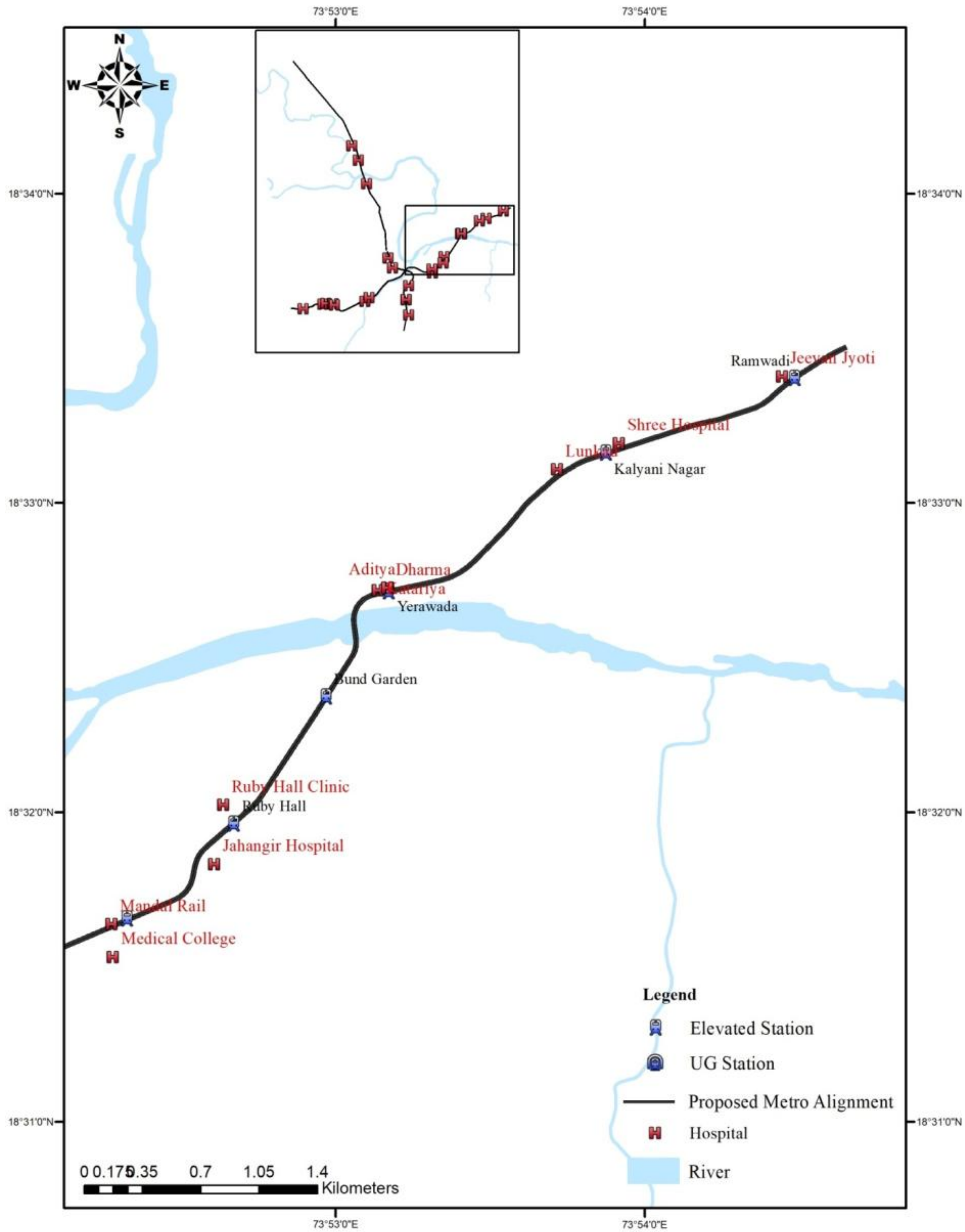
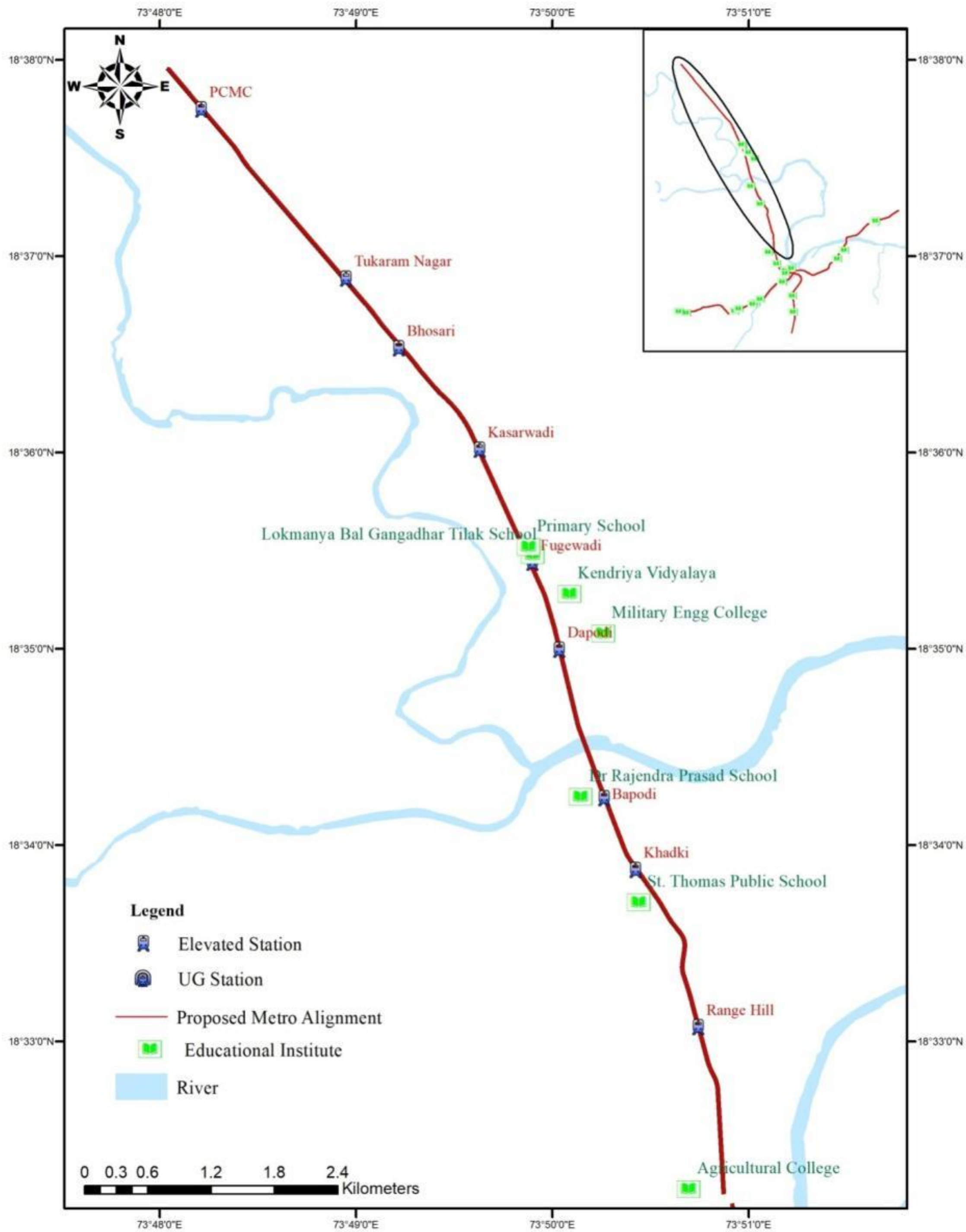

73°53'0"E
73°54'0"E
18°34'0"N
18°33'0"N
18°32'0"N
18°31'0"N
N
S
W
E
Ramwadi
Kalyani Nagar
Shree Hospital
Yerawada
AdityaDharma
Bund Garden
Ruby Hall Clinic
Jahangir Hospital
Medical College
Legend
Elevated Station
UG Station
Proposed Metro Alignment
Hospital
River
0 0.175 0.35 0.7 1.05 1.4
Kilometers

Figure 4.25: Educational Institutes along the Proposed Alignments



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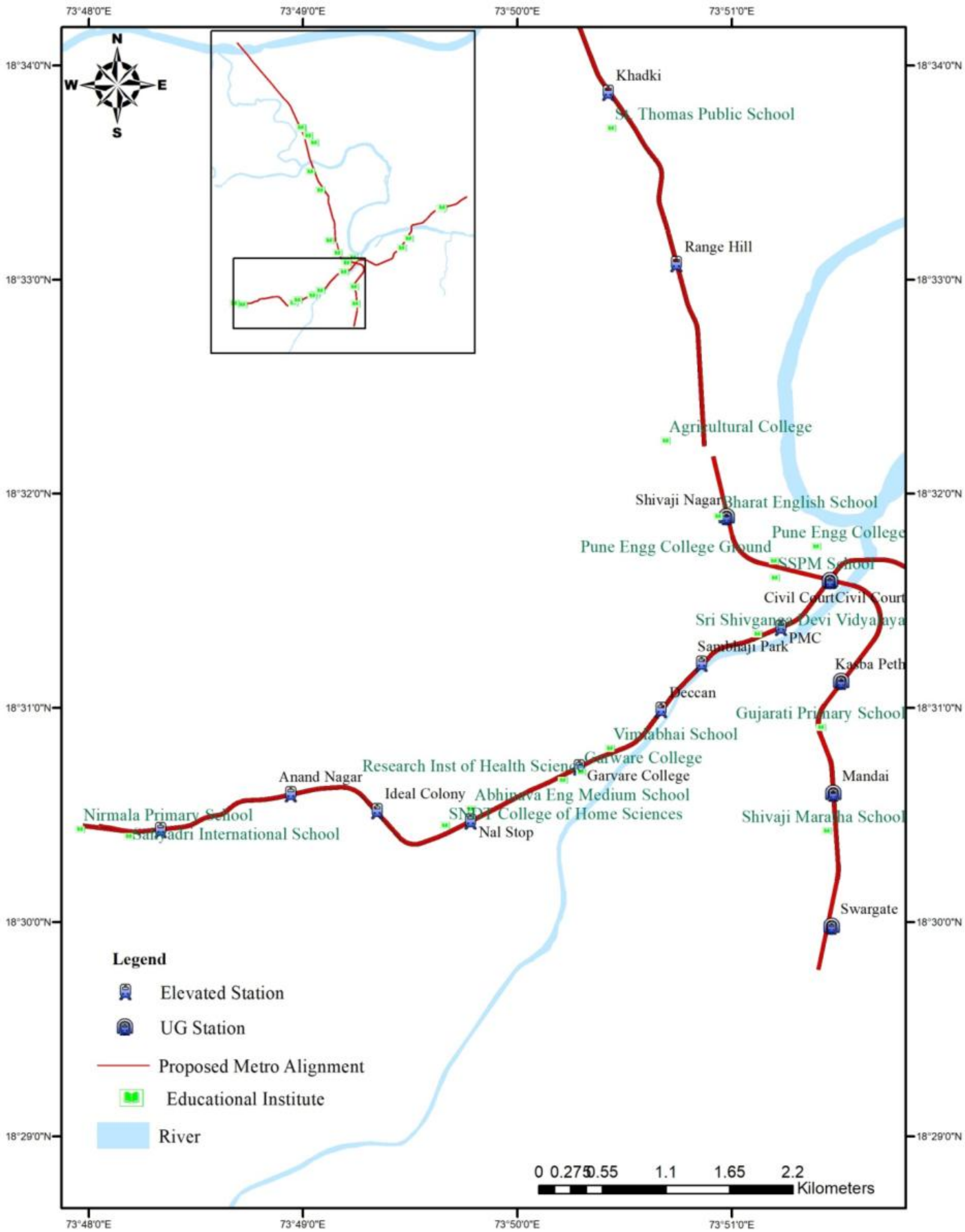
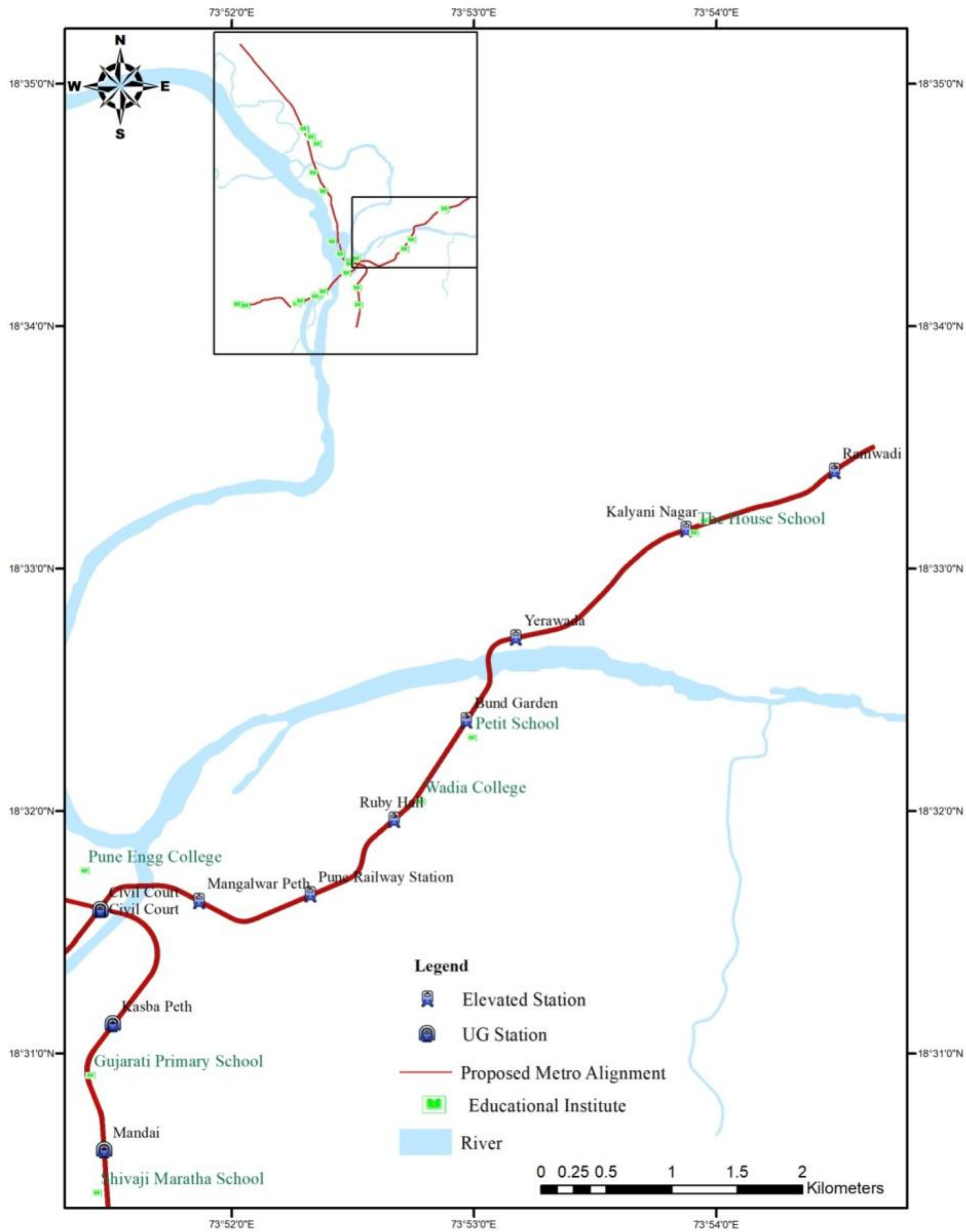

73°48'0"E
73°49'0"E
73°50'0"E
73°51'0"E
18°34'0"N
18°33'0"N
18°32'0"N
18°31'0"N
18°30'0"N
18°29'0"N
N
S
E
W
Khadki
St. Thomas Public School
Range Hill
Agricultural College
Shivaji Nagar
Bharat English School
Pune Engg College
Pune Engg College Ground
SSPM School
Civil Court
Civil Court
Sri Shivganga Devi Vidyalaya
PMC
Sambhaji Park
Kasba Peth
Deccan
Gujarati Primary School
Vimlabhai School
Garware College
Garvare College
Research Inst of Health Science
Anand Nagar
Ideal Colony
Abhinava Eng Medium School
SNDT College of Home Sciences
Nal Stop
Mandai
Shivaji Maratha School
Nirmala Primary School
Sahyadri International School
Swargate
Legend
Elevated Station
UG Station
Proposed Metro Alignment
Educational Institute
River
0 0.275 0.55 1.1 1.65 2.2
Kilometers

Contd. …



4.6.1. Hot Spots

Various hotspots like archaeological monuments notified by ASI and heritage structures identified by PMC are described below.

A. Archaeological Monuments

The Pune city has plenty of archaeological and historical monuments, which serve as the tourist attraction destinations of the city. The proposed Metro Corridors are passing near archaeological monuments which are listed in Table 4.13 and shown in Figure 4.26. The monuments listed in the table fall in regulated area (The Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010) as the distance from Metro alignment is between 100mto 300m. Prior approval is required for construction activities in regulated area of these monuments from Archaeological Survey of India.

Table 4.13: Archaeological Monuments along the Alignment

S. No	Name of the Monument	Nearest Metro Station	Distance from the Centreline of Metro Alignment	Prohibited Area/ Regulated Area
N-S Alignment				
1.	Pataleshwar Cave Temple	Shivaji Nagar	206 m	Regulated Area
2.	Shaniwarwada	KasbaPeth	259 m	Regulated Area
W-E Alignment				
3.	Agakhan Palace	Kalyani Nagar	116 m	Regulated Area

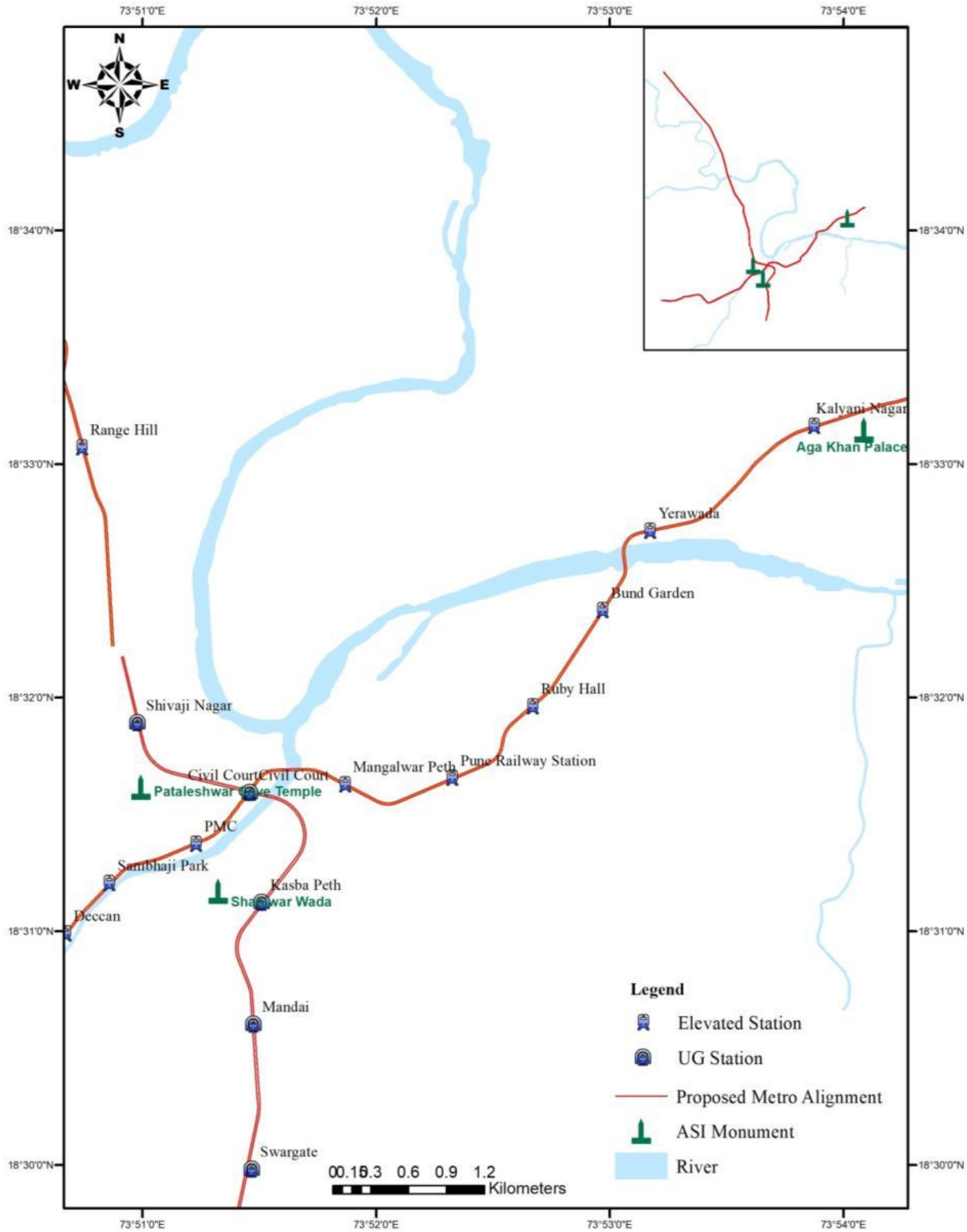
B. Heritage Buildings, Heritage Precincts and Natural Features

Pune Municipal Corporation has identified a list of heritage buildings, artifacts, structures, area and precincts of historic and/or architectural and/or cultural significance and those natural features of environmental significance including scared groves, hills, hillocks, water bodies etc.

No development or redevelopment or engineering operations or addition, repairs renovation including the painting of buildings, replacement of special features or plastering or demolition of any part thereof of the said listed buildings, or listed precincts or listed natural features shall be allowed except with the prior written permission of the Municipal Commissioner. The Municipal Commissioner shall classify the Heritage Precincts, Heritage Buildings in “Grades” such as (I), (II), (III)

Heritage List Grade I: They comprise buildings and precincts of National or Historic importance, excellence in architectural style, design technology and material usage and/or aesthetics; associated with a great historic event, personality, movement or institution. They have been and are the prime landmarks of the city and of National importance. No interventions shall be permitted either on exterior or interior unless it is necessary in the interest of strengthening and prolonging the life of the buildings or precincts or any part of features thereof.

Figure 4.26: ASI Monuments along the Proposed Alignments



Heritage List Grade II (A and B): They comprise buildings and precincts of Regional importance, possessing special Architectural or aesthetic merit, or cultural or historical significance though of a lower scale than Heritage Grade I. Internal changes and adaptive reuse and external changes may by and large be allowed but subject to strict scrutiny.

Heritage List Grade III: It comprises building and precincts of local importance for townscape; they evoke architectural, aesthetic, or sociological interest through not as in Heritage Grade II. External, internal changes and adaptive reuse would by and large be allowed.

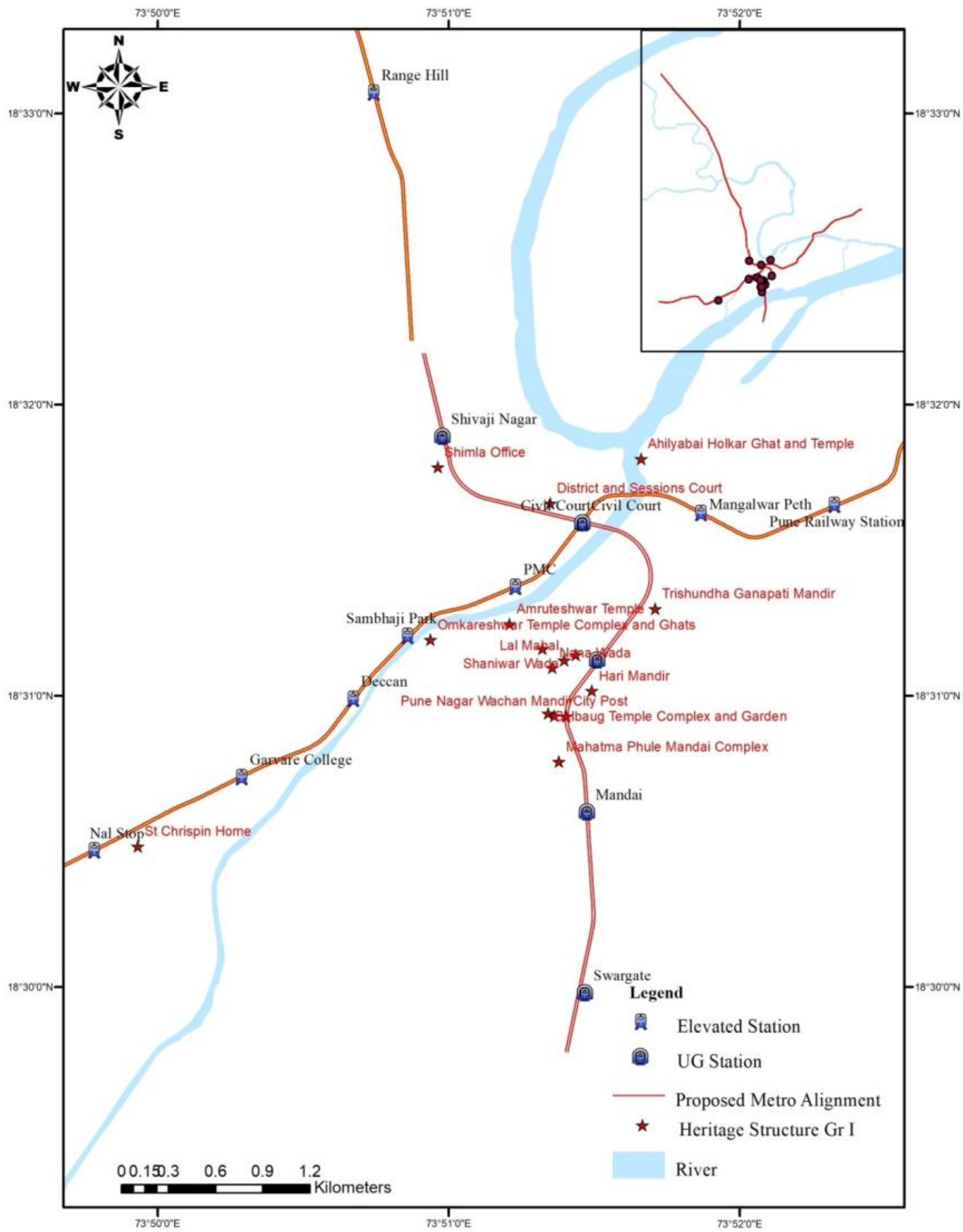
List of heritage assets near the proposed alignments is presented in Table 4.14 and shown in Figure 4.27. District and Sessions Court and City Post of Grade I List are located above the underground N-S alignment; elevated W-E alignment flies above Sambhaji Bridge and Shivaji Bridge and Vridheshwar Temple & Ghats which are Grade II assets. For construction and operation activities of the proposed metro alignment necessary prior approval need to be taken from the Municipal Commissioner.

Table 4.14: List of Heritage Assets near the Metro Alignments

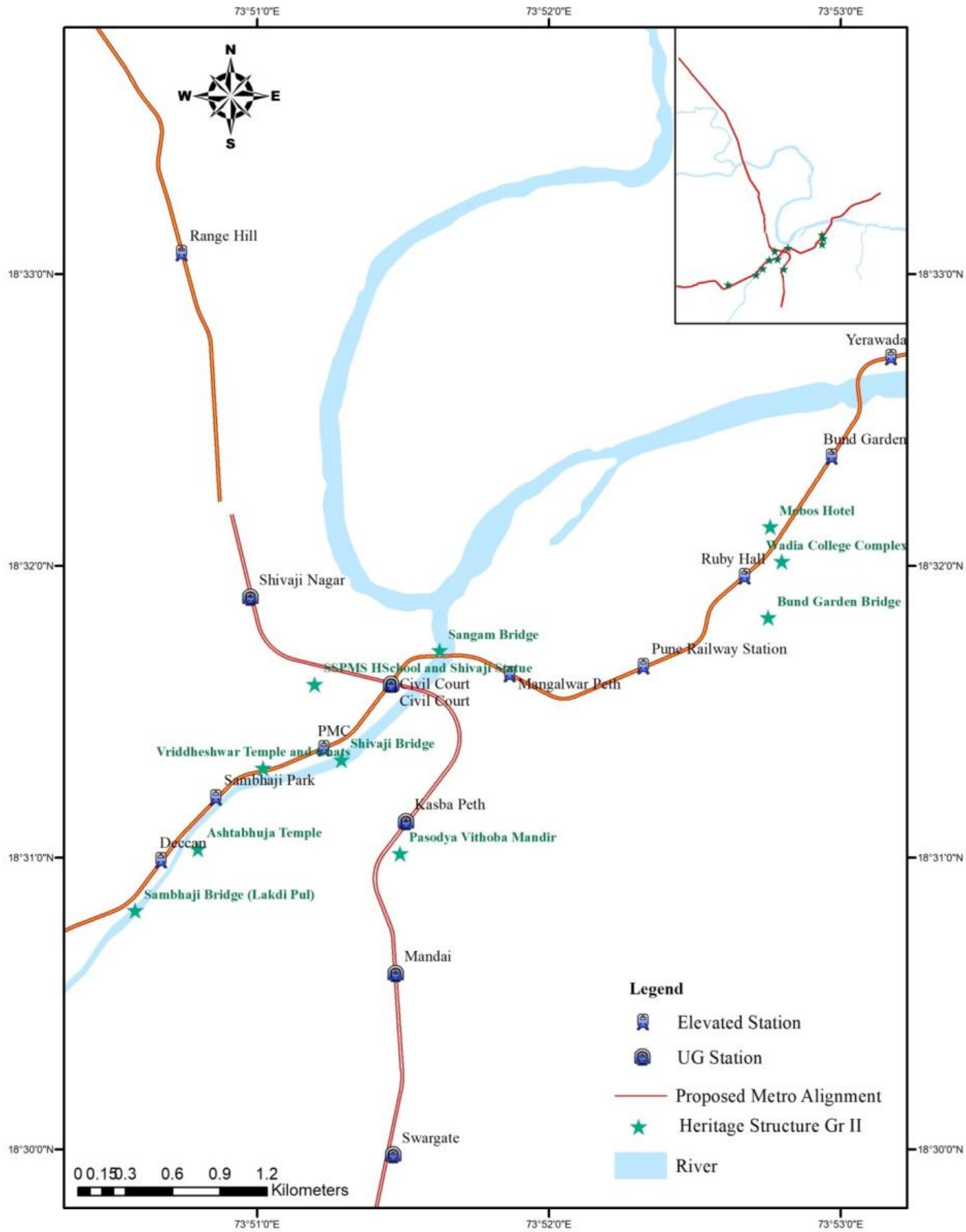
S. No	Name of the Monument	Nearest Metro Station	Distance from the Centreline of Metro Alignment	Remarks
N-S Alignment				
Grade I				
1.	Shimla Office	Shivaji Nagar	84 m	UG Section
2.	District and Sessions Court	Civil Court	0 m	UG Section
3.	Trishundha Ganapati Mandir	KasbaPeth	156 m	UG Section
4.	Kasba Ganapati Mandir	KasbaPeth	124 m	UG Section
5.	Lal Mahal	KasbaPeth	167 m	UG Section
6.	Nana Wada	KasbaPeth	199 m	UG Section
7.	Hari Mandir	KasbaPeth	84 m	UG Section
8.	City Post	KasbaPeth	0 m	UG Section
9.	Pune Nagar WachanMandir	KasbaPeth	72 m	UG Section
10.	Belbaug Temple Complex and Garden	KasbaPeth	110 m	UG Section
11.	Mahatma PhuleMandai Complex	KasbaPeth	83 m	UG Section
Grade II				
12.	SSPMS HSchool and Shivaji Statue	Civil Court	63 m	UG Section
13.	PasodyaVithobaMandir	KasbaPeth	87 m	UG Section
W-E Alignment				
Grade I				
14.	St Chrispin Home	Nal Stop	111 m	Elevated
15.	Omkareshwar Temple Complex and Ghats	Sambhaji Park	102 m	Elevated
16.	AhilyabaiHolkarGhat and Temple	MangalwarPeth	188 m	Elevated
17.	Agakhan Palace	Kalyani Nagar	116 m	Elevated
Grade II				
18.	SNDT College	Nal Stop	35 m	Elevated
19.	Sambhaji Bridge	Deccan	0 m	Elevated
20.	Ashtabhuja Temple	Deccan	148 m	Elevated
21.	Vriddheshwar Temple and Ghats	Sambhaji Park	0 m	Elevated

S. No	Name of the Monument	Nearest Metro Station	Distance from the Centreline of Metro Alignment	Remarks
22.	Shivaji Bridge	PMC	0 m	Elevated
23.	Sangam Bridge	Civil Court	36 m	Elevated
24.	Wadia College Complex	Ruby Hall	15 m	Elevated
25.	Mobos Hotel	Ruby Hall	75 m	Elevated

Figure 4.27: Heritage Structures along the Proposed Alignments



Heritage Structures – Grade I



Heritage Structures – Grade II

4.7. SOCIO-ECONOMIC PROFILE

In order to understand the region better, it is considered appropriate to take up in brief an overview of the demographic and socio-economic characteristics of the Pune in which the project is located.

As per census 2011 population of Pune City is 3,124,458 with sex ratio is 948; whereas Population of Pune Metropolitan area is 5,057,709 with sex ratio of 904. In Pune city, Children less than six years of age have been 337,062 with Child sex ratio is 908; In Pune Metropolitan area, Children less than six years of age have been 579,681 with Child sex ratio is 904. The demographic profile of the project area is indicated by profiles of the Pune City and Pune Metropolitan Areas as given in Table 4.15.The average literacy rate of Pune city and metropolitan area is 89.56%.

Table 4.15: Demographic Profile of the Project Area

S. No.	Item	Pune City	Pune Metropolitan Area*
1.0	Population Total	3124458	5057709
1.1	Population Male	1603675	2656240
1.2	Population Female	1520783	2401469
2.0	Population Children under age 06	337062	579681
2.1	Population Male Children under age 06	176624	305786
2.2	Population Female Children under age 06	160438	273895
3.0	Literates	2496324	4010594
3.1	Literate Male	1317345	2173527
3.2	Literate Female	1178979	1837067
4.0	Average Literacy (%)	89.56	89.56
4.1	Average Literacy Male (%)	92.31	92.47
4.2	Average Literacy Female (%)	86.67	86.35
5.0	Sex Ratio	948	904
6.0	Sex Ratio (under 6 years)	908	896

* Pune Metropolitan Area - Dehu, Dehu Road, Kirkee, Pimpri and Chinchwad, and Pune
Source: Census of India, 2011

The social composition constitutes people belong to Hinduism, Muslim, Sikhism, Christianity, Jainism, Buddhism, etc. Social composition of Pune City is given in Table 4.16. The local society is having 79.43% population of Hindu community followed by Muslim with 11.03%, Buddhist constitutes 3.94%. The prominent Hindus and Muslims held 90.46% and the remaining communities constitute only 9.54%.

Table 4.16: Social Composition of the Pune City

S. No	Description	Total	Percentage (%)
1	Hindu	2481627	79.43
2	Muslim	344571	11.03
3	Buddhist	123179	3.94
4	Jain	76441	2.45
5	Christian	67808	2.17
6	Sikh	13558	0.43
7	Not Stated	10906	0.35
8	Others	6368	0.2

Source: Census of India, 2011

4.8. VALUED ENVIRONMENTAL COMPONENTS

Valued Environmental Components (VECs) are fundamental elements of the physical, biological or socio-economic environment including air, water, soil, terrain, flora, fauna, land use and socio-economicthat may be affected by the proposed project.

4.8.1 Rating of proposed Metro Alignments by Environmental Impact

The proposed lines have been rated for their environmental impact using the rating matrix presented in Table 4.17.Based on quantity of impacted assets Physical and Ecological Environment have been given the highest weightage. For the purpose of this evaluation educational institutions and hospitals have been classified as sensitive receptors, places of worship and heritage assets are classified as cultural assets.

Table 4.17: Weightage to Environmental Parameters

S. No.	Environmental Component	Weightage	Weightage Breakup
A	**Physical Environment**	**40**	
(i)	Noise and Vibration	30	Number of sensitive receptors and cultural assets located within 100 m on either side of CL of Metro 01-25: 10 26-50: 15 51-75: 20 76-100: 25 More than 100: 30
(ii)	Land Use	07	Percentage length of corridor passing through built up area (03). 01-10: 01 11-20: 02 More than 20: 03 Percentage length of corridor passing through Park/Open area (04). 1-10: 01 11-20: 02 21-30: 03 More than 30: 04
(iii)	Number of drain crossings	03	01-05: 01 06-10: 02 More than 10: 03
B	**Ecological Environment**	**40**	
(i)	Trees within Metro RoW	35	Number of Trees 01-100: 10 101-200: 20 201-300: 30 More then 300: 35
(ii)	Fauna	05	Number of Species

S. No.	Environmental Component	Weightage	Weightage Breakup
			01-05: 05
C	**Socio Economic Environment**	**20**	
(i)	Sensitive Receptors/Cultural assets facing Relocation/Disruption	15	Number of Receptors/Assets 01-05: 05 06-10: 10 More than 11: 15
(ii)	Ground area of housing facing Relocation/Disruption	05	Area in sqm 01-1000: 01 1001-2000: 02 2001-3000: 03 3000-4000: 04 More than 4000: 05

Scores have been worked out for each of the parameters of physical, biological and social and a cumulative score is worked out as presented in Table 4.18.

Table 4.18: Ranking of Alignments

S. No	Environmental Parameters	Weightage Assigned	PCMC – Swargate	Vanaz - Ramwadi
A.	**Physical Environment**	**40**		
1.	**Noise and Vibration (Sensitive structures within 100m on either side of CL)**	**30**		
	01-25	10		
	26-50	15		
	51-75	20		
	76-100	25	25	
	More than 100	30		30
2.	**Land Use**	**07**		
a.	% of Length passing through Built-Up area	03		
	01-10	01		
	11-20	02		
	More than 20	03	03	03
b.	Percentage length of corridor passing through park/Open Area	04		
	01-10	01		
	11-20	02	02	02
	21-30	03		
	More than 30	04		
3.	**Number of Drain Crossings**	**03**		
	01-05	01		
	06-10	02		02
	More than 10	03	03	
B.	**Ecological Environment**	**40**		
1.	**Trees within Metro ROW**	**35**		
	01-100	**10**		
	101-200	**20**		
	201-300	30		30
	More than 300	35	35	

S. No	Environmental Parameters	Weightage Assigned	PCMC – Swargate	Vanaz - Ramwadi
2.	**Fauna**	**05**		
	01-5	05	0	0
C.	**Socio Economic Environment**	**20**		
1.	**Sensitive Receptors/Cultural assets facing Relocation/Disruption (in RoW)**	**15**		
	01-5	05	05	
	06-10	10		10
	More than 11	15		
2.	**Ground area of housing facing Relocation/Disruption***	**05**		
	01-1000 sq.m	01		
	1001-2000 sq.m	02	02	
	2001-3000 sq.m	03		
	3001-4000 sq.m	04		
	More than 4000 sq.m	05		05
	Total Score	**100**	**75**	**82**

* Ground area of housing facing relocation/disruption is indicative: these figures are not to be compared with number of structures affected as per Inventory in SIA report

4.9. PUBLIC CONSULTATIONS

Project level consultations with local people were conducted at Range Hill station, Kasarwadi, PCMC, Near Lukund hospital, Khadaki, Managlwar Peth, near Vanaz Kachara Depot, Vanaz Metro station and Pune railway station in the month of October 2017. Local people were invited to participate. The consultant briefed the participants about the objective of the meeting and discussed on various environmental and social issues related to the project. The participants were invited to give their valuable suggestions on both environmental and social issues and were assured for suitable incorporation of such suggestions in the project within the technical limitations and scope of the project. Photographs of the Public Consultation are shown in Figure 4.28.Views expressed, suggestion given or queries raised by the participants are given in Table 4.19.

Figure 4.28: Photographs of the Public Consultation

Public consultation at Range hill station


ICICI Petrol pump Vanaz


Near Kachara depot


Vanaz Metro Station


Tea stall near Pune railway station

Table 4.19: Minutes of Public Consultation

Place	Date	No. of participants	Issues	Suggestions/Opinions
Range hill station	06/10/2017	27	Need of adequate compensation	Participants were staying in slum area from last 30 years. Out of them, 70% were from Karnataka and rest 30% are from mixed population. Participants suggested that the affected persons should get adequate compensation in terms of House. As these people are staying from last 30 years.
			No air pollution	Presently, there is no air pollution and need to be sustained at construction phase.
Kasarwadi, near bridge (near nashik phata)	06/10/2017	13	Heavy traffic in the area	Participants strongly reported that during peak hours the traffic congestion is routine phenomenon and Metro train will solve the issue of traffic jam and smooth the traffic flow.
			Need of basic facilities in the	Participants added that the metro rail should have all basic amenities such as toilet and

Place	Date	No. of participants	Issues	Suggestions/Opinions
			Metro Rail	others.
			Need of environment sensitive projects	In the city of Pune, pollution is increasing day by day and need to protect trees from infrastructure development projects.
			Metro will reduced the air pollution	Metro will be helpful in reducing the air pollution.
			Development should not lead to displacement	Participants suggested that it's good to see the development of Pune City, but it should not lead to displacement.
			Smooth transportation and reduce in air pollution	Participants anticipating that metro rail will be helpful in smooth transportation in the city and reduce air pollution by decreasing the vehicle load.
			Reduce the road accident	Metro train will be helpful in reducing the road accident.
			Extension of proposed Metro alignment	The train need to be extended up to Nigdi instead of PCMC.
			Trees must be saved	Trees must be saved; trees absorb CO2 and exhales O2, do plantation.
Lukund Hospital,Mumbai Pune road,Dapodi	06/10/2017	14	Metro rail reduce noise pollution	There is always traffic jam in the area, metro come reduce noise pollution
			Re-plantation of trees	Trees must be replanted .do some plan for sparrows. Additionally, it is also suggested that the alignment must be extended up to Nigadi.
			Metro will reduce traffic and reduce road accident	Lukund hospital employees says they want good transport ,traffic congestion less .safe way of transport no accidents
			Pollution reduction measures	Due to vicinity of hospital ,patients may get disturb (particularly during construction phase –air pollution reduction management must be considered)
Khadki railway station	07/10/2017	13	Metro rail is needed in the city	Metro rail is very much needed in the city and the construction work must complete within time.
			Road need to be widen	Due to metro rail, there may be congestion and increase traffic jam and hence the existing roads must be widened before the construction of Metro Rail Project.
Mangalwar Peth,Pune	29/10/2017	13	Reduce traffic	Metro will reduce traffic in the city and will also solve transportation problem.
			Adequate compensation	Adequate compensation need to be provided in order to reinstate the life of project

Place	Date	No. of participants	Issues	Suggestions/Opinions
			for rehabilitation of affected families	affected families it any.
			Public notice before construction of Metro Rail	Participants from Mangalwar Peth suggested that there should be public notice before start of construction work.
Vanaz Kachara depot,Pune	06/10/ 2017	26	Reduce traffic jam and noise pollution	Metro rail may reduce traffic jam ,noise pollution , long time to reach at work place
			User friendly transport	Participants welcome the Metro Rail project in Pune and shared that it's a user friendly transport.
Vanaz chowk Bus stop ,Proposed Vanaz metro station	07/10/ 2017	14	Good source of transport	Road traffic must not be disturbed during construction phase of metro rail. They are requesting not to divert the traffic;they also say In future Metro is good source of transport.
			Do not cut trees	Metro is good but during construction phase do not cut more trees
			Basic facilities to people	Basic civic facilities must be provided before starting metro project
			Road widening	Road should be widen in order to reduce traffic issue during construction phase.
			Time saving	Metro rail will save time ,so good transport
			Need to enrich basic facilities	The basic facilities need to be enriched in the city.
Pune Railway station	07/10/ 2017	19	Increase city infrastructure	Because of metro common man will reach their destination in Pune very fast and easily, because of metro rail Pune city will look beautiful.

Major Findings of Preliminary Public Consultations:-

The major findings of public consultation are as follows:

1. Adequate compensation need to be provided in order to reinstate the life of project affected families, in terms of House for House. As the slum people at Range Hill are staying from last 30 years.
2. Due to metro rail, there may be congestion and increase traffic jam and hence the existing roads must be widened before the construction of Metro Rail Project.
3. The metroneed to be extended up to Nigdi instead of PCMC.
4. Participants suggested that it's good to see the development of Pune City, but it should not lead to displacement.
5. In the city of Pune, pollution is increasing day by day and need to protect trees from infrastructure development projects. Presently, there is no air pollution and need to be sustained at construction phase.

Chapter 5 : Environmental Impacts

5.1. GENERAL

Environmental impacts could be positive or negative, direct or indirect, local, regional or global, reversible or irreversible.This chapter discusses the potential negative impacts on the environment due to project activities. The negative impacts due to proposed project activities identified on the basis of project description (Chapter 3) and environmental baseline data (Chapter 4).Impacts on ambient air quality, noise and vibration level have been quantified while impact on water, soil and archaeological / heritage assets are presented in terms of `alert` in case norms and standards are likely to be violated during construction and operation of the project. Impact on ecology has been assessed quantitatively in terms of trees to be felled / relocated and in terms of adverse impact on aquatic species or their habitats. Other impacts have been flagged. Significant impacts pre-construction, during construction and during operation of the project have been assessed.

Negative impacts likely to result from the proposed development have been described in this Chapter under the following headings while recommendations for mitigating measures have been elaborated in Chapter 8.

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

For each of these headings, potential impacts have been considered, while recommendations for mitigating measures have been stated in Chapter 8.

Impacts due to the proposed Metro project and their brief description along with rating are given in Table 5.1.

Table 5.1: Rating of Environmental Impacts

S. No	Parameter	Impact Rating	Short Term / Long Term
A.	**IMPACTS DUE TO PROJECT LOCATION AND DESIGN**		
1.	Displacement and loss of livelihood of Project Affected People (PAPs)	To be assessed as part SIA report	Permanent, negative, irreversible, can be mitigated, scale to be evaluated.
2.	Change of Land use	R2	Permanent, negative, irreversible, can be mitigated, small scale.
3.	Loss of trees and impact on ecology	R1	Small scale ,permanent and irreversible with both positive and negative impact ,can be mitigated
4.	Drainage and Utilities:Diversion/shifting	R2	Short term and/orpermanent, negative, irreversible can be mitigated; small scale.
5.	Impact on Archaeological Monuments and Heritage	R2	Small scale ,permanent and irreversible with both positive and

S. No	Parameter	Impact Rating	Short Term / Long Term
	Assets		negative impact ,can be mitigated
6.	Right of Way: Optimal choice of length of elevated and underground sections.	R1	Small scale ,permanent and irreversible with both positive and negative impact ,can be mitigated
7.	Alignment: • Route and design of alignment • Stations, Track design and Architecture	R1	Small scale ,permanent and irreversible with both positive and negative impact ,can be mitigated
8.	Inter Modal Integration	R1	Small scale ,permanent and irreversible with both positive and negative impact ,can be mitigated
9.	Use of Energy and Water at stations and depots	R1	Small scale ,permanent and irreversible with both positive and negative impact ,can be mitigated.
10.	Risk Due to Natural Hazards	R4	Permanent, negative, irreversible & can be mitigated,
B.	**IMPACTS DUE TO PROJECT CONSTRUCTION**		
1.	➢ Air pollution: • Particulate air pollution due to activities like excavation; • emissions due to transportation of muck and material ➢ Noise, Vibration	R1	Small scale ,temporary, negative, reversible except in severe cases of casuality .Can be mitigated.
2.	Disposal of muck, C&D waste and hazardous waste; pre-casting and material yards	R1	Small scale ,Permanent, negative, irreversible and can be mitigated.
3.	Water demand and water quality	R1	Temporary, negative, reversible, can be mitigated, small scale.
4.	Soil erosion and land subsidence	R2	Temporary, negative, irreversible, can be mitigated, small scale.
5.	Traffic diversions	R2	Temporary, negative, reversible, can be mitigated, small scale.
6.	Labor camp and on-site labour safety/ welfare	R1	Temporary, negative, reversible, can be mitigated, small scale.
7.	Supply of construction material	R2	Temporary, negative, irreversible, can be mitigated, small scale.
C.	**IMPACTS DUE TO PROJECT OPERATION**		
1.	Noise and Vibration	R1	Small scale,permanent and negative can be mitigated.
2.	Energy and water supply at stations and depots	R1	Small scale Permanent, negative, irreversible, can be mitigated.

S. No	Parameter	Impact Rating	Short Term / Long Term
3.	Traffic congestions around stations	R1	Small scale Permanent, negative, irreversible, can be mitigated.
4.	Impacts due to Depots: Water supply, Waste water disposal, Oil Pollution, Noise Pollution, Solid Waste disposal, Loss of trees.	R1	Permanent, negative, reversible except in case of ecology, can be mitigated, small scale
D.	**POSITIVE IMPACTS DUE TO PROJECT**		
1.	Employment Opportunities	Positive impact	Permanent, positive, small scale.
2.	Benefits to Economy: access, reduced costs of road infrastructure, vehicle operating & time, accidents.	Positive impact	Permanent, positive, large scale.
3.	Reduction in road traffic, fuel consumption and air pollution, GHG emission	Positive impact	Permanent, positive, large scale.

Rating: R1: Significant negative impact is expected. R2: Some negative impact is expected.
R3: Extent of impact is unknown R4: No impact is expected

5.2. ENVIRONMENTAL IMPACTS

This section identifies and appraises the negative impacts on various aspects of the environment likely to result from the proposed development. The environmental aspects are:

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

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

5.3. IMPACTS DUE TO PROJECT LOCATION

- Displacement and loss of livelihood of Project Affected People (PAPs)
- Change of Land use
- Impact on/loss of wildlife/trees/forest
- Utility/Drainage Problems
- Impact on Archaeological Monuments and Heritage Assets

5.3.1. Displacement and loss of livelihood of Project Affected People (PAPs)

This impact does not form part of this Report.

5.3.2. Change of Land Use

Land will be required permanently for stations, and running sections. Both government and private land will be acquired for the project and the details are given in civil engineering in the DPR. No forest land is required for the proposed project corridors.

5.3.3. Impact on/loss of wildlife/trees/forest

The proposed corridors are in urban/city area. An inventory of trees along the project corridor was carried out. Number of trees likely to be lost due to the proposed project is about 1124. The number of trees within corridor is given in the Table 5.2 and details from station to station are presented in Annexure 5.1.No rare or endangered species of trees have been noticed during field studies.

Table 5.2: Number of Trees along the Corridor/Depots

S. No	Alignment/Depots	Number of Trees	Cut	Transplant
1.	PCMC - Range Hill	396	121	275
2.	Vanaz – Ramwadi	206	13	193
	Sub-Total along the Alignment (A)	**602**	**134**	**468**
3.	Range Hill Depot	403	0	403
4.	Vanaz Depot	119	32	87
	Sub-Total at Depot (B)	**522**	**32**	**490**
	Total Trees (A+B)	1124	166	958

With removal of these trees, the process for CO_2 conversion will get affected and the losses are reported below:

Total number of Trees : 190
Decrease in CO_2 absorption @ 3 Kg/year/ tree : 498 kg/year
Decrease in Oxygen production @ 11 Kg/year/ tree : 1826 kg/year

5.3.4. Utility/Drainage Problems

The proposed Metro corridors are planned to run through the urban area above the ground (elevated) in less densely populated and underground in populated and sensitive areas. The alignment will cross drains, large number of sub-surface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, traffic signals 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.Plans and cost of such diversions are covered in the section on Civil Engineering.

5.3.5. Impact on Archaeological Monuments/ Heritage Sites

No Archaeological Monuments / Heritage structures are directly affected due to the proposed metro rail project. Some of the Archaeological Monuments/heritage structures are close to the proposed metro alignment as given in Table 4.14.

5.4. IMPACTS DUE TO PROJECT DESIGN

Impacts due to project design are seen in following ways:

- Consumption of energy and water at stations and noise impact of underground line in trade off with visual intrusion resulting from elevated line.
- Measures relevant to both underground and elevated alignment

5.4.1. Right of Way

Impact due to project design shall be vary depending upon whether the alignment is located underground, elevated or at-grade. In case of underground metro the space at ground level and above can continue to be used for roads and light structures and visual intrusion will be minimize. Visually less-intrusive viaduct and stations can be constructed subject to construction cost on account of specialized formwork and high strength materials.

Underground metro also allows the advantage of low noise as compared to elevated line during construction and operation. However energy consumption in underground metro is higher compare to elevated metro.

5.4.2. Alignment, Stations, Track design and Architecture

An alignment with less number of curves and radius - which is desirable rather than minimum, optimal station spacing, track with elastic fittings result in decrease in energy consumption, wear & tear and noise & vibration. Elevated metro with sleek structural elements provides aesthetically appealing structures. The spatial design of station has significant impact on safely of passengers, time spent in ingress & egress from station and energy consumption in stations.

5.4.3. Inter Modal Integration

Physical and operational integration of metro with other modes especially walk, public transport and intermediate public transport (hired modes) is found to increase ridershipand decrease congestion inside and outside the stations.

5.4.4. Use of Energy and Water at stations and depots

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

5.4.5. Risk Due to Natural Hazards

The project area lies in Zone III as per revised Seismic Zoning Map of India corresponding to moderate seismic hazard. Engineering construction shall be done so as to meet codal provisions. No other natural hazards such as due to climate change are foreseen.

5.5. IMPACT DUE TO PROJECT CONSTRUCTION

Negative environmental impacts are:

- Air pollution
- Noise Pollution
- Vibration and risk to existing buildings
- Impact due to Muck disposal
- Impact due to construction/demolition waste
- Impact due to Hazardous waste
- Impact due to Pre-casting yards and Material stockpiling
- Increased water demand
- Impact on ground and surface water quality
- Soil erosion and land subsidence
- Impacts due to traffic diversions
- Impacts due to Labour Camp
- Welfare of labour on site
- Safety of labour
- Impacts due to supply of construction material
- Impacts on human health.

5.5.1. Air pollution

Air pollution occurs due to excavation, loading and unloading of construction materials, and emissions from vehicles, construction equipment and DG sets etc.It also occurs in sites of muck disposal, debris disposal and pre-casting yards.

Air pollution due to transportation of construction material and excavated/fill material is quantified as follows.Trucks and cranes are required to transport civil construction material from pre-cast yards and batching plants to construction site and between construction site and soil disposal site. Emission during the period of construction due to truck movement on account of transportation of civil construction material and disposal/backfill of earth is estimated as summarized in Table 5.3.

Table 5.3: Total Emissions due to Truck Movement during Construction

Pollutant	Quantity (ton)	
	PCMC - Swargate	Vanaz - Ramwadi

Pollutant	Quantity (ton)	
	PCMC - Swargate	Vanaz - Ramwadi
Carbon Monoxide	21.0	15.0
Particulate Matter 2.5	0.9	0.5
Hydro-Carbons	0.7	0.5
Nitrogen Oxide	43.0	30.0
Carbon dioxide	2703.0	1895.0
Fugitive dust	5.1	3.6

5.5.2. Noise Pollution

Noise is a contributing factor to degradation of human health. The major sources of noise pollution during construction are movement of vehicles for transportation of material and equipment. Noise emissions levels from construction equipment (*Construction Noise Handbook, FHWA, USA*) are given in Table 5.4. Actual noise from construction equipment (Lmax) measured at 50 feet distance ranged from 76 dB(A) to 98 dB(A), which decreases with increase in distance.

Table 5.4: Construction Equipment Noise Emission Levels

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

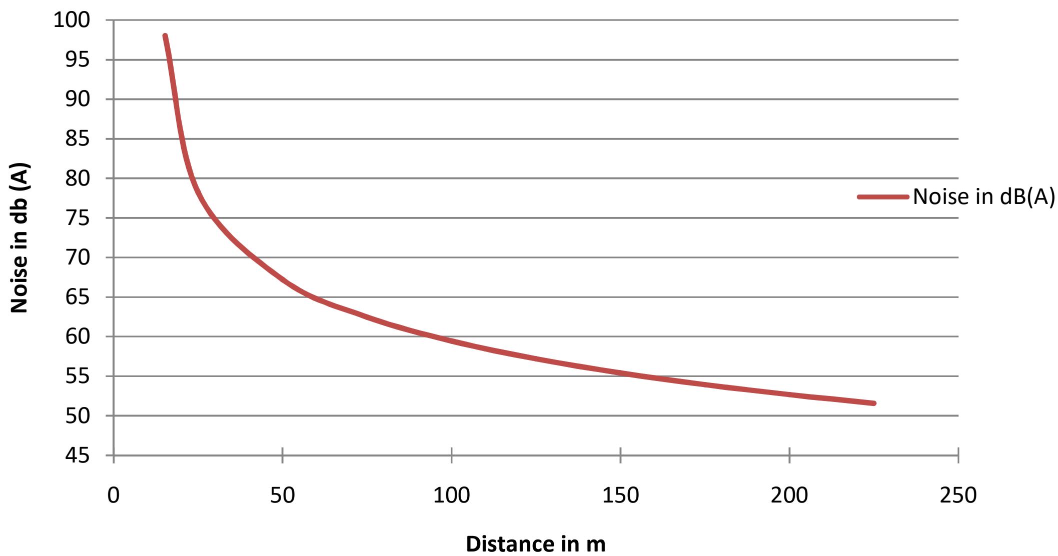
Source: Construction Noise Handbook, FHWA

Construction of noise barriers, such as temporary walls between noisy activities and receivers reduces noise by up to 15 dB (A)and alsovegetation cover also reduces the noise level.A standard mathematical model is used as given for an approximate estimation of dispersion of noise in the surroundings:

$$\mathbf{Noise_{(receptor)} = Noise_{(source)} - 20 \ X \ Log[distance_{(receptor)}/distance_{(source)}]}$$

For modeling purposes, flat terrain is considered and environmental attenuation factors are not considered so as to formulate the worst-case scenario. The noise levels predicted by logarithmic equation up to a receptor location of 225 m are presented in Figure 5.1. From the figure, the noise level reduces to 65 dB (A) (Noise threshold limit for commercial area) at a distance of 60m from the equipment;the noise level reduces to 55 dB (A) (Noise threshold limit for residential zone) at a distance of 160m and to less than 50 dB (A) (Noise threshold limit for Silence zone) at a distance of 270m from the equipment.

Figure 5.1: Construction Equipment Noise



5.5.3. Vibration Impacts and Risk to Existing Buildings

If significant impacts due to vibration are expected, mitigation measures have to be implemented and building condition survey have to be conducted before, during and after construction.

Damage to structures is a possibility in case of pile driving or trains passing within 7.5 m from normal buildings or unreinforced structures or between 15m to 30m from historical buildings or buildings in poor condition; heavy truck traffic within 30m, major construction within 60m, freight trains within 90m or pile diving within 180m can cause disruption of operation of sensitive instrumentation (Transportation and Construction Vibration Guidance Manual, Caltrans, September 2013.). Threshold criteria are listed in Table 5.5. These criteria for monuments are more stringent than those prescribed in UK, Germany, Switzerland and Japan.Vibration source levels for typical construction equipment are listed in Table 5.6.

Table 5.5: Guideline Vibration Damage Threshold Criteria

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

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

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

Table 5.6: Vibration Source levels for Construction Equipment

Equipment		PPV at 25 ft (in/sec)	Approximate L_v# at 25 ft
Pile Driver (impact)	upper range	1.518	112
	Typical	0.644	104
Pile Driver (sonic)	upper range	0.734	105
	Typical	0.170	93
Calm shove drop (slurry wall)		0.202	94
Hydromill (slurry wall)	in soil	0.008	66
	in rock	0.017	75
Large bulldozer		0.089	87
Caisson drilling		0.089	87
Loaded trucks		0.076	85
Jackhammer		0.0345	79
Small bulldozer		0.003	58
# RMS velocity in decibels (VdB) re 1 µinch/sec			

A. Vibration Impact due to Vibratory Pile Driver

The advantages (Comparison of impact versus vibratory driven piles, DFI-GDG Solutions) of using vibratory hammers (particularly into wet granular soils) over impact hammers include high rates of penetration, reduced ground vibrations and noise levels, and the possibility of extraction/correction of misplacement errors. Super high frequencies have demonstrated a very low level of ground vibrations which allows working in very close proximity to any structure. On average the vibrated piles had 80% of the axial capacity of impact piles, with some load tests yielding capacities as low as 50%: for both cohesive deposits and dense sands, the 40% derating of pile capacity seems appropriate.

Vibratory pile drivers advance the pile by vibrating it into the ground. They are especially effective for soils that are vibratorily mobile, such as sands and silts. Vibration is created in the gear case by rotating eccentric weights powered by hydraulic motors, and sometimes by electric motors. Only vertical vibration is created in the gear case. Horizontal vibration is cancelled by the paired eccentrics, which are interconnected with gears to maintain synchronization. The vibration created in the gear case is transmitted into the pile being driven or extracted by means of a hydraulic clamp attached to the bottom of the gear case. The complete vibrator assembly is held by crane. To prevent the vibration created in the gear case from affecting the crane line, a vibration suppresser assembly is attached to the top of the gear case. Vibratory pile drivers generate the maximum vibration levels during the start-up and shut-down phases of the operation because of the various resonances that occur during vibratory pile driving (Woods 1997). Maximum vibration occurs when the vibratory pile driver is operating at the resonance frequency of the soil-pile-driver system. The frequency depends on properties of the soil strata being penetrated by the pile.

Since the primary concern with regard to construction vibration is building damage, construction vibration is assessed in terms of peak particle velocity (PPV). Based on review of the available literature (Wood and Theissen 1982;Wiss 1967, 1974, 1981) and information provided by International Construction Equipment (ICE) (Morris 1991, 1996, 1997), vibration amplitudes produced by vibratory pile drivers can be estimated by the following empirical equation determined by Woods and Jedele (1985).

$$\mathbf{PPV_{Vibratory\ Pile\ Driver}}(\text{in/sec}) \mathbf{= PPV_{Ref}\ (25/D)^n}$$

Where:

PPV_{Ref} = 0.65 in/sec for a reference pile driver at 25 ft
D = distance from pile driver to the receiver in ft.
n = 1.1 (the value related to the attenuation rate through ground for Hard soils: dense compacted sand, dry consolidated clay, consolidated glacial till, some exposed rock (cannot dig with shovel, need pick to break up)

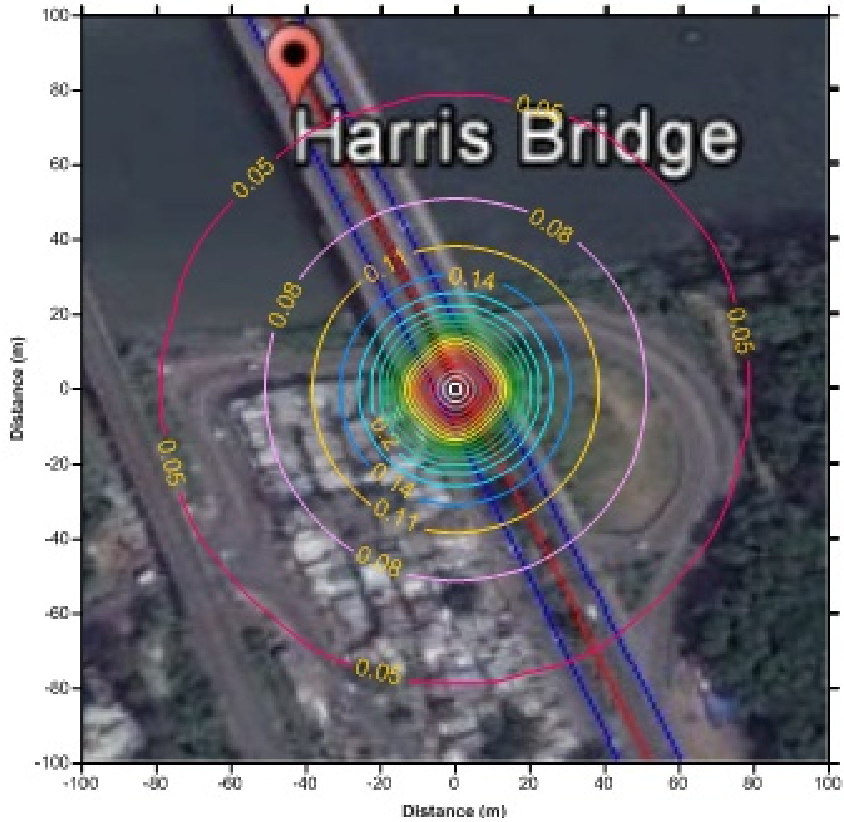
Using the above empirical propagation equation peak particle velocity (PPV) in in/sec of the equipment adjusted for the distance (D) has been estimated conservatively (no mitigation measure along the wave propagation) at the receptor locations and presented in Table 5.7& in Figure 5.2. The same empirical equation can be used to estimate the vibration amplitude during the resonant start-up and shut-down phases of the pile driving operation.

Table 5.7: Vibration due to Vibratory Pile Driver

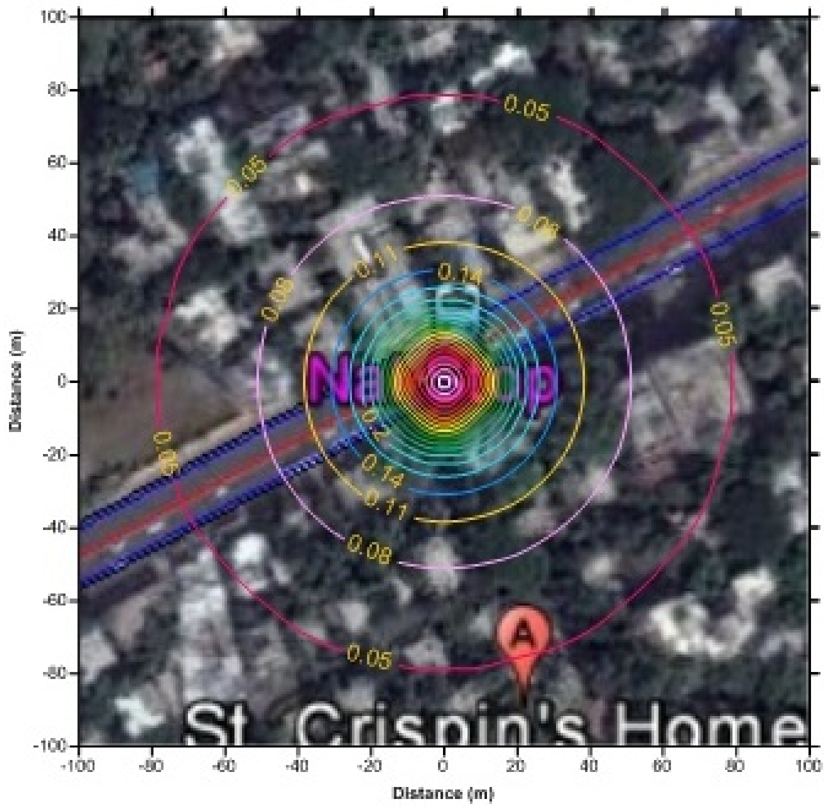
S. No	Location	Distance from Alignment in m	PPV(in/sec)			
			Monitored	Predicted	Resultant	Permissible
1.	Ruby Hall*	11	0.035	**0.434**	**0.469**	0.08
2.	Aga Khan Palace	120	0.021	0.031	0.052	0.25
3.	Rajeev Gandhi Hospital	85	0.032	0.046	0.078	0.08
4.	Galaxy Care Hospital	35	0.035	**0.122**	**0.157**	0.08
5.	St. Crispin Church	110	0.0213	0.034	0.055	0.25
6.	Sangam Bridge	27	0.024	0.162	0.186	0.25
7.	Harris Bridge near Bapodi	4	0.138	**1.321**	**1.459**	0.25

*Specialmitigation interventions will be undertaken for reducing vibration levels at Ruby Hall .

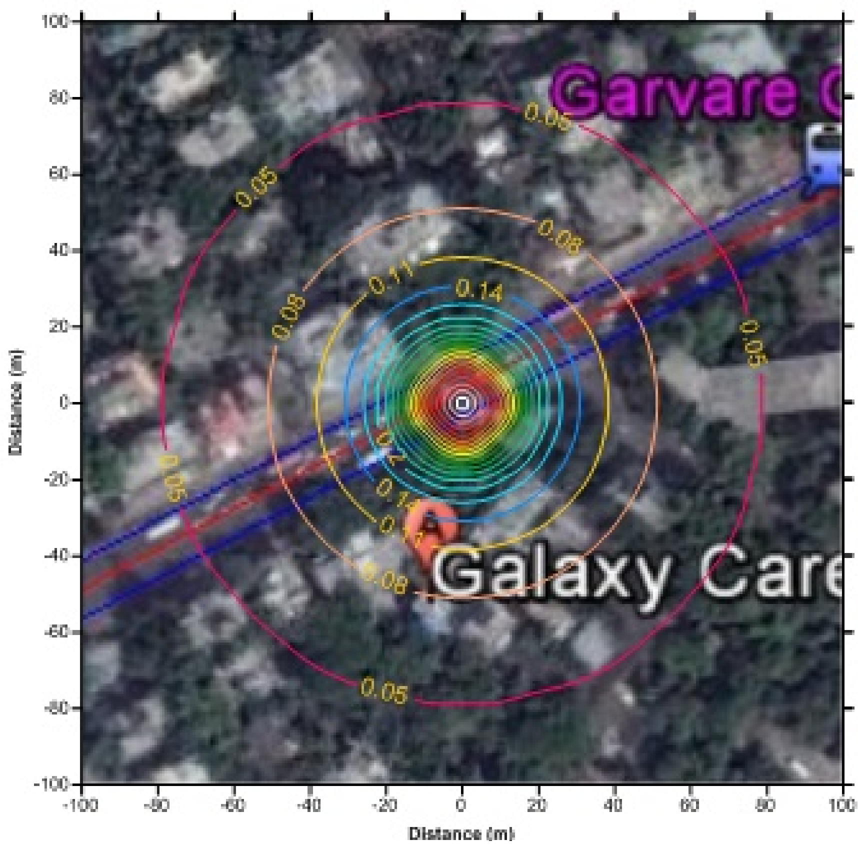
Figure 5.2: Vibration at monitoring locations due to Vibratory Pile Driver



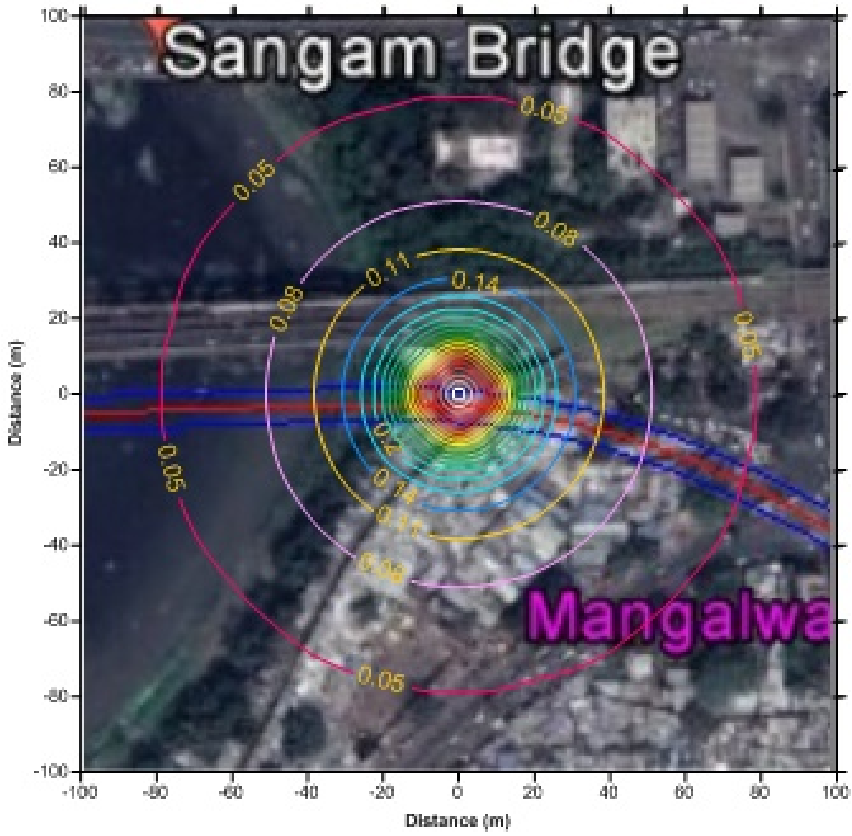
1. Harris Bridge



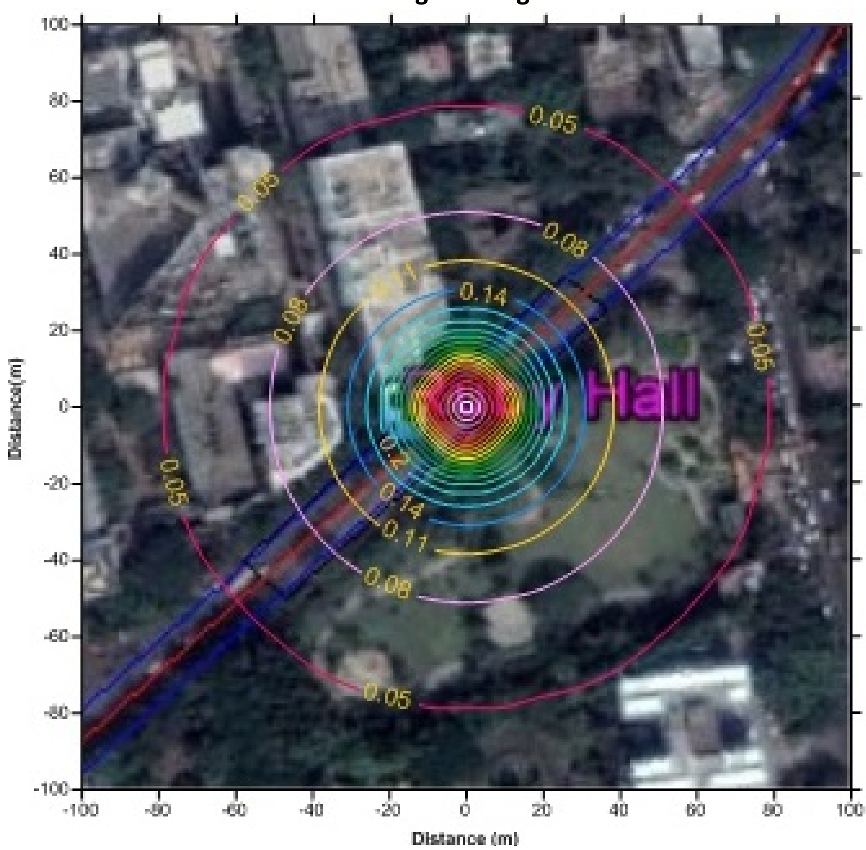
2. ST. Crispin Church



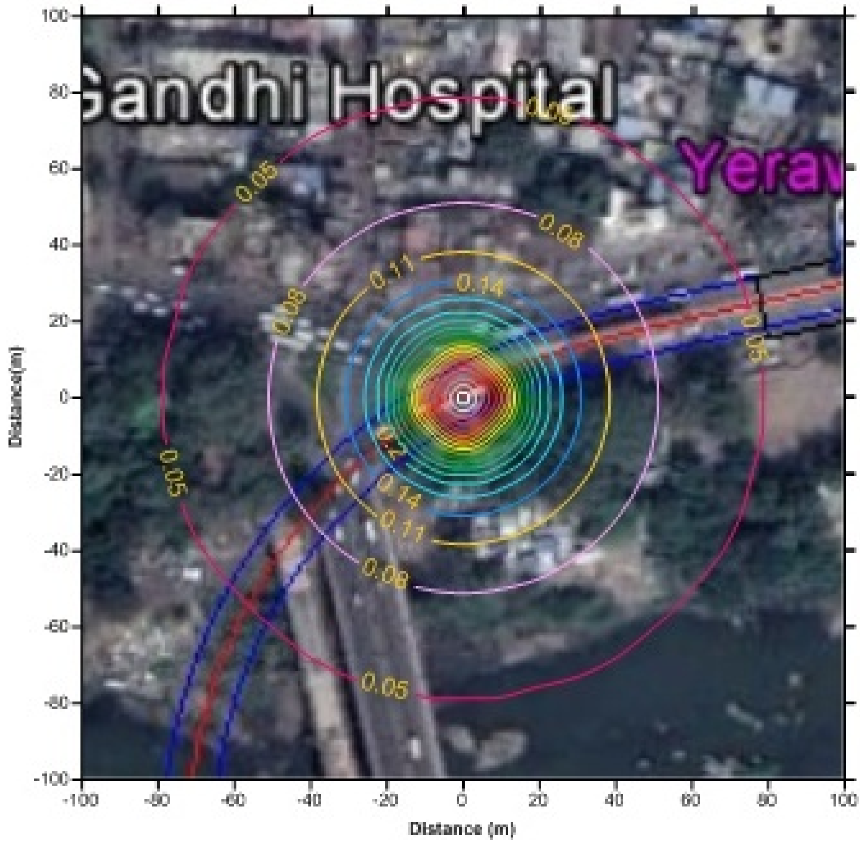
3. Galaxy Care Hospital



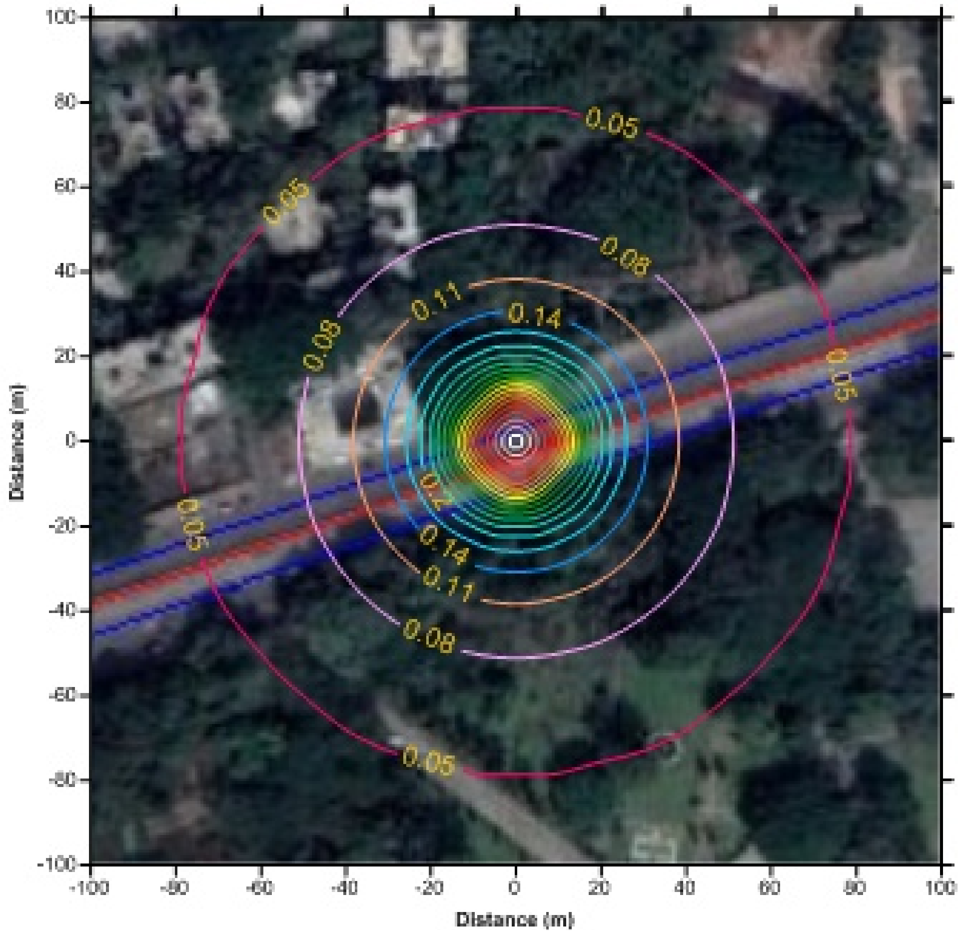
4. Sangam Bridge



5. Ruby Hall



6. Rajiv Gandhi Hospital



7. Aga Khan Palace

Maximum PPV is predicted at Harris Bridge near Bapodi (1.321) and minimum (0.031) at Agha Khan Palace. Exceedance of the threshold criteria at Harris Bridge, Galaxy Care Hospital and Ruby Hall may be attributed to their proximity to the alignment.During the primary driving phase when resonance between hammer-pile and soil-pile systems will be absent, PPV could be 50% or less of the maximum levels that may occur during the start-up and shut-down phases. However, the predicted values correspond to maximum levels during the start-up and shut-down phases.

Spatial variation of predicted PPV reveals that predicted PPV attenuates from the source location to 0.08 in/sec at a distance about45 m without adopting any mitigation measures. With reference to Vibration damage potential threshold criteria presented in Table 5.5, this distance of 45 m may be considered as a safe distance for extremely fragile historic buildings, ruins, ancient monuments with respect to vibratory pile work during construction phase and hence, prior survey should be carried out before commencing the vibratory pile driving operation.

B. Vibration Impact due to Impact Pile Driver (if used)

Vibration amplitudes produced by Impact pile drivers can be estimated by the following empirical equation

$$PPV_{Impact\ Pile\ Driver} = PPV_{ref}\ (25/D)^{n}(E_{equiip}/E_{ref})^{0.5}\ (in/sec)$$

Where:

PPV_{Ref} = 0.65 in/sec
D = distance from pile driver to the receiver in ft.
n = 1.1

Using the above empirical propagation equation, peak particle velocity (PPV) in in/sec has been predicted estimated conservatively (no mitigation measure along the wave propagation) at the receptor locations and presented in Table 5.8. At Ruby Hall, Rajeev Gandhi Hospital, Galaxy Care Hospital, Sangam Bridge and Harris Bridge predicted levels are likely to exceed permissible limits without mitigation measures.

It is understood that the predicted PPV from the Impact pile driver is very higher than the vibratory pile driver.

Table 5.8: Vibration due to Impact Pile Driver

S. No	Location	Distance from Alignment in m	PPV(in/sec)			
			Monitored	Predicted	Resultant	Permissible
1.	*Ruby Hall	11	0.035	**1.94**	**1.975**	0.08
2.	Aga Khan Palace	120	0.021	0.14	0.161	0.25
3.	*Rajeev Gandhi Hospital	85	0.032	**0.21**	**0.242**	0.08
4.	*Galaxy Care Hospital	35	0.035	**0.54**	**0.575**	0.08
5.	St. Crispin Church	110	0.0213	0.15	0.171	0.25
6.	Sangam Bridge	27	0.024	**0.72**	**0.744**	0.25
7.	Harris Bridge near Bapodi	4	0.138	**5.92**	**6.058**	0.25

*In caseple driver is used special interventions will be provided for vibration control.

C. Vibration Impact due to Tunnel Boring Machine (TBM)

Summary of tunneling methods are given in Table 5.9 (Priyadarshi Hem, Norman B. Keevil Institute of Mining Engineering - University of British Columbia,September 2015, www.technology.infomine.com).

Table 5.9: Tunneling Methods

Tunnelling Methods	Advance Rate (m/day)	Cross-section Area (m^2)/ Dia (m)	Rock Properties	Comments
Pipe Jacking	5 – 20	12 mm (0.5") 3.6 m (12')	Best suited for cohesive soil; can also be applied to non-cohesive and dry conditions and in hard rocks.	Primarily for laying pipelines; small cross-section and limited capability in hard rock's show little scope of its use in underground mining

Tunnelling Methods	Advance Rate (m/day)	Cross-section Area (m^2)/ Dia (m)	Rock Properties	Comments
Hammer Tunnelling	2 – 10	Up to 30 m^2	Low to medium strength; RQD: 0 - 100	Breaking, mucking and reinforcement can go together; low investment
Road headers	5 – 15	Up to 45 m^2	Up to 140 MPa (UCS); can adapt to changing rock mass conditions	Low investment, 15% - 30% of TM investment for same cross-section; can be rented; can be delivered and ready for operation in 3-6 months; free space and accessibility; can handle a variety of subsections
TBMs	15 – 50	Up to 160 m^2	From 20 to 140 MPa (UCS); can be fabricated to a variety of ground conditions	Fabrication period of around 12 months; Onsite set up time 3-6 months
Drill & Blast	3.5 m - 5 m & 7 - 15 m (without rock support installation)	-	-	-

MPa ~ 10.20 kg/sq cm

TBM typically consists 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. Ground borne vibration caused by tunneling operations have the potential to cause significant community annoyance because, in general the operations are continuous. Vibration from operating TBM machines is influenced by distance, structural rock conditions, physical rock properties, ground water and depth of overburden. Vibration magnitude in term of peak particle velocity (PPV) from the TBM has been predicted using following empirical formula (Godio et al., 1992 cited in Hillar&Crabb, 2000) and Code of Practice for Noise and Vibration control on construction and open sites –Part 2: BS5228-2 Annex E as given below.

$$\mathbf{PPV(mm/s)= A\ D^{-1.3}}$$

Where:

A is a constant whose value depends on the ground condition (assumed hard ground; A=180) and

D is the direct distance (m) from the vibration source to the measurement location.

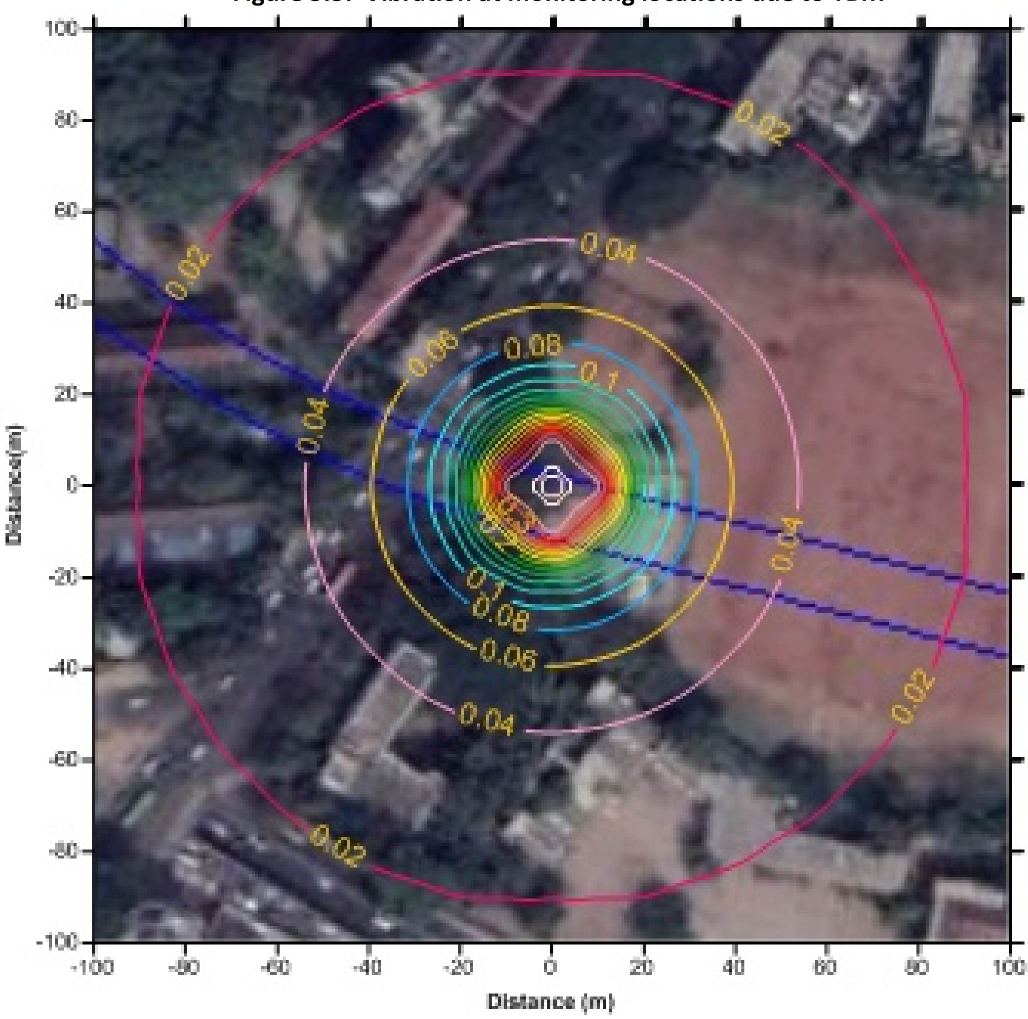
Using the above empirical propagation equation, peak particle velocity (PPV) due to TBM has been predicted and presented in Table 5.10& shown in Figure 5.3.Maximum predicted PPV of 0.20 in/sec is estimated at City Post.

Table 5.10: Vibration due to TBM

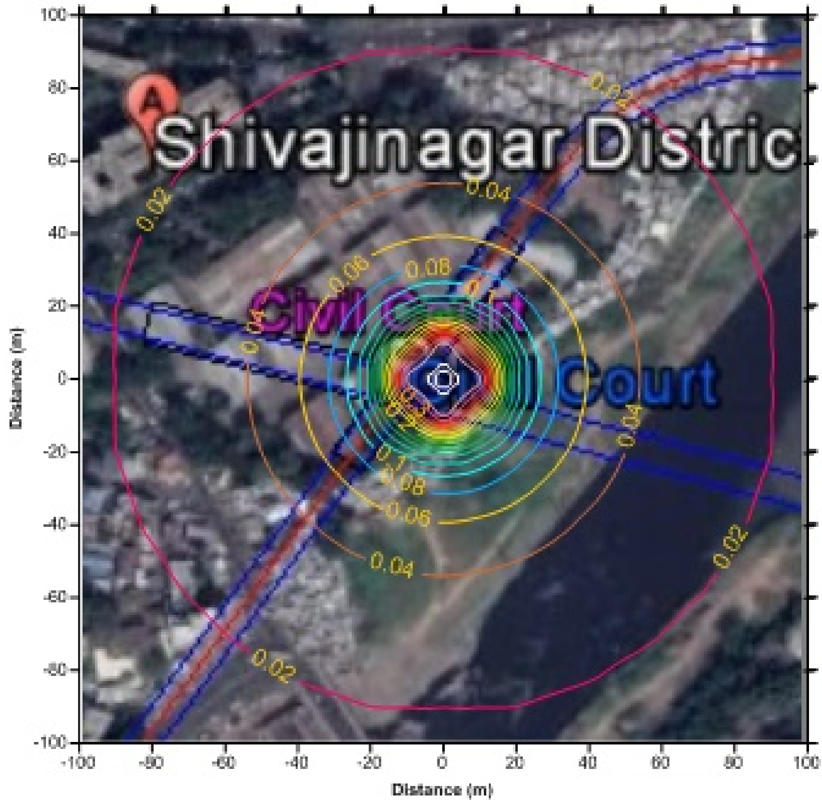
S. No	Location	Radial Distance* from UG Alignment in m	PPV(in/sec)			
			Monitored	Predicted	Resultant	Permissible
1.	Pataleswar Cave Mandir	208	0.028	0.01	0.03	0.25
2.	District and sessions court	18	0.018	0.17	0.18	0.25
3.	Shaniwar wada	232	0.031	0.01	0.04	0.08
4.	Kasba Ganapati mandir	125	0.030	0.01	0.05	0.08
5.	Dagduseth Ganapathi Mandir	104	0.032	0.02	0.05	0.08
6.	City post	16	0.027	0.20	0.23	0.25
7.	Old wooden structure near Mandai	52	0.031	0.04	0.07	0.08

* Radial distance assuming depth of top of tunnel is 15m below ground

Figure 5.3: Vibration at monitoring locations due to TBM

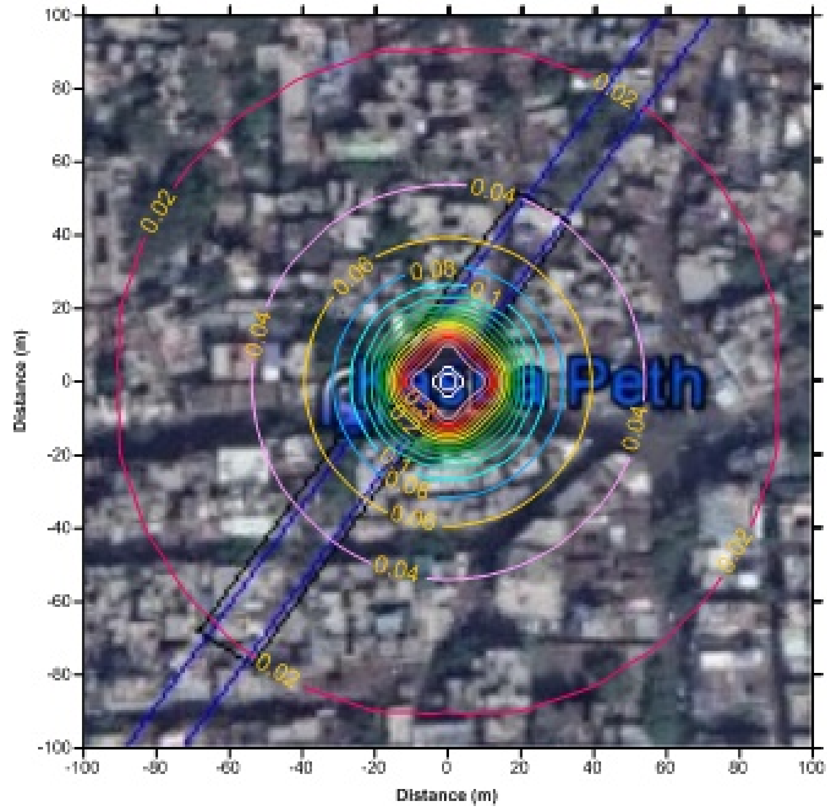


1. Pataleshwar Cave Mandir

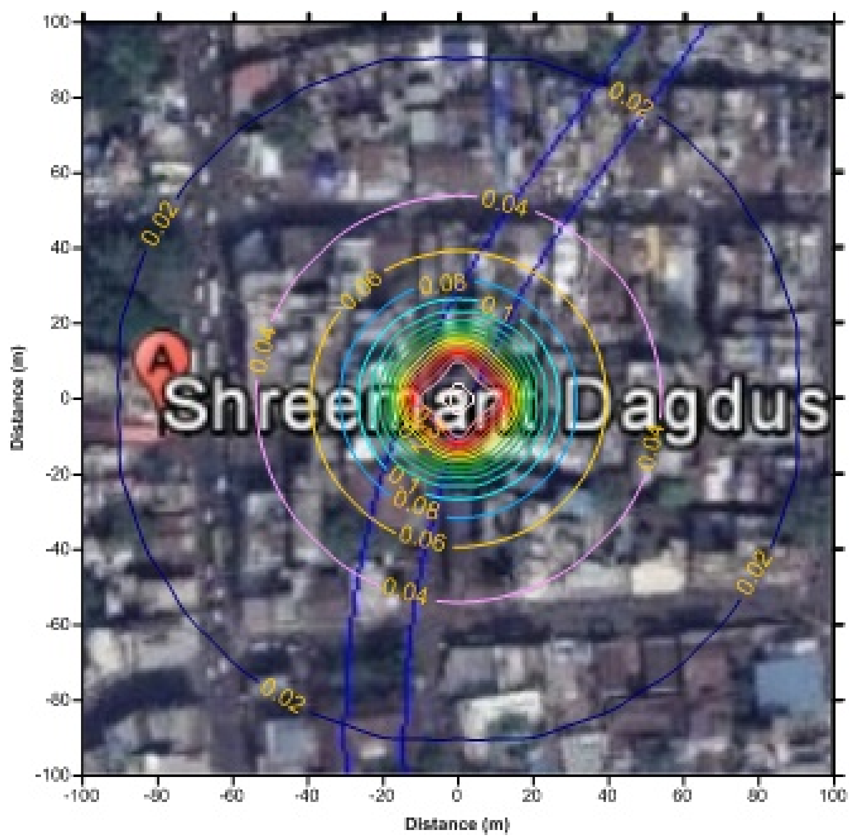


2. District & Session court

3. Shaniwar wada

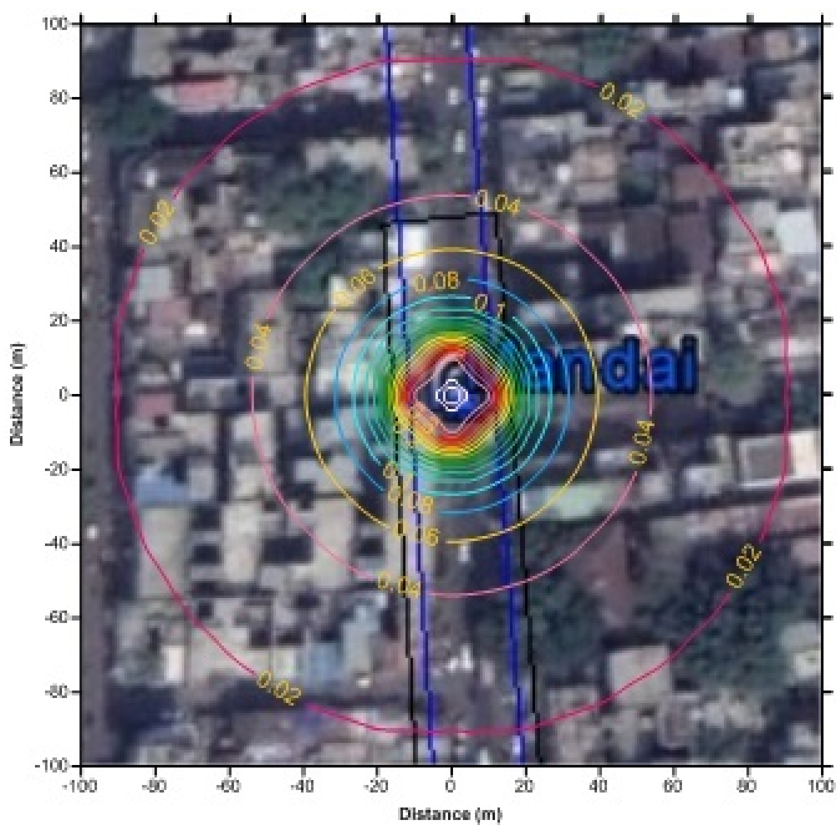


4. Kasba Ganapati Mandir



5. Dagduseth Ganpati Mandir

6. City Post



7. Mandai

Spatial variation of resultant PPV shows that predicted PPV attenuates from the source location to permissible levels at all receptors without considering any mitigation measures. However, prior building condition survey should be taken up before commencing the TBM operation.

D. VibrationImpact due to Controlled Blasting

In case of construction of underground stations or tunneling by NATM in hard rock which require controlled blasting, vibration in structures will be observed.

Controlled blasting operations may have to be carried out to excavate for certain underground stations close to important buildings, old and sensitive structures. When an explosive charge is detonated inside a blast-hole, it is instantly converted into hot gases and the expanding gases exert intense pressure on the blast-hole walls. A high intensity shock wave travels through the rock mass which attenuates sharply with distance. As seismic waves travel through the rock mass, they generate particle motions which are termed as ground vibrations. Damage caused by ground vibration is dependent on peak particle velocity (PPV) and the frequency (Hz) of the ground motion. In order to predict PPV, a derived predictor empirical equation (RERA 2016) based on 0.125 kg MCD (maximum charge per delay) for ground vibration frequency range greater than 10 Hz has been employed and predicted PPV (mm/s) at the seven receptor locations are presented in Table 5.11. Vibration results at each UG station is shown in Figure 5.4.

$$\mathbf{PPV(mm/s)= 432\ (D/\sqrt{Q}^{)-1.34}}$$

Where:

PPV = peak particle velocity (mm/s)

(D/√Q) = scaled distance

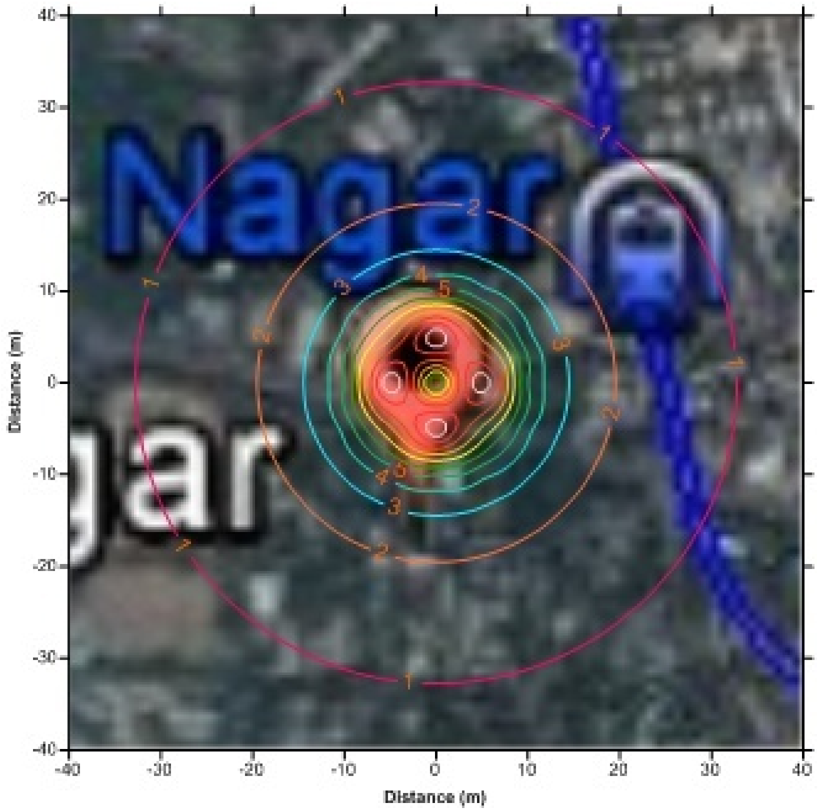
D = radial distance from blast to monitoring station (m)

Q = maximum charge per delay (kg),

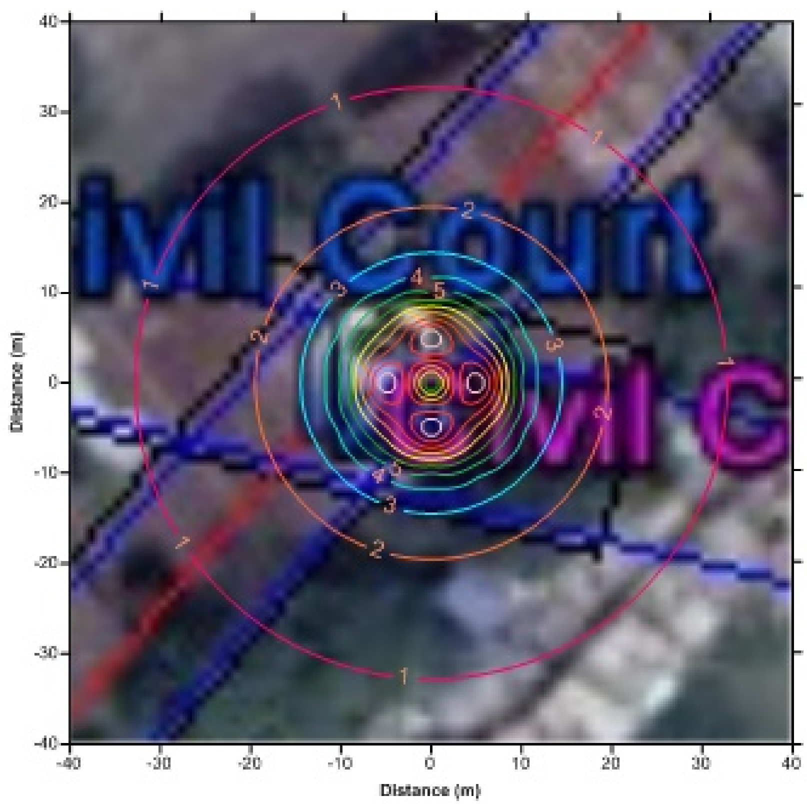
Table 5.11: Vibration due to Controlled Blasting

S. No	Location	Horizontal Distance from nearest station in m	Nearest Metro Station	Monitored PPV (mm/sec)	Predicted PPV (mm/sec)	Resultant PPV (mm/sec)
1.	Pataleswar Cave Mandir	492	Shivaji Nagar	0.6858	0.026	0.712
2.	District and Sessions Court	100	Civil Court	0.4572	0.224	0.681
3.	Shaniwar Wada	207	Kasba Peth	0.7874	0.085	0.872
4.	Kasba Ganapati Mandir	121	Kasba Peth	0.8128	0.174	0.986
5.	Dagduseth Ganapathi Mandir	270	Kasba Peth	0.762	0.059	0.821
6.	City post	311	Kasba Peth	0.7112	0.049	0.760
7.	Old wooden structure near Mandai	320	Mandai	0.7874	0.047	0.835

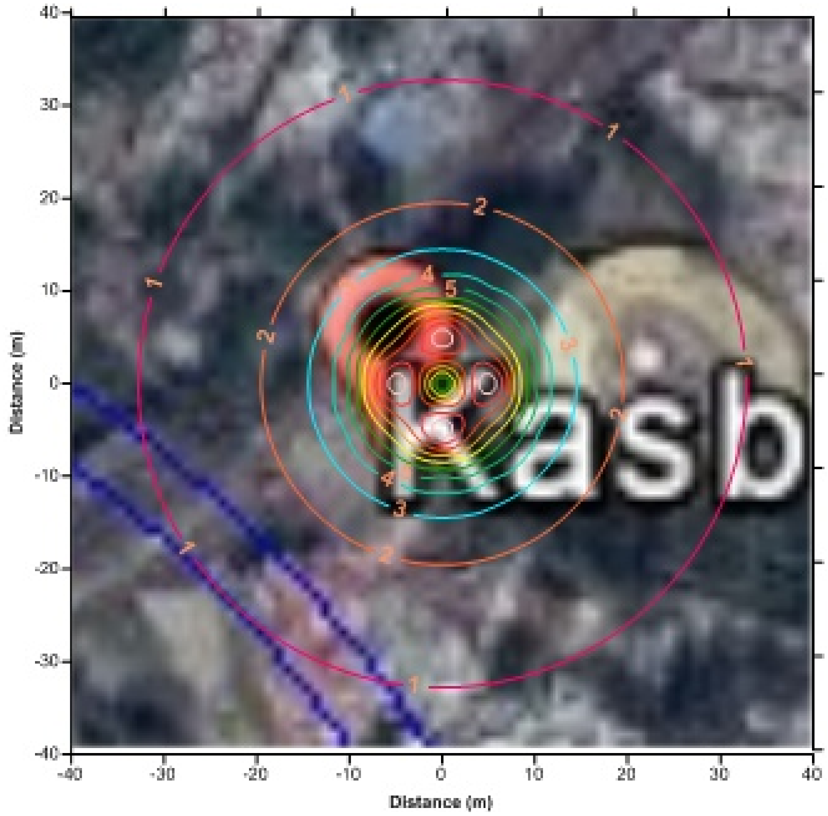
Figure 5.4: Vibration due to Controlled Blasting



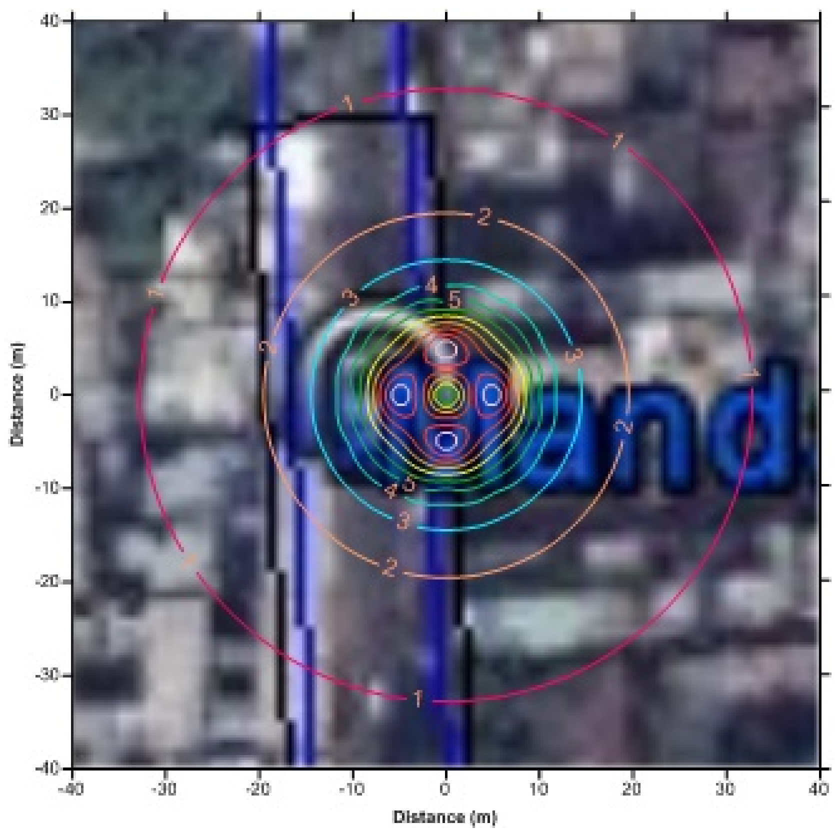
1. **Shivaji Nagar: Controlled Blasting Construction Phase**



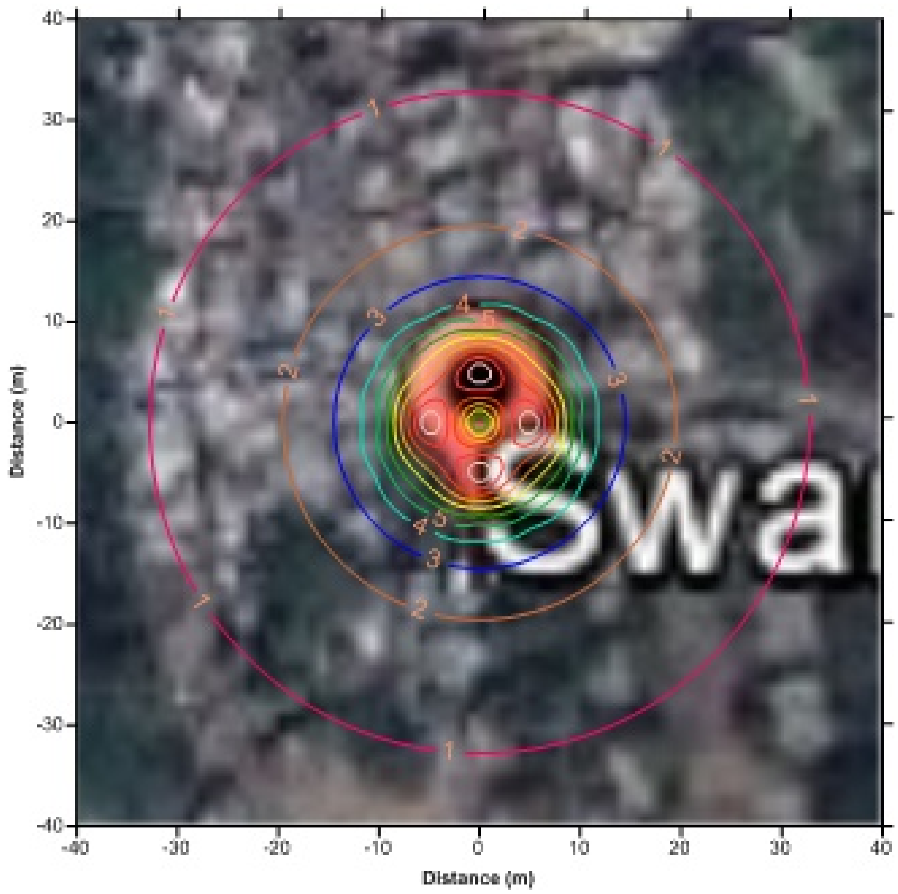
2. **Civil Court: Controlled Blasting Construction Phase**



3. Kasbapeth: Controlled Blasting Construction Phase



4. Mandai: Controlled Blasting Construction Phase



5. Swargate: Controlled Blasting during Construction Phase

Modeling result at all locations infers that vibration level significantly within the permissible limits of Director General of Mine Safety (DGMS). Further, as precautionary measures all the buildings/structures in the vicinity to excavation site should be surveyed carefully to assess the type and condition of structures for assigning threshold ground vibration limits as per DGMS (India) standards provided in Table 5.12 before commencing the blasting.

Table 5.12: DGMS Prescribed Permissible Limit (mm/sec) of Ground Vibration (INDIA)

Type of Structure	Dominant Excitation Frequency, (Hz)		
	<5 Hz	25 Hz	>25 Hz
A) Building structures not belonging to the owner			
Domestic houses, structures (Kuchha, brick and Cement)	5	10	15
Industrial Building (RCC and Framed Structure	10	20	25
Objects of historical importance and sensitive structure	2	5	10
B) Building structures belonging to the owner with limited span of life			
Domestic houses, structures (Kuchha, brick and Cement)	10	15	25
Industrial Building (RCC and Framed Structure	15	25	50

Spatial variation of PPV due to controlled blasting at each UG station reveals that PPV attenuates from the source location to 2 mm/sec at a distance about 20 m without adopting any mitigation measures. Thus levels at all receptors are within limits. Influence of side effect of rock blasting and its control measures are also given in Table 5.13.

Table 5.13:Influence of Side Effects of Rock Blasting and Control Measures

Parameter	Effect	Control
Ground Vibration	• Damage to Structure • Annoyance and health impacts to people	• Proper blast design • Increase delays • Proper initiation system and sequence • Decrease maximum charge per delay • Reduce confinement • Create a spilt/channel between blast site and structure
Fly Rock	• Damage to structures/machinery • Injury to people • Fatal accidents	• Blast design • Change explosive • Change initiation system • Reduce confinement • Muffling arrangement

5.5.4. Impact due to Muck Disposal

Out of the two metro corridors, one metro corridor is a mix of elevated and underground right of way and other corridor is fully elevated. The construction activity involves cut and cover, tunneling, excavation and fill. All these activities will result in excavation of about 6.65 lakh cum and fill of about 1.35 lakh cum with net quantity to be disposed of about 5.30 lakh cum. Muck disposal if not properly done can result in air and water pollution, noise, diversion of green parks and temporary displacement.

5.5.5. Impact due to construction/demolition waste Disposal

Debris disposal can result in air and water pollution, noise, diversion of green parks and temporary displacement.

5.5.6. Impact due to Hazardous Waste

Hazardous waste would mainly arise from the maintenance of equipment which may include used engine oils, hydraulic fluids, waste fuel, spent mineral oil/cleaning fluids from mechanical machinery, scrap batteries or spent acid/alkali, spent solvents etc.Unsafe disposal can result in water and soil pollution, diversion of green parks and temporary displacement.

5.5.7. Increased Water Demand

The water demand will increase during construction phase. The water demand is estimated to be 498 kilolitres per day (kld).

5.5.8. Impact due to Pre-casting yards and Material stockpiling

Sites for casting of structural concrete elements and material stockpiling can result in air and water pollution, noise,diversion of open areas like green parks and temporary displacement.

5.5.9. Impact on Ground and Surface Water Quality

Ground water contamination can take place if sewage at labour camps orchemical substances from construction site or dumped muck or construction/demolition waste or used water from the RMC plant get leached by precipitation of water and percolate to the ground water table.

5.5.10. Soil Erosion and land subsidence

Run off from unprotected excavated areas can result in excessive soil erosion, especially when the erodability of soil is high.Land subsidence is anticipated at stations which will be constructed by cut and cover method.

5.5.11. Traffic Diversions

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

5.5.12. Impacts due to Labour Camps

Improper disposal of municipal solid waste generated by labour camps can pollute surface water bodies and groundwater. Burning of waste can cause air pollution.Construction workers are more prone to infectious diseases due to unsafe sexual activity and lack of sanitation facilities (water supply and human waste disposal) and insect vectors. Problems could arise due to cultural differences between workers from outside and local residents. About 450 persons in Corridor 1 and 108 persons in corridor 2 are likely to work during peak construction activity. Two labour camps will be proposed at appropriate locations. The water requirement at labour camp on corridor 1 will be 60.75 KLD, waste water generation 48.6 KLD & Municipal solid waste generation 135 Kg per day; similarly The water requirement at labour camp on corridor 2 will be 14.6 KLD, waste water generation 11.7 KLD & Municipal solid waste generation 32 Kg per day.

5.5.13. Welfare of Labour on construction site

Facilities such as shelter at workplace, canteen, first aid and day crèche are statutory requirement and essential to productivity.

5.5.14. Safety of Labour

Safety of labour during construction on elevated and underground sections is a statutory requirement and also has impact on progress of work.

5.5.15. Impact due to Supply of Construction Material

Construction material such as aggregate and earth are sourced from approved quarries such that environmental impacts as well as wastage of natural resources are minimized and mitigated.

5.5.16. Impacts of Ambient Pollution on Human Health

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

- Higher levels of exposure to ambient PM are associated with worse cognitive decline[2].
- Increased risk of fatal CHD associated with each 10 µg/m^3 increase in annual PM2.5 exposure[3].
- Significant association between exposure to PM2.5 and risk of incident CKD, eGFR decline, and ESRD[4].
- The mortality rate advancement attributable to traffic pollution was similar to that associated with chronic respiratory and pulmonary diseases and diabetes[5].
- Exposure to ambient PM2.5 air pollution is associated with a lower level of sperm normal morphology and a higher level of sperm concentration[6].
- In addition to noise induced hearing loss, stress hormone increases and increase in the risk of myocardial infarction are caused by noise[7].

5.6. IMPACTS DUE TO PROJECT OPERATION

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

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

[2] *Exposure to Particulate Air Pollution and Cognitive Decline in Older Women, Jennifer Weuve et al, JAMA Internal Medicine, February 2012*

[3] *Chronic fine and coarse particulate exposure, mortality, and coronary heart disease in the Nurses' Health Study, Puett RC et al , Environ Health Perspect. November 2009*

[4] *Particulate Matter Air Pollution and the Risk of Incident CKD and Progression to ESRD, Benjamin Bowe et al, Journal of the American Society of Nephrology, September 2017*

[5] *Traffic Air Pollution and Mortality Rate Advancement Periods, Murray M. Finkelstein et al, American Journal of Epidemiology, July 2004*

[6] *Exposure to ambient fine particulate matter and semen quality in Taiwan,* Xiang Qian Lao et al,, Occupational and Environmental Medicine, November 2017

[7] *Health effects caused by noise: Evidence in the literature from the past 25 years, H Ising, B Kruppa, Noise & Health, 2004*

5.6.1. Noise Pollution

Typical noise level due to rapid rail transit on viaduct at speed 50 mph and distance 50 feet from tracks is 85 dB (A); respective value for at grade is 80 dB (A); and rail transit at stations is 65dB (A) (*Fig. 1.5 and Fig 1.11 respectively, Metro Rail Transit System Guidelines for Noise and Vibrations, RDSO, Sept 2015*).However Maha Metro is examining the options of alternative equipment to further reduce the noise levels.

Airborne noise is radiated from at-grade and elevated structures, while ground-borne noise and vibration are of primary concern in underground operations. During the operation phase the main source of noise will be from running of metro trains. Basic sources of wayside airborne noise are:

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

Wide range of noise levels depends on following factors:

i. Train speed (V): Car interior noise levels vary from 15 log10 V to 40 log10 V.
ii. Type of Way structure: Noise levels lowest on AG ballast and tie-welded track and highest for operations on light-weight structures and in tunnels with concrete track bed and no acoustic treatment.
iii. Sound Insulations of car body: Single leaf or Sandwich construction.
iv. Type & Design of Mechanical Equipment: Propulsion system & Auxiliary Equipment (A/c system, compressors and motor generator sets).
v. Wheel and Rail conditions: Rail corrugations and wheel flats can increase the noise levels by 10-15 dB(A).

Future noise levels in the Project area were estimated based on existing measured sound levels and future daily metro rail operations. The cumulative noise due to Metro Rail and existing ambient noisewithout any attenuation factors/barriers is given in Table 5.14.

Table 5.14: Cumulative Noise during Operation Phase

Name of the Location	Ele/UG	Cumulative Noise in dB (A)
PCMC - Range Hill Corridor		
PCMC	Ele	75.3
Sant Tukaram Nagar	Ele	68.4
Bhosari (Nashik Phata)	Ele	75.6
Kasarwadi	Ele	75.3

Name of the Location	Ele/UG	Cumulative Noise in dB (A)
Phugewadi	Ele	77.4
Dapodi	Ele	74.1
Bopodi	Ele	74.3
Khadki	Ele	74.1
Range Hill	Ele	65.5
Shivaji Nagar	UG	65.0
Civil Court - *Interchange Station*	UG	65.0
Kasba Peth	UG	65.0
Mandai	UG	65.0
Swargate	UG	65.0
Vanaz-Ramwadi Corridor		
Vanaz	Ele	74.2
Anand Nagar	Ele	73.4
Ideal Colony	Ele	72.4
Nal Stop	Ele	73.7
Garware College	Ele	74.5
Deccan Gymkhana	Ele	73.7
Sambhaji Park	Ele	73.7
PMC	Ele	74.3
Mangalwar Peth	Ele	71.3
Pune Rly. Stn	Ele	74.9
Ruby Hall Clinic	Ele	76.8
Bund Garden	Ele	70.2
Yerawada	Ele	72.8
Kalyani Nagar	Ele	75.1
Ramwadi	Ele	72.0

The cumulative noise is more than the Noise Standards for Commercial area at all elevated stations. The noise will be reduced to noise permissible limits for commercial zone at a distance of 20m from the track. Due to reduction of vehicular traffic, the road traffic noise is expected to come down, which ultimately reduces the noise at elevated stations.

5.6.2. Vibration

During operation phase vibration is induced by the rapid transit rail along the metro corridor. Vibration impact has been predicted at the selected potential receptor for the design speed of 33 kmph with high resilience track fasteners. Vibration impact assessment has been carried out using Transit Noise vibration Model (TNV-1) and the predicted vibration level (in/sec) is presented in the Table 5.15 considering the following conservative conditions:

i. Vehicles with stiff primary suspension
ii. Worn or Wheel with flats
iii. Worn/Corrugated Track
iv. Jointed Track

v. Efficient propagation in soil
vi. Large Masonry on Piles
vii. Amplification due to resonance of floors and walls

Table 5.15: Predicted Vibration Level due to Rapid Transit Railwithout Control Measures

S No.	Location	Impact Distance (D) from source (m)/Metro alignment	Monitored Vibration Level (in/sec)	Predicted Vibration Level (in/sec) without Control measures	Resultant Vibration Level (in/sec)
PCMC – Swargate Corridor					
1.	Harris Bridge near Bapodi	4	0.138	0.129	**0.267**
2.	Pataleswar Cave Mandir (UG)	207	0.027	0.004	0.031
3.	District and sessions court(UG)	10	0.018	0.124	0.141
4.	Shaniwar Wada (UG)	232	0.031	0.003	0.034
5.	Kasba Ganapati Mandir (UG)	124	0.032	0.008	0.041
6.	DagdusethGanapathiMandir (UG)	103	0.030	0.011	0.041
7.	City post (UG)	4	0.028	0.225	**0.253**
8.	Old wooden structure at Mandai (UG)	50	0.031	0.029	0.060
Vanaz – Ramwadi Corridor					
9.	St. Crispin Church	110	0.021	0.006	0.027
10.	Galaxy Care Hospital	35	0.035	0.024	0.059
11.	Sangam Bridge	27	0.024	0.031	0.055
12.	Ruby Hall (Hospital)	11	0.035	0.065	**0.100**
13.	Rajeev Gandhi Hospital	85	0.031	0.008	0.040
14.	Agha Khan Palace	120	0.021	0.005	0.026

Predicted vibration without control measures as above reveals that most of the receptor locations fall within vibration damage threshold criteria listed in Table 5.5 excepts three locations i.e. Ruby Hall (Hospital), City Post and Harris bridge near Bapodi where resultant vibration level PPV(in/sec) marginally exceeds the threshold criteria under conservative approach. However, the predicted vibration level can be significantly reduced by incorporating the following standard measures/factors:

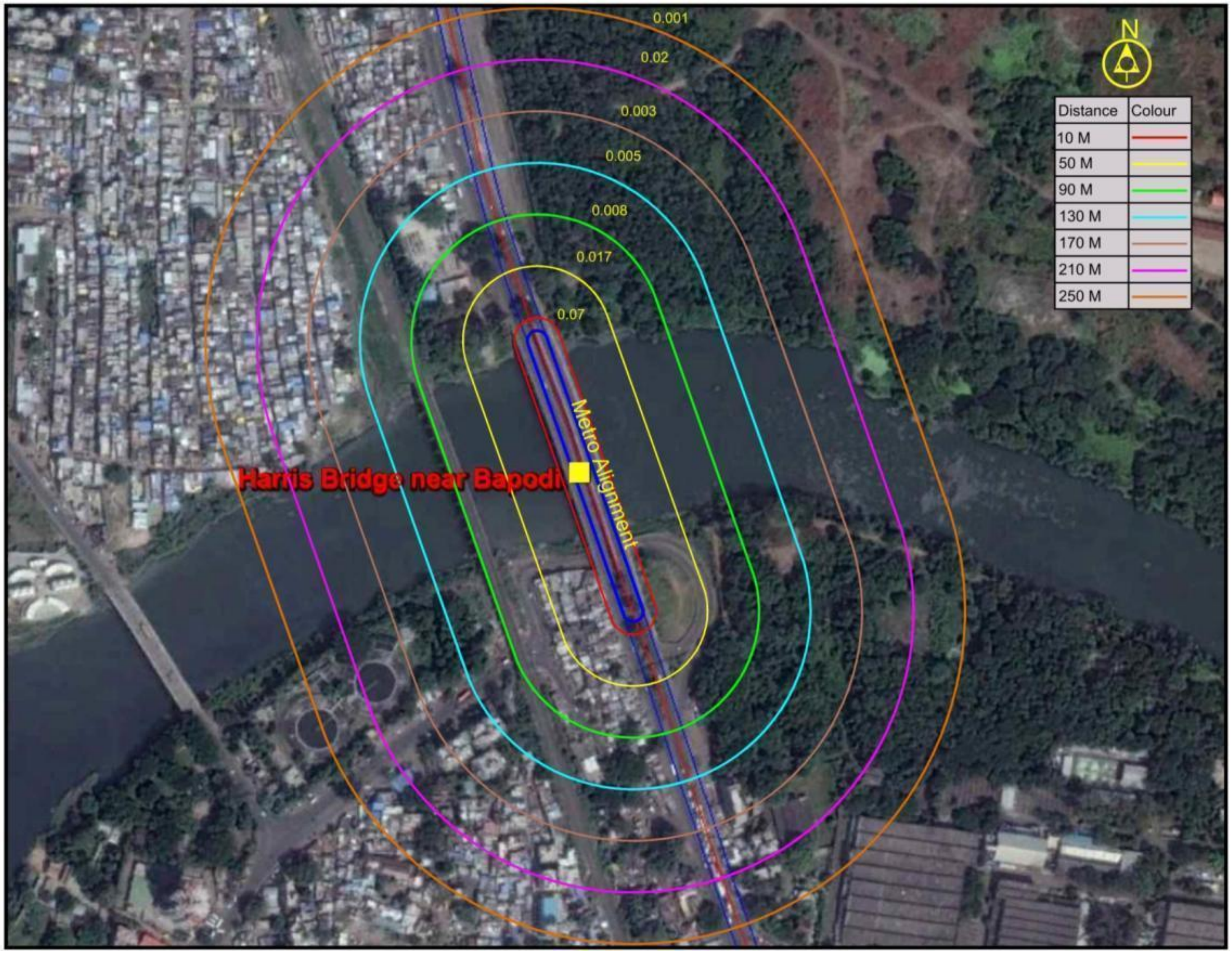
i. Vehicles with NO stiff primary suspension
ii. NO Worn or Wheel with flats
iii. NO Worn/Corrugated Track
iv. NO Jointed Track
v. With Floor-to-Floor Attenuation in receptor buildings

In the light of above non-conservative conditions modelling results are given in Table 5.16 and resultant magnitude of PPV at all receptors locations are predicted to be within vibration damage threshold criteria. Vibration contours during operation phase of the project are shown in Figure 5.5.

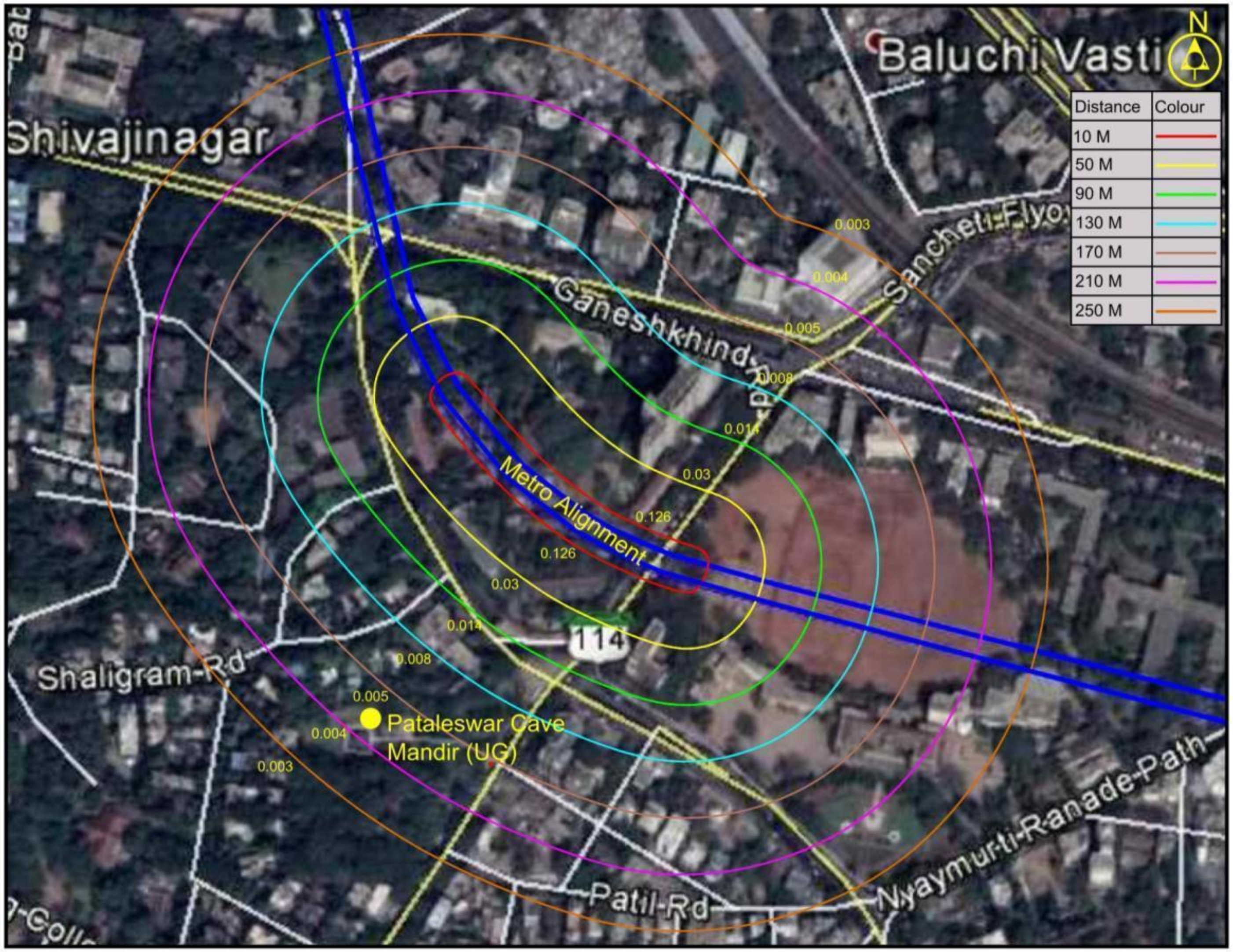
Table 5.16: Predicted Vibration Level due to Rapid Transit Railwith Control Measures

S No.	Location	Impact Distance (D) from source (m)/Metro alignment	Monitored Vibration Level (in/sec)	Predicted Vibration Level (in/sec) with Control measures	Resultant Vibration Level (in/sec)
PCMC - Swargate Corridor					
1.	Harris Bridge near Bapodi	4	0.138	0.003	0.141
2.	Pataleswar Cave Mandir (UG)	207	0.027	0.001	0.028
3.	District and sessions court(UG)	10	0.018	0.002	0.020
4.	Shaniwar Wada (UG)	232	0.031	0.001	0.032
5.	Kasba Ganapati Mandir (UG)	124	0.032	0.001	0.033
6.	DagdusethGanapathiMandir (UG)	103	0.030	0.001	0.031
7.	City post (UG)	4	0.028	0.004	0.032
8.	Old wooden structure at Mandai (UG)	50	0.031	0.001	0.032
Vanaz - Ramwadi Corridor					
9.	St. Crispin Church	110	0.021	0.0004	0.021
10.	Galaxy Care Hospital	35	0.035	0.001	0.036
11.	Sangam Bridge	27	0.024	0.001	0.025
12.	Ruby Hall (Hospital)	11	0.035	0.001	0.036
13.	Rajeev Gandhi Hospital	85	0.031	0.0004	0.021
14.	Agha Khan Palace	120	0.021	0.001	0.033

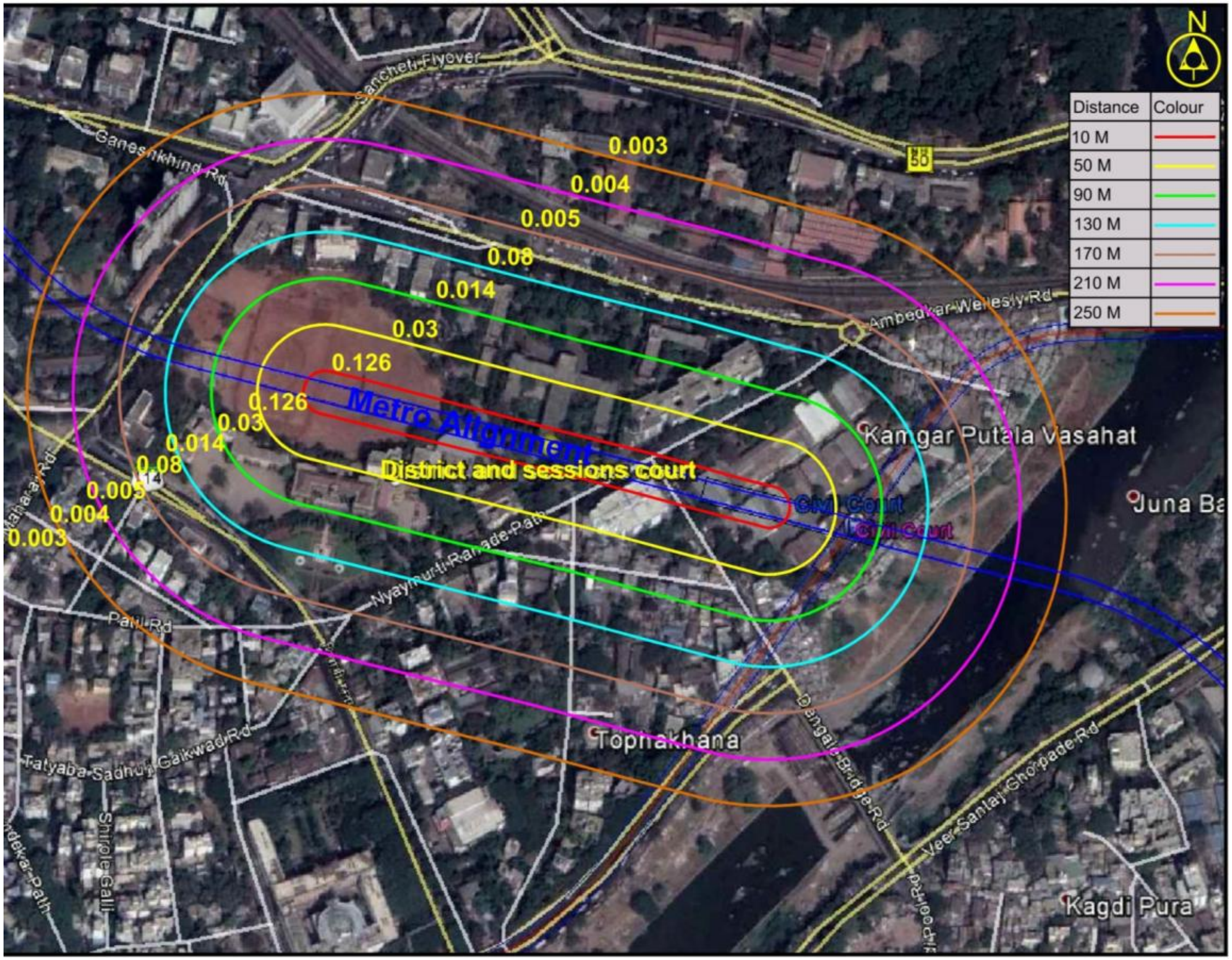
Figure 5.5:Vibration at Monitoring Locations during Operation Phase



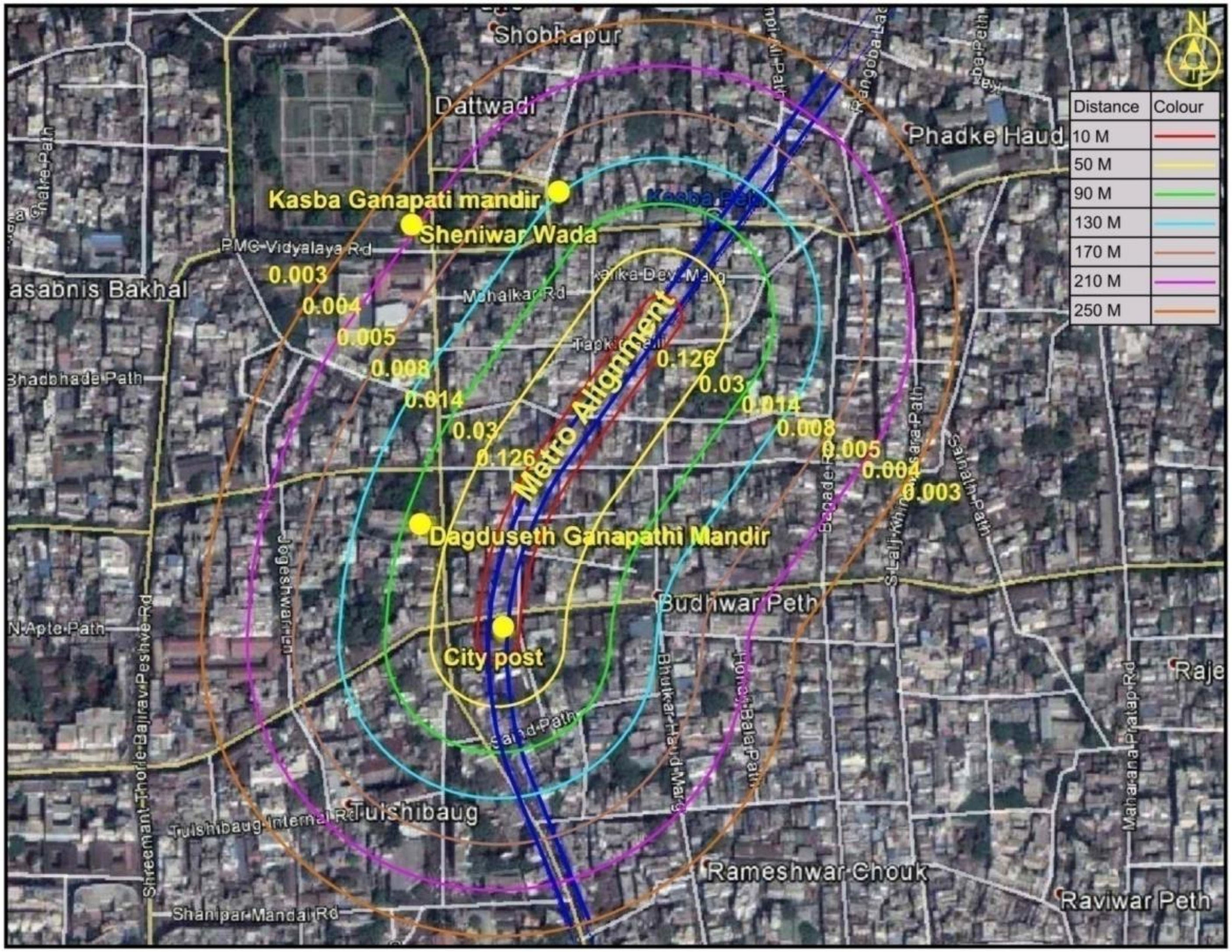
Harris Bridge near Bapodi



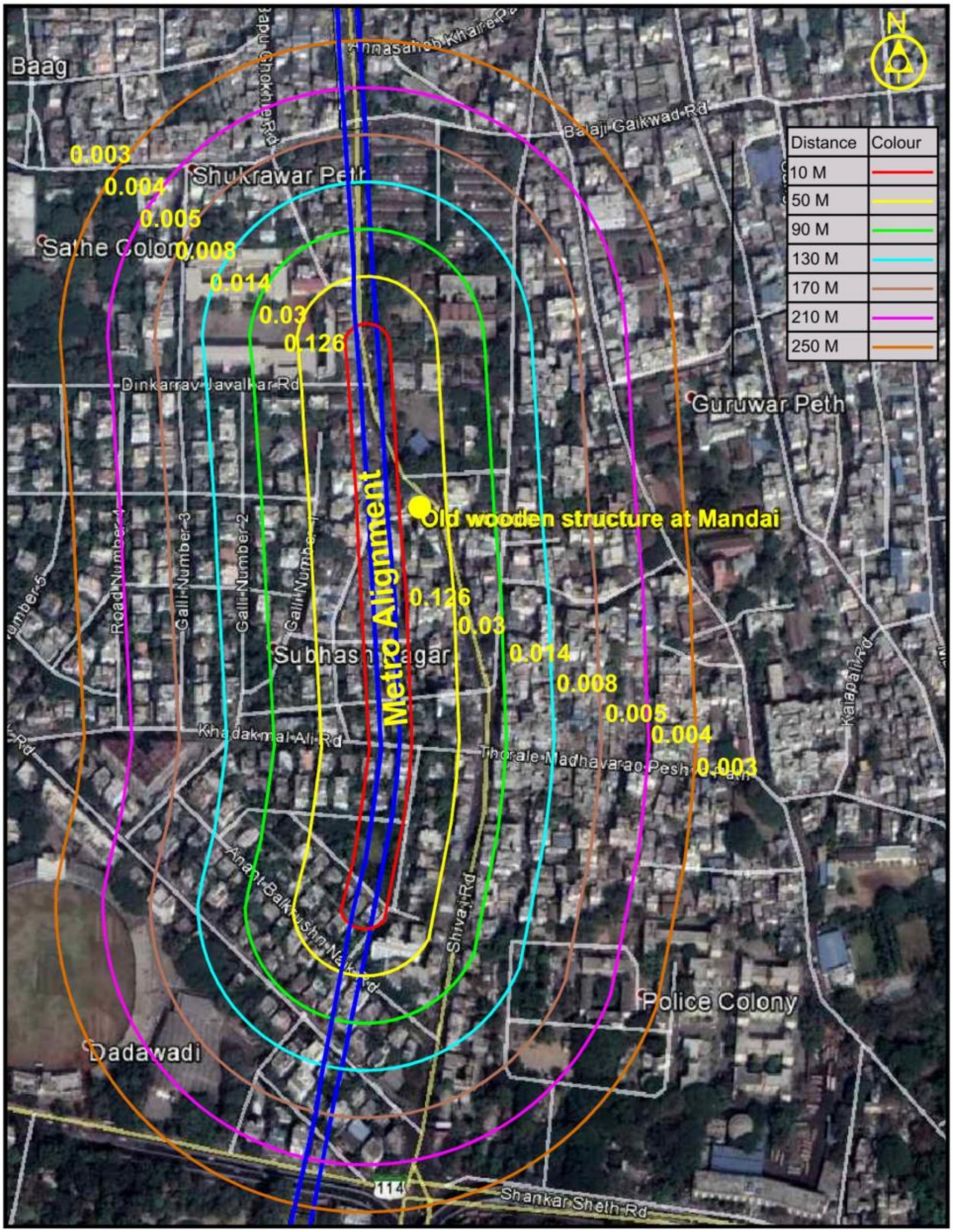
Pataleswar Cave Mandir



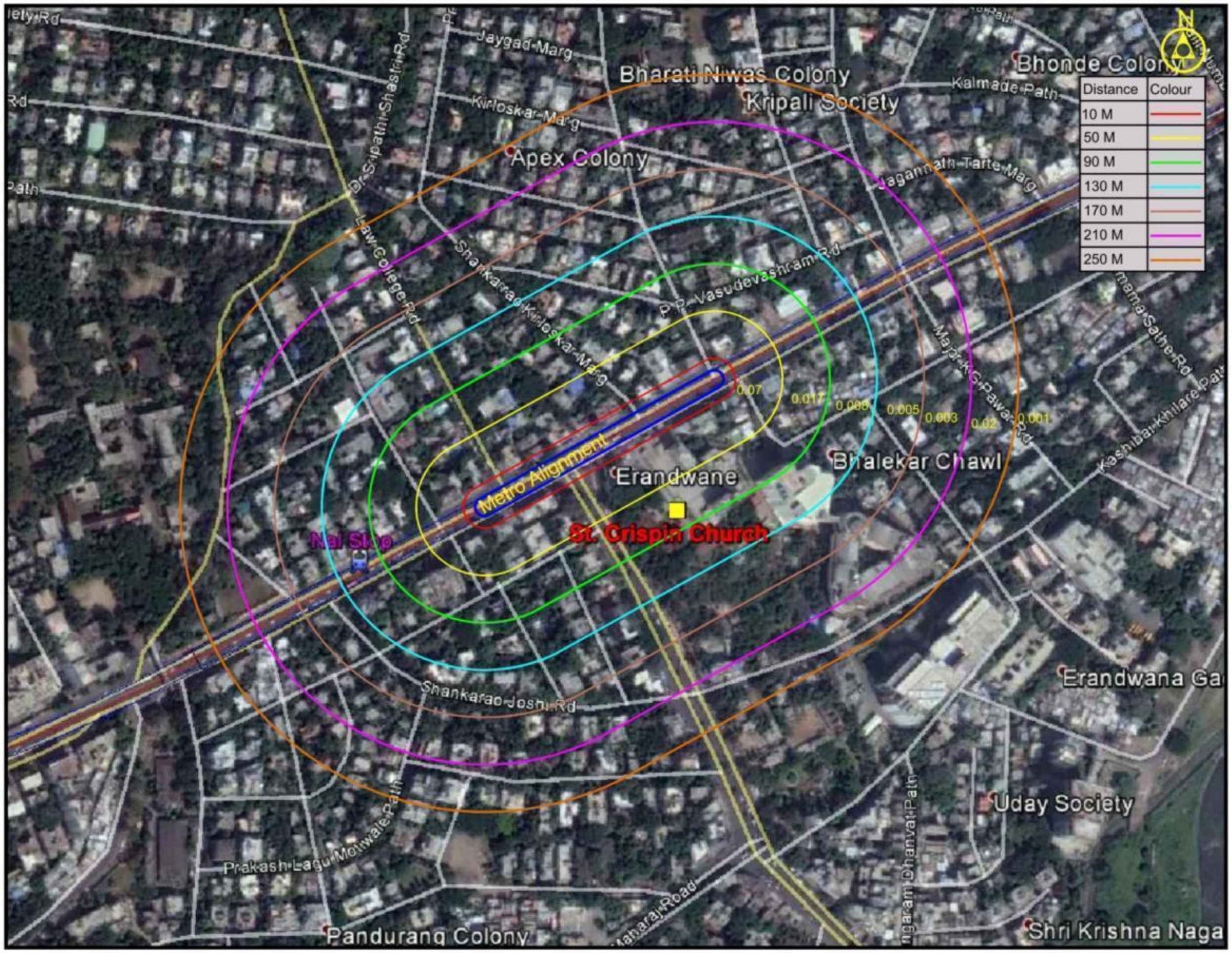
District and sessions court



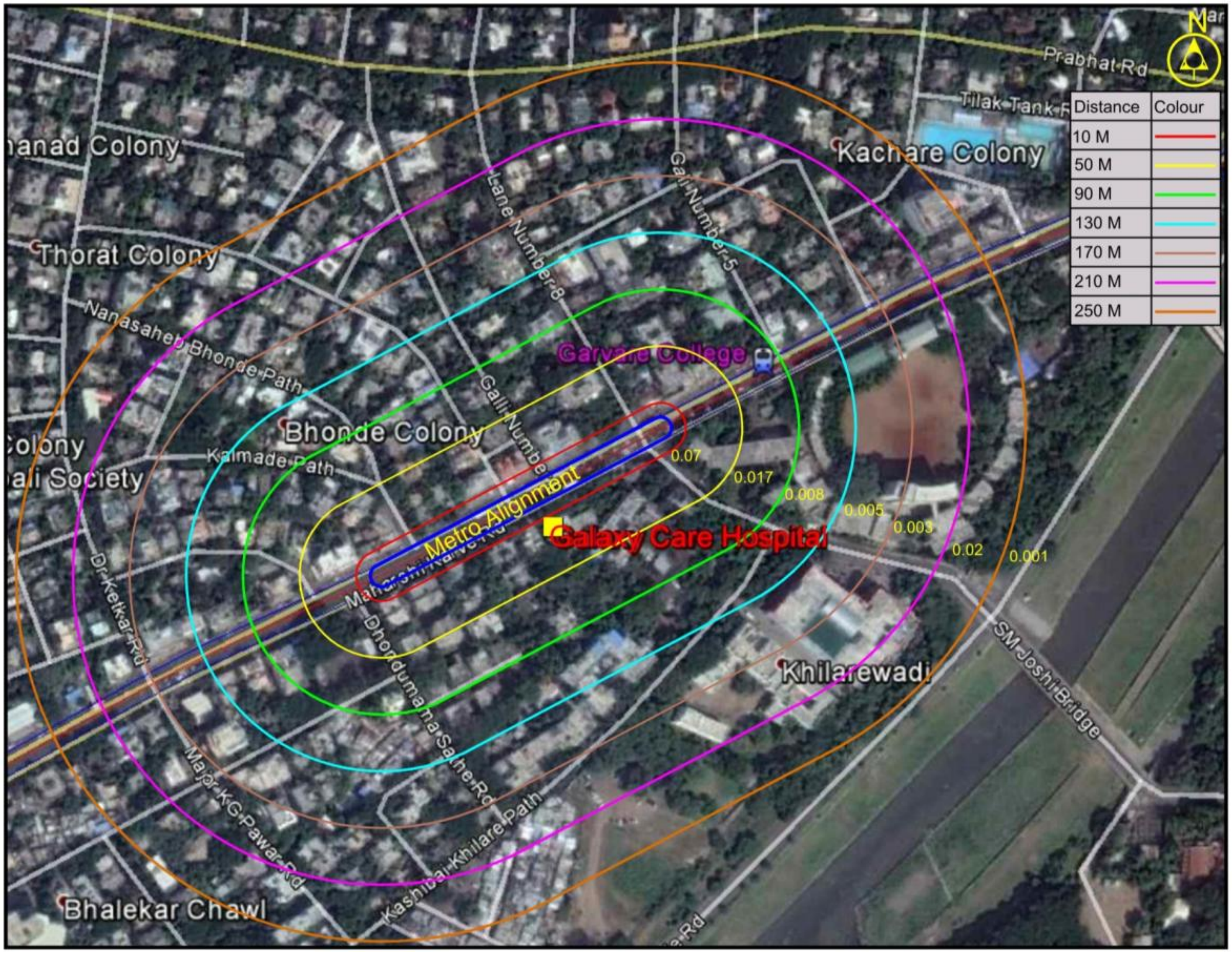
Shaniwar Wada, Kasba Ganapati Mandir, DagdusethGanapathiMandir and City Post



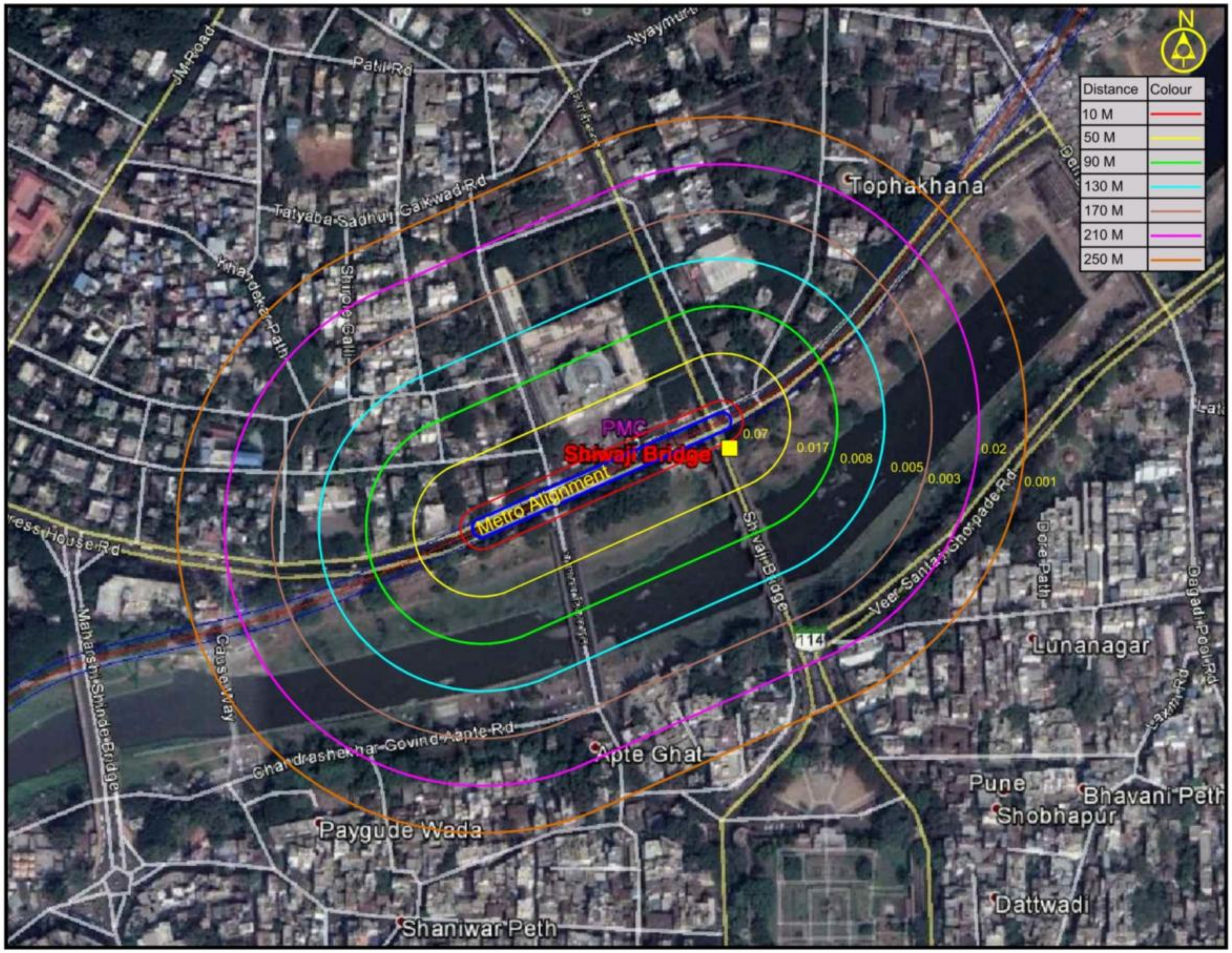
Old wooden structure at Mandai



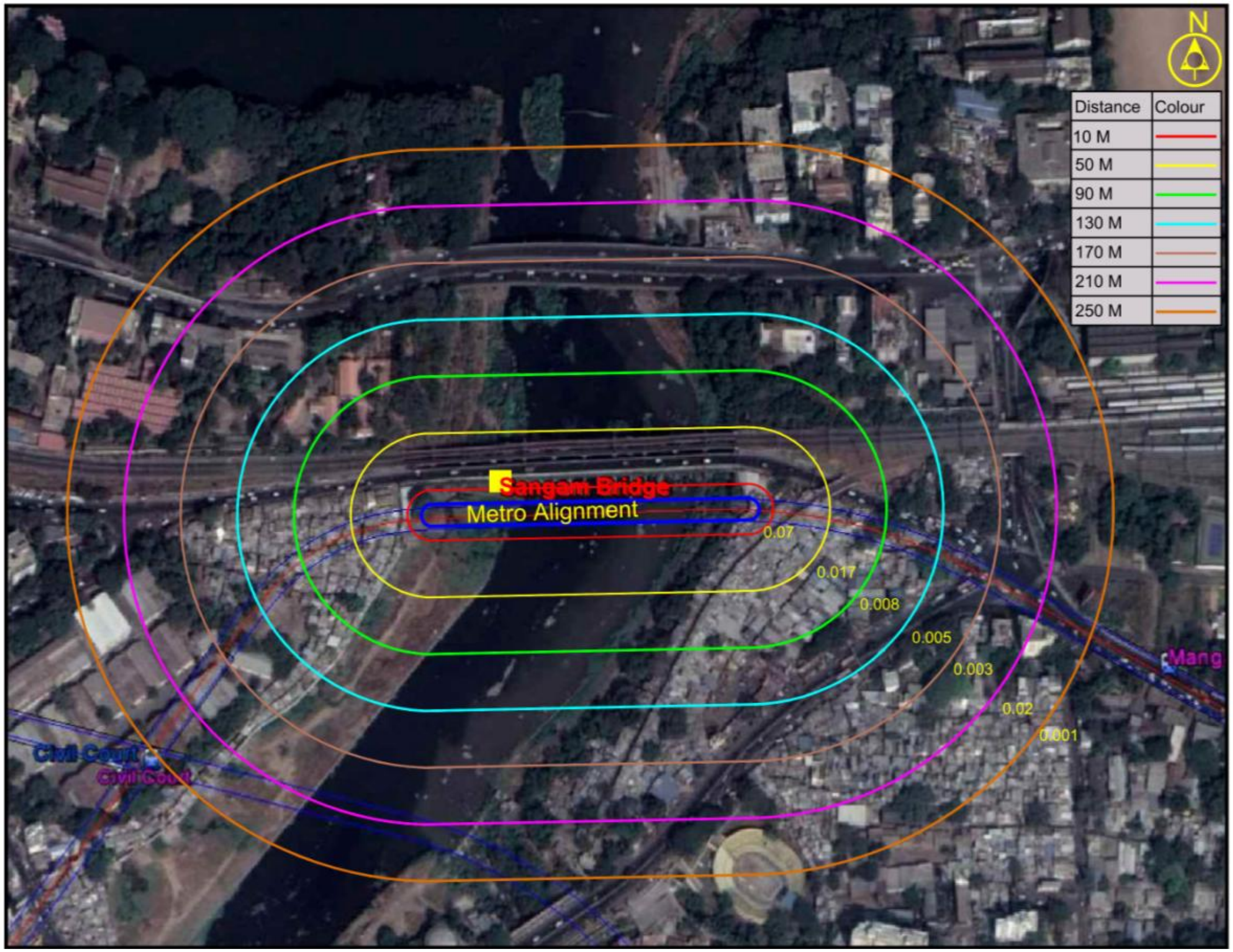
St. Crispin Church



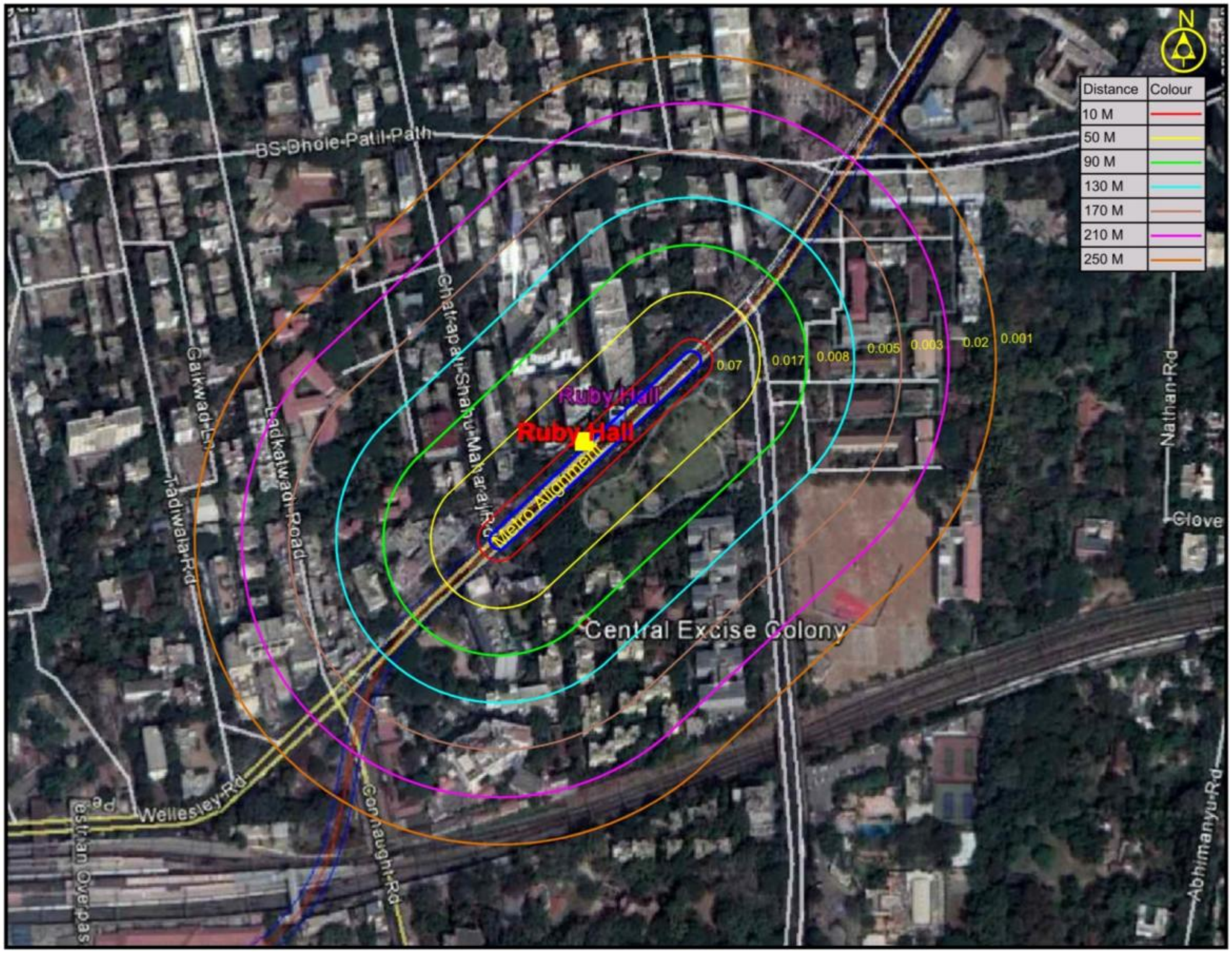
Galaxy Care Hospital



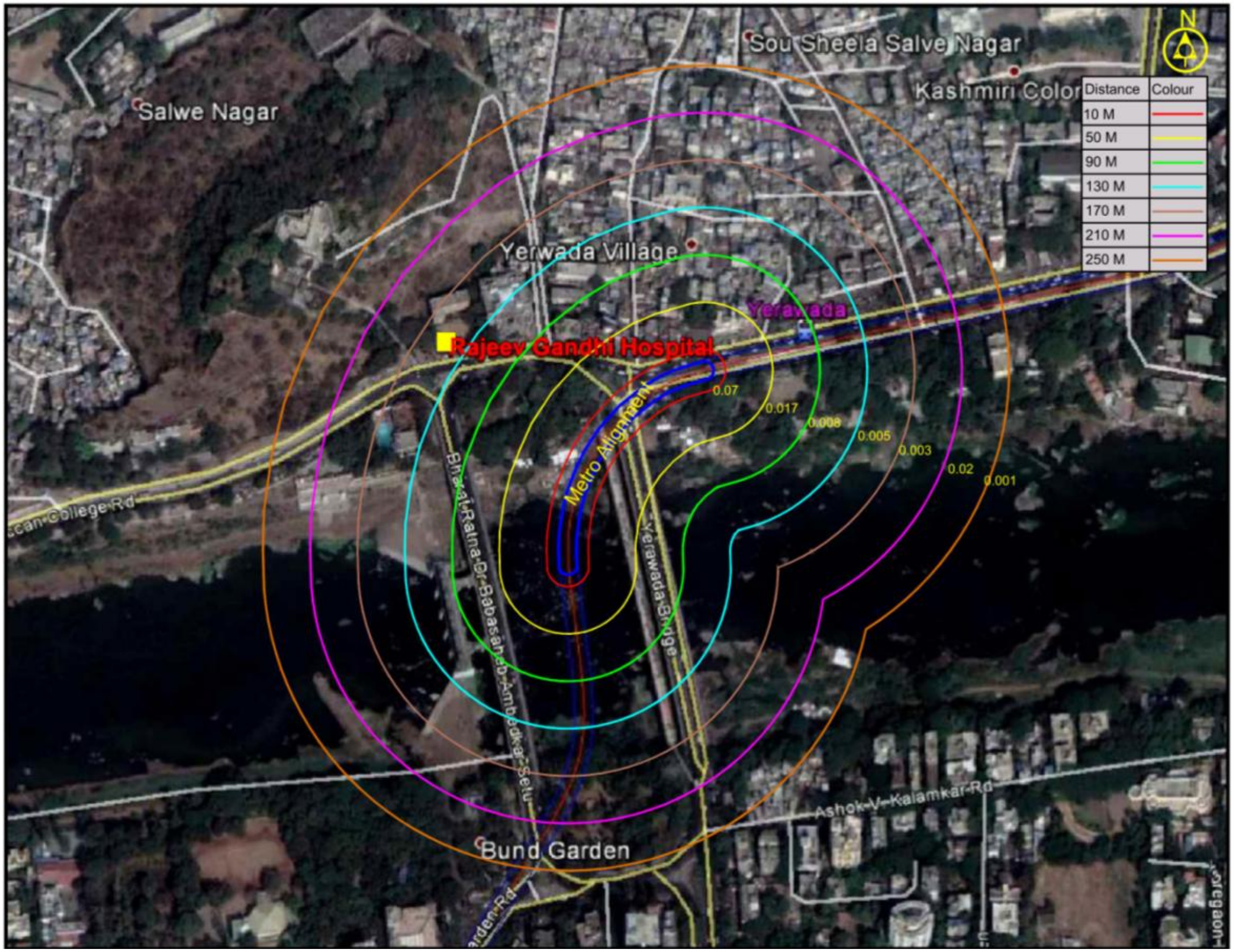
Shivaji Bridge



Sangam Bridge



Ruby Hall (Hospital)



Rajeev Gandhi Hospital

Agha Khan Palace

5.6.3. Energy Consumption at Stations

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

5.6.4. Water Supply, Waste Water and municipal solid waste disposal at Stations

The water demand at stations comprising drinking and toilet demands for passengers and staffwill be of the order of magnitude as indicated in Table 5.17. The demand is estimated on the following assumptions:

- 15% of Alighting passengers at each station will use the toilets
- Water requirement for each user will be 5 lit/passenger/day
- Solid Waste generation will be 100gm/passenger/day

The water demand during operation phase will be supplied by Pune Municipal Corporation. Daily sewage flow is considered as 90% of the water requirement at each station as given in the Table, which will be treated through Bio Digesters.

Table 5.17: Water and Sewage Demand

S. No.	Station Name	Water requirement in KLD	Waste Water in KLD	Solid Waste in Kg
PCMC-Swargate				
1	PCMC	70.0	63.0	933
2	Tukaram Nagar	26.2	23.6	349
3	Bhosari (Nashik Phata)	14.6	13.1	194
4	Kasarwadi	22.7	20.4	302
5	Fugewadi	43.0	38.7	573
6	Dapodi	8.2	7.3	109
7	Bopodi	21.2	19.1	283
8	Khadki	4.0	3.6	54
9	Range Hill	14.6	13.1	194
10	Shivaji Nagar	18.8	16.9	251
11	ASI	1.6	1.4	21
12	PMC	11.0	9.9	146
13	Budhwar Peth	8.1	7.3	108
14	Mandai	16.7	15.0	223
15	Swargate	52.4	47.1	698
	Total	**333**	**300**	**4438**
Vanaz - Ramwadi				
1	Vanaz	23.2	20.8	309
2	Anand Nagar	1.9	1.7	26
3	ideal Colony	0.2	0.1	2
4	Nal Stop	33.4	30.1	446
5	Garware College	6.1	5.5	81
6	Deccan	29.9	26.9	399

S. No.	Station Name	Water requirement in KLD	Waste Water in KLD	Solid Waste in Kg
7	ASI	9.8	8.8	131
8	Civil Court	27.8	25.1	371
9	Mangalwar Peth	15.0	13.5	199
10	Pune Railway Station	22.8	20.5	303
11	Ruby Clinic	5.1	4.6	68
12	Bund Garden	8.9	8.0	119
13	Yerawada	8.9	8.0	119
14	Kalyani Nagar	16.8	15.1	224
15	Ramwadi	8.1	7.3	109
	Total	**218**	**196**	**2905**

5.6.5. Traffic Congestion around Stations

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

5.6.6. Impacts due to Depot

Two depots have been proposed at Range Hill for PCMC – Swargate Alignment and Vanaz for Vanaz – Ramwadi Alignment. The depots will have following facilities:

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

The depot area will be levelled through cut and fill method within the depot.Impacts anticipated at depot sites are:

- Water supply
- Effluent Treatment
- Oil Pollution
- Noise Pollution
- Surface drainage changes
- Solid Waste disposal
- Loss of trees.

i. Water Supply

Water supply will be required for different purposes in the depot. Water quantity required in the depots for train wash at 360 litre per car every 3 days (Delhi Metro). For different uses about 29.6 KLD of water will be required at Range Hill Depot and 24.8 KLD for Vanaz Depot. Other water requirement for horticulture, flushing urinals/closet will be met from recycled water. Drinking water requirement will be met from supply water by Municipal Corporation.

ii. Effluent Treatment

About23.6 KLD of waste water will be required at Range Hill Depot and 19.8 KLD for Vanaz Depot. The waste water will be treated by Bio Digesters and treated water will be recycled to use at depot horticulture and flushing purpose.

iii. 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.

iv. Noise Pollution

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

v. Surface Drainage

In case of filling in low-lying area of depot sites, the surface drainage pattern may change.Suitable drainage measures will be adopted to drain off the area suitably in the nearby water body.

vi. Loss of Trees

At Range Hill depot 403 trees will have to be relocated. At Vanaz depot 32 trees will have to be felled and87 trees will have to be relocated.

Chapter 6 : Positive Environmental Impacts

Various positive impacts have been listed under the following headings:

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

6.1. EMPLOYMENT OPPORTUNITIES

During construction local skilled and unskilled labourers will have an opportunity for employment directly or indirectly. Approximately 600 persons are likely to work at 2 labour campsduring project construction. In operation phase of the project, about 35 persons per kilometre length of the corridor, ieabout 1100 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.

6.2. BENEFITS TO ECONOMY

The project will facilitate movement of people from different parts of Pune City. These corridors will yield benefits in terms of growth in economic activity due to better accessibility;reduction in vehicle operating costs, cost of road construction and maintenance,loss of productivity due to health disorders resulting from pollution and accidents, savings in travel time and improvement in quality of life due to reduction in road travel.

In this studyonly savings in fuel consumption and reduction in air pollution have been quantified.

6.3. DIRECT BENEFITS TO PASSENGERS

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

6.4. TRAFFIC NOISE REDUCTION

A 50% reduction of the traffic volume may result 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[8].

6.5. REDUCTION OF TRAFFIC ON ROAD

The basis of reduction of vehicle is shift of ridership from road vehicle to the metro railway. The reduction in number of vehicles gives benefits to economy by reduction in Vehicle Operating Cost (VOC), Fuel Consumption, Pollution Load, Accidents and Travel Time etc. On implementation of the project, the consumption of petrol, diesel and CNG will get reduced. The estimated daily vehicle-kilometre that will be reduced due to the metro rail is given in Table 6.1.

Table 6.1: Reduction in Daily Vehicle kilometers (lakh)

Vehicle Type	2031
Car	33.0
2W	318.0
Auto (3W)	32.5
Bus	1.8

Note: Estimated based on Pune CMP 2008& Pune Metro DPR, DMRC 2008

6.6. LESS FUEL CONSUMPTION

Reduced fuel consumption and emissions from passenger vehicles during operation of Metro were estimated using the following: a) based on mode-wise yearly number of registered vehicles from year 2005 to 2016 estimate yearly number up to year 2020-21 b) retiral of pre-BS VI vehicles without addition starting 2020 c) presence of BS VI vehicles as in 2030 d) presence of electric vehicles as in 2030 as per RMI-NitiAayog report of May 2017 : 40% of cars and 2 wheelers, all 3 wheelers and buses will be electric d) respective shares in vehicle, no impact of increased public transport or land use changes e) emission factors and fuel efficiency factors from CMP Toolkit 2014 for sustainable transport scenario and draft BS VI emission factors issued in February 2016 converted to gm/km f) Co2 emissions from petrol and diesel consumed and from grid power produced to operate electric vehicles and Metro. CO2 emissions from manufacturing and operation of petrol cars are estimated to be twice as much as BEVs. *(Cleaner cars from cradle to grave, Union of Concerned Scientists, Nov 2015).*However CO2 emissions from manufacturing have not been incorporated in this EIA.

Based on number of daily vehicle kilometre reduction, daily reduction in fuel (diesel and petrol) consumption is reported in Table 6.2.

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

Table 6.2: Reduction in Daily Fuel Consumption (Thousand liters)

Mode/Year	2031	Cost (Rs lakh) 2017 prices
Car (Diesel)	5.4	3.0
Car (Petrol)	62.2	44.0
2 Wheeler (Petrol)	153.6	108.0
3 Wheeler (Diesel)	Nil	Nil

6.7. REDUCED AIR POLLUTION

Human Health cost of total lifecycle PM2.5 emissions caused by production and consumption of gasoline and cost of capturing carbon in GHG caused by production and consumption of gasoline was estimated by Hill et al (*Climate change and health costs of air emissions from bio fuels and gasoline, Jason Hill et al, PNAS, 2008*). Based on these estimates, benefits of the project for this project were estimated as presented in Table 6.3.

Table 6.3: Benefits due to Metro in air pollutants, GHG emissions and Costs

Benefit	Year 2031
Reduction in Carbon Monoxide emission (ton/day)	20.99
Reduction in Particulate Matter (ton/day)	0.09
Reduction in Hydro-Carbons (HC) & Nitrogen Oxide (NOx) emission (ton/day)	3.37
Reduction in Carbon dioxide (CO_2) emission (ton)	889
Net reduction in CO2 after accounting for CO2 added due to grid power generated for Metro operation (ton/day)	806
Reduction in cost of Human Health from lifecycle emissions of PM2.5 caused by gasoline and diesel (Rs lakh/day)	12.89
Reduction in cost of carbon capture* from lifecycle emissions of GHG caused by gasoline and diesel (Rs lakh/day)	14.22

One of the two parameters of relationship of project to climate change is contribution of project to mitigation of climate change by reducing emissions of greenhouse gases.

Chapter 7 : Other Studies

7.1. BACKGROUND

Part of the Vanaz to Ramwadi Corridor (1.45 km length) is passing through the left bank of the Mutha River from Panchaleshwar temple to Vridheshwar Temple. Following concerns have been raised with respect to the metro alignment passing through the river bed.

- Construction in the blue line will cause tremendous environmental and ecological damage in terms of adverse effect on free flow of the river,
- Lead to unprecedented flooding,
- Add to water and air pollution,
- Cause irreversible damage to biodiversity giving rise to disaster in loss of lives and property, large number of trees will be destroyed for carrying out the construction etc.

Pune Maha Metro has invited tender for EIAand Hydraulic Studies of metro rail alignment passing through Mutha River. The work hasbeen awarded to MITCON Consultancy & Engineering Services Ltd., Pune. EIA and EMPstudies were carried out as per guidelines of MoEFCC, CPCB, World Bank and as persuggestions given by Biodiversity Management Committee, Pune Municipal Corporation.

The initial length of the metro alignment along the Mutha river bank was 1.7 Km. Consideringthe sensitivity of construction along the river bed, effort was made to reduce the environmentalimpact by reducing the length to 1.45 Km. This was achieved by reducing the 250 meter stretch from ShivajiBridge to Dengale Bridge. A radius for turning was required and this was achieved by takingadditional space at the food grain godown located opposite the civil court.

1.7 Km stretch - The initial alignment involved entry onto the river bed just before thePanchaleshwar temple and exit at Someshwar temple and again entered the river bed at ShivajiBridge and exited near Dengale Bridge.

1.45 Km stretch - It enters the river bed only once at the Panchaleshwar temple and exits at theVridheshwar /Someshwar temple. Care has been taken to ensure that neither of these heritagestructures is affected and the alignment stays on the landward side as near as feasible. Thischange also reduces number of affected trees from 60 to 32.

The alignment of 1.45 km will reduce the construction along river front by 15%, piers by 10% and, area required for construction by 11%.

7.1.1. Land requirement for the Project

Proposed alignment of 1.45 km is passing through Mutha River. Land required on left bank ofriver for 39+20 (viaduct + stations) will be 1475 sq.m for actual construction on ground. Theland belongs to Irrigation Department, Government of Maharashtra.

There is no acquisition of private land for the alignment. However, land other than Mutha Riverbasin of 2500 Sq.m. private land shall be acquired for Parking, entry/ exit, 2800 Sq.m forMultimodal Hub at Deccan Metro Station. Similarly 1225 sq.m of Pune Municipal Corporationland shall be utilized for parking of Chhatrapati Sambhaji Metro Station.

7.2. BASELINE STUDY

7.2.1. Study Area

The total proposed length of Pune Metro Project is 31.254 km, out of which 1.45 km is thestretch passing through the left bank of the Mutha river. The studies were conducted for theperiod from May 2017 to December 2017.

Water quality, soil quality, Noise & Vibration study were carried out in the month of May2017; Air quality monitoring was conducted in the months of May to June 2017. Ecology and biodiversity studies were conducted during May to December2017 (Pre-Monsoon, Monsoon and Post-Monsoon).Study area is considered as 500 m on either side of the alignment as shown in Figure 7.1 and features are presented in Table 7.1.

7.2.2. Hydrogeology

The hydro geological studies with help of general well inventory shows that the basaltic rockspermeability depends upon the vertical and horizontal joints, fractures, pores, vesicularcondition, and their connection with each other, which permits the storage and movement ofwater. Most of the bore wells tap both semi confined andconfined aquifers. In short, entire succession of the basaltic lava flow acts as a multi aquifersystem including productive and less productive zones. They are permeable and impermeablein nature. Well inventory is a tool of hydro geological study. The following are the observationsfor the open well inventory in the study area.

The basaltic lava flows constitute the shallow and deeper aquifers in the Punecityand present an inconsistent and complex hydrogeological framework. The groundwaterpotential of these aquifers is highly variable and a function of physiography and internalstructure of the lavas. These aquifers are important as these are primary repositories of safe and potable groundwater although some show signs of deterioratinggroundwater quality (Duraiswami, 2008).

Figure 7.1: Image showing 500 m Study Area

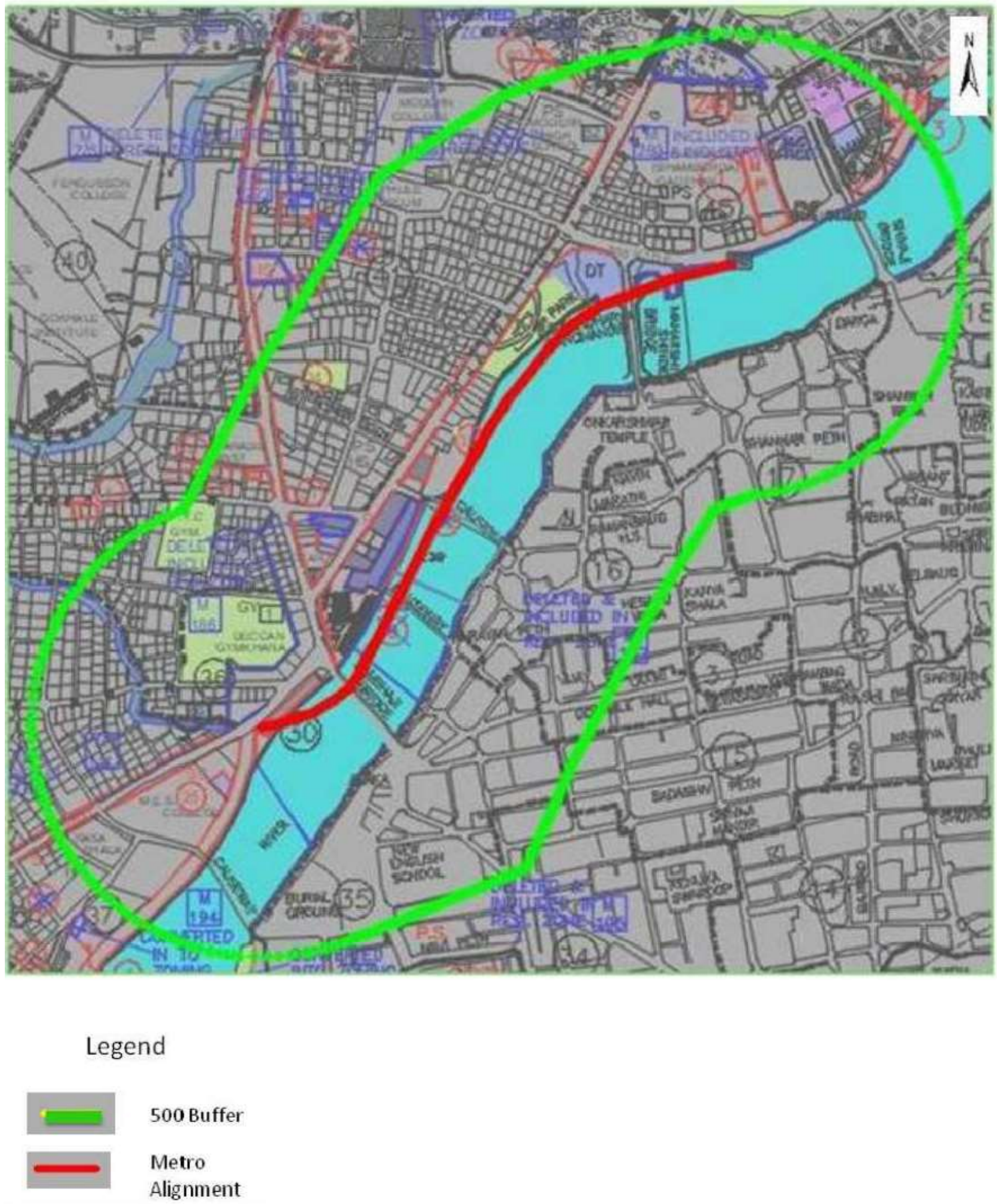


Table 7.1: Environmental & Infrastructure Setting of the Study Area

S. No.	Particulars	Details	Distance fromproject site
1.	ProjectLocation	1.45 km alignment on left bank of Mutha River (Panchaleshwar Temple to Vridheshwar Temple)	0
2.	Water Bodies	Mutha River (Along the stretch)	0

3.	Forest Land	Bhamburda Hill : 250 Acre Panchgaon Parvati : 613.18 Acres Warje : 125 Acres Ghorpadi – 15.12 Acres Wanawadi – 109.7 Acres Vadgaon Sheri – 8 Acres Kondhwa Budruk –361.5 Acres Kondhwa Kh – 60.62 Acres Mohammadwadi – 175 Acres Kharadi – 8.5 Acres Warje – 100 Acres	Nearest forest land 06 km
4.	Roads		
	Highways	1. National Highway No. 4 (Mumbai-Bangalore) 2. National Highway No. 9 (Pune-Solapur-Hyderabad) 3. National Highway No. 50 (Pune-Nashik).	05 04 10
	Nearest City Road	1. Karve Road 2. Jangali Maharaj Road 3. River Side Road (Left Bank) 4. River Side Road (Right Bank	00 0.2 00 0.2
5.	Railway station	Shivajinagar Rly station Pune Rly station	2.4 3.5
6.	Bridges crossing	5. Sambhaji Bridge (Lakdi Pul) 6. Kakasaheb Gadgil Bridge (Z Birdge) 7. Baba Bhide Bridge 8. Maharshi Vitthal Ramji Shinde Bridge	- - - -
7.	Nearest School/College	Vimalabai Garware High School And Junior College	0.2
8.	Nearest Hospital	Prayag Hospital Poona Hospital and Research Center	0.2 0.2
9.	Nearest Heritage site	Panchaleshwar Mandir Sambhaji Bridge (LakdiPul) Vriddheshwar Temple and Ghats	- - -
10.	International Air port	Lohagaon	10
11.	Nearest IMD	Pune	-
12.	Seismic Zone	III	-

The compound lava flows exposed beneath the Pune city constitute the main aquifer system (Kulkarni et al., 2000; Duraiswami et al, 2012). They are phreatic and unconfined meaning thatthey receive their recharge from annual rainfall and their water table are at normal atmospherepressures. Dugwells and bore wells near such features have higher yields.

Well inventory of some dug wells from the area near the 1.45 km metro stretchin the Mutha River channel (Please refer Table 7.2) was undertaken to understand thehydrogeology of the aquifers in the vicinity.

Table 7.2: Well inventory of Dug Wells from the area in close proximity to the Metro Alignment

WellNo	MR-01	MR-02	MR-03	MR-04	MR-05	MR-06	MR-07	MR-08
Area	Deccan	Deccan	Deccan	Deccan	J.M. Road	J.M. Road	J.M. Road	Shaniwar Peth
Location	AyurvedRasashala, 24, Near Garware College	Garware College, Karve Road	Mr. Santanu Pawar, 1257, Behind Bank of Maharashtra	Sensex Chamber, Near Bank of Maharashtra	Ch. Sambhaji Udyan	Balgandharv Natya Mandir	Pataleshwar Mandir	Shaniwar wada complex
Type of well	Dug well	Dug well	Dug well	Dug well	Dug well	Dug well	Dug well	Dug well
Dimension top (m)	5.6	4.0	6.1	5.5	6.2	3 x 3	5.3	5.4
Dimension bottom (m)	5.0	3.8	6.0	5.5	6	3 x 3	5.3	5.4
Depth (m)	9.60	8.70	7.00	13.00	5.9	6.80	20.0	10.2
Depth of lining (m)	9	8.5	na	na	3.1	2	na	6.1
Lining type	Concrete	Concrete	Stone	Stone	Concrete	Concrete	Stone	Stone
Lining condition	Good	Good	Good	Good	Good	Good	Good	Good
Static Water Level (m)	5.2	7.7	6.7	6.4	2.0	1.0	9.3	4.5
Water use	Domestic	Domestic	Not in use	Domestic	Gardening	Domestic + Gardening	Gardening	Domestic + Gardening
State of use	Perennial	Perennial	Not in use	Perennial	Perennial	Perennial	Seasonal	Perennial
Quality of water	Good	Good	Good	Good	Not potable	Fresh	Not potable	Not potable
Aquifer	Vesicular Basalt	Alluvium	Vesicular Basalt	Vesicular Basalt	Basalt + Alluvium	Vesicular Basalt	Vesicular Basalt	Vesicular Basalt

Two types of phreatic aquifers are encountered inthe area viz. shallow alluvial aquifer and vesicular basalt (compound pahoehoe) aquifer. The dugwells tapping these aquifers are large diameter wells with variable depths ranging from 5.9 to 20meters below ground level (m bgl). The static water level ranges from ~ 2 m bgl in winter to ~ 9m bgl in the summer. The depth to groundwater level (DTW) ranges from 0.50 to more than 8 mbelow ground level (bgl). Most of these wells are perennial but some like the dug well at SambajiPark are augmented with bore well water. The groundwater is usedmostly for domestic purposes, but waters from a few wells are used for gardening. Most wellsyield potable, good quality water, but many wells like those from Sambhaji Park and Pataleshwarare not potable. Several bore wells have been sunk in the area.The shallow basaltic aquifers aretapped by bore wells with depths between 60 to 90 m are common. Based on a previous study(Duraiswami et al, 2009) the density of abstraction structures (number of dug wells plus borewells per sq. km) in the Shivajinagar area is about 60.

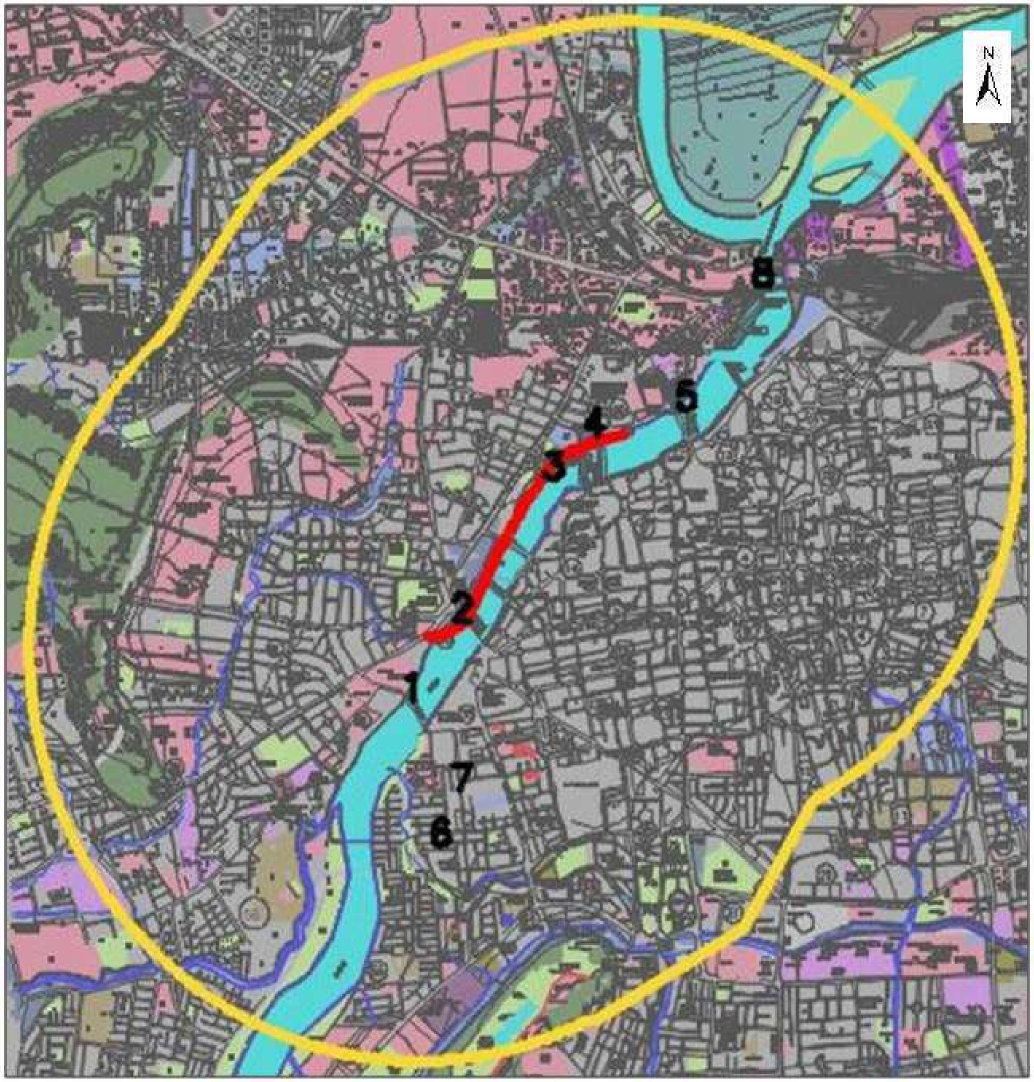
7.2.3. Soil Quality

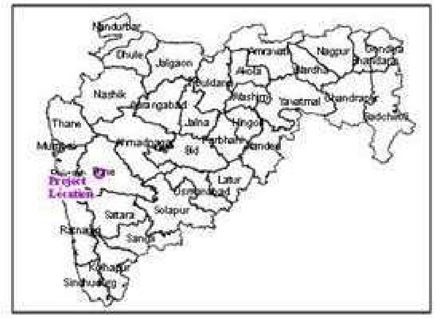
Selection of the sampling stations was based on the reconnaissance visit of the entire study area. Accordingly 8 samples were collected near the proposed corridor part passing through the Mutha River. Soil sampling locations are given in Table 7.3 and shown in Figure 7.2. Physico-chemical Characteristics of Soils along Mutha River are given in Table 7.4 and interpretation of test results are given below.

Table 7.3: Soil Sampling Locations along Mutha River

S.No.	Name of the Location	Latitude	Longitude
1	Garware BridgeU/S	18° 30.767'N	73° 50.487'E
2	Panchaleshwar TempleGhat	18° 30.822'N	73° 50.556'E
3	OppositeChhatrapati Sambhaji Udyan	18° 31.148'N	73° 50.798'E
4	Near Savarkar Bhavan	18° 31.289'N	73° 51.004'E
5	Shivaji Bridge	18° 31.393'N	73° 51.306'E
6	Rajendranagar	18° 30.250'N	73° 50.417'E
7	David Sasoon Anath Pangu GrihaNiwara	18° 30.319'N	73° 50.450'E
8	SangamBridge	18°31'45.64"N	73°51'35.32"E

Figure 7.2: Soil Sampling Location Map





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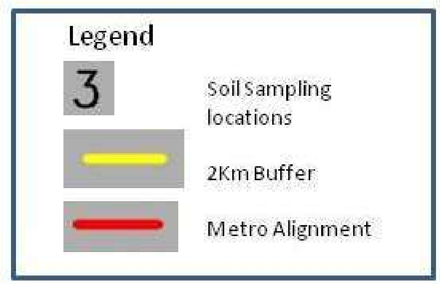


Table 7.4: Physico-chemical Characteristics of Soils along Mutha River

S. No.	Parameter	Units	Garware Bridge U/S	Panchaleshwar Temple Ghat	Opposite Chhatrapati Sambhaji	Near SavarkarBhavan	Shivaji Bridge	Rajendra nagar	David sasoon Anath Pangu Griha Niwara	Sangam Bridge
1.	Texture	-	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam
2.	Percentage Of Different Components									
	Sand	%	27	22	22	25	23	27	21	24
	Silt	%	32	34	30	32	31	32	34	35
	Clay	%	41	44	48	43	46	41	45	41
3.	Soil Moisture	%	8.20	8.2	10.3	10.9	10.3	8.20	9.09	9.38
4.	Bulk Density	gm/cm^2	1.14	1.13	1.16	1.18	1.16	1.14	1.12	1.14
5.	Water Holding Capacity	%	60	62	60	66	60	60	56	58
6.	pH	--	7.20	7.84	7.24	7.18	7.14	7.20	7.24	7.35
7.	Conductivity	µs/cm	812	560	1178	1464	1178	812	579.4	986.8
8.	Organic Carbon	%	1.14	0.82	1.14	0.65	1.14	1.14	0.70	0.98
9.	Calcium (as Ca)	mg/kg	560.4	544.9	528.4	608.5	592.6	512.4	496	624.9
10.	Magnesium (as Mg)	mg/kg	154.9	145.6	126.3	106.8	124.1	145.8	116.4	135.7
11.	Available Nitrogen	kg/ha	162.7	225.5	225.6	350.9	212.9	162.7	213.1	175.3
12.	Phosphorous (as P)	kg/ha	8.52	7.12	8.18	8.17	8.18	8.52	8.32	7.52
13.	Potassium (as K)	kg/ha	239.6	230	236.6	245.6	553.4	215.7	878.2	254.6
14.	Iron (as Fe)	mg/kg	3.14	2.24	6.02	2.48	6.02	3.14	11.9	5.83
15.	Zinc (as Zn)	mg/kg	0.40	0.55	0.29	0.33	0.21	0.40	0.89	0.30
16.	Copper (as Cu)	mg/kg	0.32	0.25	0.23	0.27	0.33	0.32	0.13	0.22
17.	Sodium	mg/kg	38	45	40.4	46.2	45	32	38.13	45
18.	Manganese (as Mn)	mg/kg	2.52	2.12	<0.05	1.2	3.23	2.52	4.20	3.02
19.	Total Chromium (as Cr)	mg/kg	<0.05	<0.05	<0.05	0.08	<0.05	<0.05	<0.05	<0.05
20.	Nickel (as Ni)	mg/kg	<0.02	<0.02	<0.02	0.06	0.04	<0.02	0.08	0.06
21.	Cadmium (as Cd)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
22.	Lead (as Pb)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.11	0.12
23.	Sodium Adsorption Ratio	-	2.01	2.43	2.24	7.49	2.38	1.76	2.18	2.48

- The pH values ranged from 7.14 to 7.84. Electrical Conductivity was maximum at NearSavarkar Bhavan (1464 µs/cm) and minimum at Panchaleshwar Temple Ghat (560 µs/cm).
- Organic carbon ranged from 0.70 to 1.14%. Maximum Calcium 624.9 mg/kg was found atSangam Bridge. Minimum Calcium 496 mg/kg was found at David Sasoon Anath Pangu GrihaNiwara. Similarly, maximum Magnesium 154.92 mg/kg was found at Garware Bridge U/Sand minimum magnesium 116.4 mg/kg was found David Sasoon Anath Pangu Griha Niwara.
- Nitrogen (350.9 kg/ha) was higher Near Savarkar Bhavan and lower (162.71kg/ha) at Rajendranagar and Garware Bridge U/S. Phosphorous ranges from 7.12 kg/ha to 8.52

kg/ha. Maximumconcentration of Potassium (878.2 kg/ha) was found at David Sasoon Anath Pangu GrihaNiwara and minimum amount (215.7 kg/ha) was found at Rajendra nagar.

- Maximum concentration of Iron (11.9 kg/ha) was found at David Sasoon Anath Pangu GrihaNiwara and minimum amount (2.24 kg/ha) was found at Panchaleshwar Temple Ghat.

It is concluded that soils in the study area are moderately fertile. Soils in the river basin foundto be fertile with predominantly clay-loam texture. These soils are favorable to nurtureherbaceous flora in the project area. It is proposed to use excavated top soil for plantation andlandscaping purpose. Fertility of the soils is due to higher organic content.

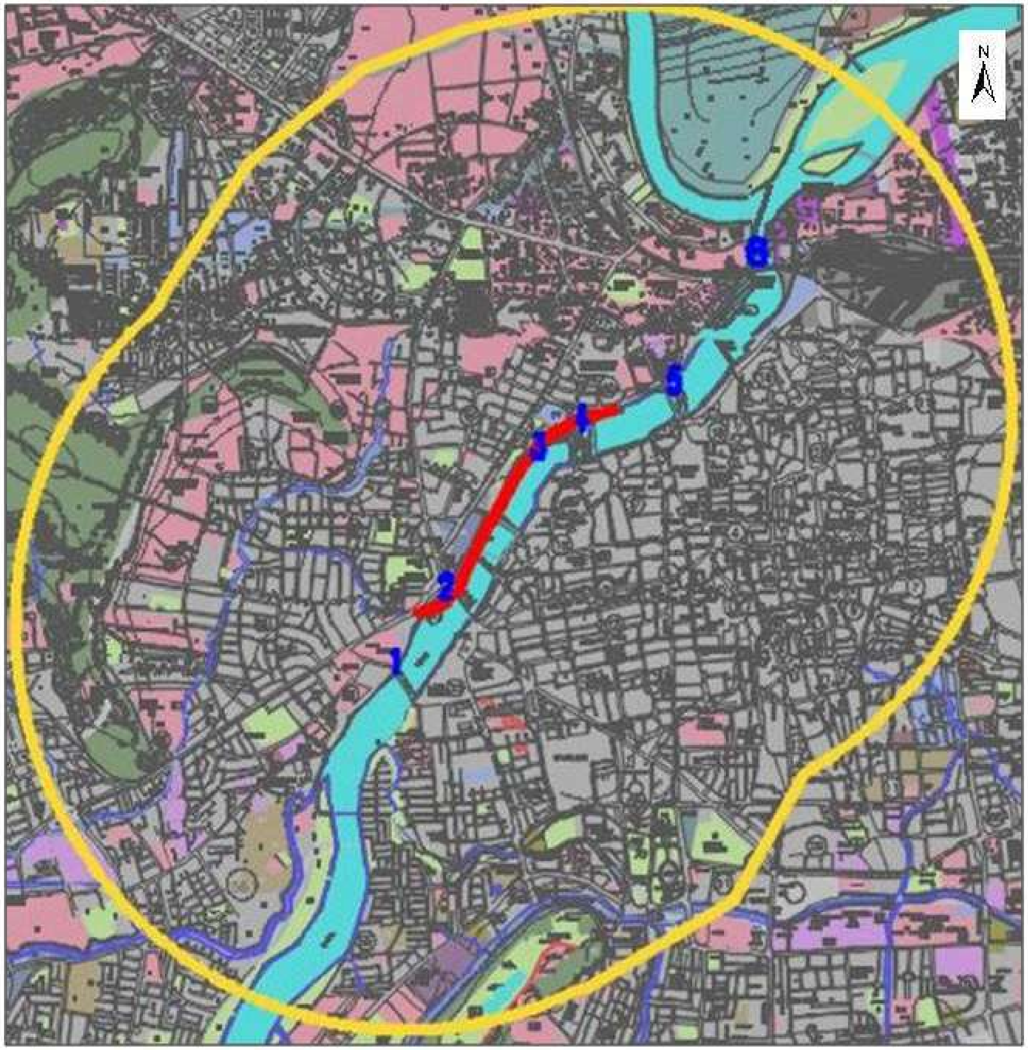
7.2.4. Water Quality Study

River water sampling locations were selected based on sewage release point, Ghat and otheranthropogenic activities at the upstream, along the stretch and downstream side of thealignment. Representative ground water samples werecollected within the study area andthe samples were collected from dug well as well as bore well. The sampling locations are given in Table 7.5 and Surface Water Sampling Location Map is showing Figure 7.3 &Ground Water Sampling Location Map is showing Figure 7.4.

Table 7.5: Water Sampling Locations

S. No.	Name of the Location	Type	Latitude	Longitude
Surface Water				
1.	Garware Bridge U/S	Mutha River	18° 30.748'N	73° 50.493'E
2.	Panchaleshwar Temple Ghat	Mutha River	18° 30.810'N	73° 50.556'E
3.	Opposite ChhatrapatiSambhajiUdyan	Mutha River	18° 31.130'N	73° 50.805'E
4.	Near Savarkar Bhavan	Mutha River	18° 31.276'N	73° 51.026'E
5.	Shivaji Bridge	Mutha River	18° 31.365'N	73° 51.303'E
6.	Sangam Bridge	Confluence ofMula Mutha River	18°31'51.72"N	73°51'35.92"E
Ground Water				
7.	Chhatrapati Sambhaji Udyan	Open Well	18° 31.154'N	73° 50.789'E
8.	Subhadra Bhavan, Apte Road	Bore Well	18° 31.212'N	73° 50.627'E
9.	Shri Mahila Griha Udyog Lijjat Papad	Bore Well	18° 30.850'N	73° 50.240'E
10.	David Sasoon Anath PanguGriha Niwara	Open Well	18° 30.319'N	73° 50.450'E
11.	Tilakwada	Open Well	18° 30.950'N	73° 50.926'E
12.	Parchure Wada	Open Well	18° 31.045'N	73° 51.189'E
13.	DIC, Pune	Bore Well	18° 31.986'N	73° 50.719'E

Figure 7.3: Surface Water Sampling Location Map



Surface Water Sampling Locations				
Sr.No.	Name of the Location	Type	Latitude	Longitude
1	Garware Bridge U/S	Mutha River	18° 30.748'N	73° 50.493'E
2	Panchaleshwar Temple Ghat	Mutha River	18° 30.810'N	73° 50.556'E
3	Opposite Sambhaji Udyan	Mutha River	18° 31.130'N	73° 50.805'E
4	Near Savarkar Bhavan	Mutha River	18° 31.276'N	73° 51.026'E
5	Shivaji Bridge	Mutha River	18° 31.365'N	73° 51.303'E
6	Sangam Bridge	Mula Mutha River	18°31'51.72"N	73°51'35.92"E

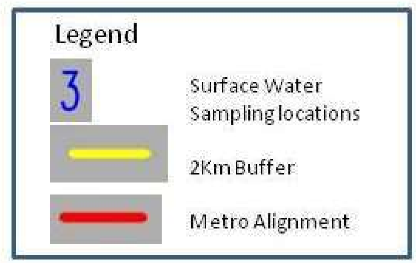
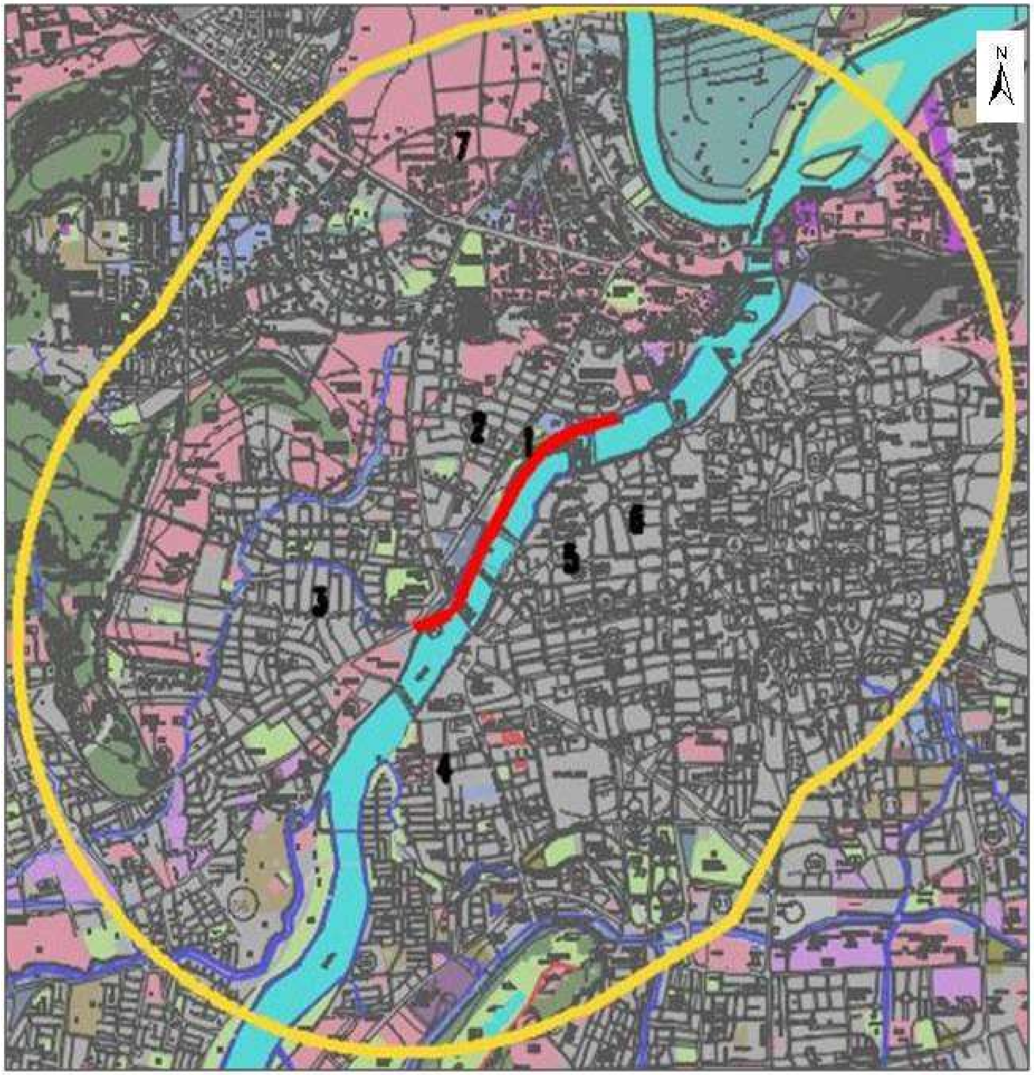
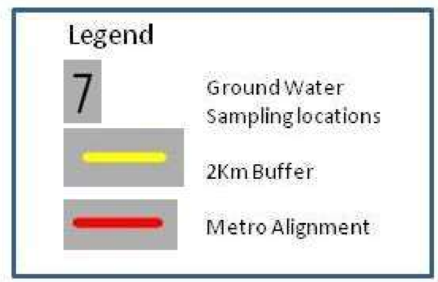


Figure 7.4: Ground Water Sampling Location Map



Ground Water Sampling Locations				
Sr.No.	Name of the Location	Type	Latitude	Longitude
1	Sambhaji Udyan	Open Well	18° 31.154'N	73° 50.789'E
2	Subhadra Bhavan, Apte Road	Bore Well	18° 31.212'N	73° 50.627'E
3	Shri Mahila Griha Udyog Lijjat Papad	Bore Well	18° 30.650'N	73° 50.240'E
4	David Sasoon Anath Pangu Griha Niwas	Open Well	18° 30.319'N	73° 50.450'E
5	Tilakwada	Open Well	18° 30.950'N	73° 50.926'E
6	Parchure Wada	Open Well	18° 31.045'N	73° 51.189'E
7	DIC, Pune	Bore Well	18° 31.986'N	73° 50.719'E



A. Surface Water Quality

Surface water samples from 6 representative areas were taken from Mutha River near the proposed alignments and results were given in Table 7.6. The interpretation of the test results were given below.

Table 7.6: Physico-chemical Characteristics Surface Water Monitoring

S. No.	Parameter	Units	Garware Bridge U/S- Mutha River	Pancholeshwar Temple Ghat- Mutha River	Opposite Chhatrapati Sambhaji Udyan- Mutha River	Near Savarkar Bhavan- Mutha River	Shivaji Bridge- Mutha River	Sangam Bridge-Mula Mutha River	Tolerance limits for Inland Surface Waters, Class C (Clause 3.3)
1.	Colour	Hazen	<5	<5	<5	<5	<5	<5	N.S.
2.	Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-
3.	pH at 25 oC	-	6.92	6.9	6.85	6.85	6.9	6.82	6.5-8.5
4.	Temperature	0C	24	24	23	24	24	24	N.S
5.	Electrical Conductivity at 25 oC	µS/cm	486	520	552	585	524	561	N.S
6.	Turbidity	NTU	<1	12	10	7.0	8.2	8.4	N.S
7.	Total Dissolved Solids	mg/l	292	310	328	350	308	340	1500
8.	Total Solids	mg/l	295	324	336	360	317	352	N.S
9.	Total Suspended Solids	mg/l	<5	14	8	10	9	12	N.S
10.	Biochemical Oxygen Demand at 270C for 3 days	mg/l	55	58	61	78	56	86	3.0
11.	Chemical Oxygen Demand	mg/l	183	196	212	254	175	308	N.S
12.	Dissolved Oxygen	mg/l	2.4	2.6	2.7	2.0	2.5	2.1	4.0
13.	Acidity as CaCO3	mg/l	<5	<5	<5	<5	<5	<5	N.S
14.	Total Alkalinity as CaCO3	mg/l	110	156	124.8	76.96	60.32	124	N.S
15.	Carbonate as CaCO3	mg/l	<5	<5	<5	<5	<5	<5	N.S
16.	Bicarbonate as HCO3	mg/l	110	156	124.8	76.96	60.32	124	N.S
17.	Total Hardness as CaCO3	mg/l	112.08	108	112.08	80.06	86.06	118.09	N.S
18.	Calcium as Ca	mg/l	27	40	36	20	31.26	14.42	N.S
19.	Magnesium as Mg	mg/l	11	12	18	15	8	19.93	N.S
20.	Chloride as Cl-	mg/l	134.24	102.28	114	126.42	132	140	600
21.	Sulphates as SO4	mg/l	8.0	28.25	30.0	24.03	24	15.65	400
22.	Nitrate as NO3	mg/l	5.50	5.6	7.5	6.5	8.15	7.45	50

S. No.	Parameter	Units	Garware Bridge U/S- Mutha River	Panchaleshwar Temple Ghat- Mutha River	Opposite Chhatrapati Sambhaji Udyan- Mutha River	Near Savarkar Bhavan- Mutha River	Shivaji Bridge- Mutha River	Sangam Bridge-Mula Mutha River	Tolerance limits for Inland Surface Waters, Class C (Clause 3.3)
23.	Nitrite as NO2	mg/l	0.29	0.29	0.23	0.20	0.06	0.09	N.S
24.	Ammonical Nitrogen as NH4-N	mg/l	1.32	1.14	1.15	0.63	2.03	2.36	N.S
25.	Total Kjeldahl Nitrogen as NH3-N	mg/l	4.48	2.56	3.36	1.12	3.36	3.56	N.S
26.	Fluoride as F	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.5
27.	Total Phosphorous	mg/l	<2	<2	<2	3.46	2.80	3.77	N.S
28.	Silica as SiO3	mg/l	12.33	11.72	11.56	13.29	13.22	13.16	N.S

- The observed pH values in water samples were in the range of neutral range (6.5-7.3).
- Electrical Conductivity was highest at Savarkar Bhavan - Mutha River (585 µS/cm) and minimum at Garware Bridge- Mutha River (486 µS/cm).
- Turbidity was observed in the range from <1 to 12 NTU.
- Maximum Total Dissolved Solids was observed (350 mg/l) at Savarkar Bhavan - Mutha River and minimum (292 mg/l) at Garware Bridge- Mutha River.
- Maximum Total Solids was observed (360 mg/l) at Savarkar Bhavan - Mutha River and minimum (295 mg/l) at Garware Bridge- Mutha River. Similarly, observed Total Suspended Solids ranged from <5 to 14 mg/l.
- The Biochemical oxygen demand (BOD) had highest value (86 mg/l) at Sangam Bridge-Mula Mutha River and minimum (55 mg/l) at Garware Bridge U/S- Mutha River.
- The COD ranged from 308 mg/l to 175 mg/l. The highest count of COD was observed at Sangam Bridge - confluence of Mula and Mutha Rivers while minimum was recorded at Shivaji Bridge-Mutha River.
- The DO values indicate the degree of pollution in water bodies. DO values varied from 2.0 to 2.7. The sampling location of Sangam Bridge-Mula Mutha River showed low DO value indicating heavy contamination by organic matter.
- Total alkalinity ranged from 60.32 mg/l to 156 mg/l. Maximum calcium 40.0 mg/l was found at Panchaleshwar Temple Ghat- Mutha River. Minimum calcium 14.12 mg/l was found at Sangam Bridge-Mula Mutha River. Similarly, maximum magnesium 19.93 mg/l was found at Sangam Bridge-Mula Mutha River and minimum magnesium 8.0 mg/l was found at Shivaji Bridge- Mutha River. Concentration of Calcium was always greater than that of magnesium.
- The hardness (118.09 mg/l) was higher at Sangam Bridge-Mula Mutha River and lower (80.06 mg/l) Near Savarkar Bhavan- Mutha River.

- Maximum concentration of Sodium 22.0 mg/l was found at Sangam Bridge-Mula Mutha River and minimum 7.0 mg/l at Shivaji Bridge- Mutha River. Similarly, maximum concentration of potassium 8.0 mg/lit was found at Sangam Bridge-Mula Mutha River and minimum 1.2 mg/l at Savarkar Bhavan- Mutha River. Sodium was found to have greater values than potassium throughout the study reach of Mutha River.
- Maximum amount of Nitrate (8.15mg/l) was found at Shivaji Bridge- Mutha River and minimum amount (5.50mg/l) was found at Garware Bridge U/S- Mutha River. Nitrate concentration depends upon the activity of nitrifying bacteria.
- Ammonical Nitrogen (2.36 mg/l) was higher at Sangam Bridge-Mula Mutha River and lower (0.63 mg/l) Near Savarkar Bhavan- Mutha River.
- Total Kjeldahl Nitrogen (4.48 mg/l) was higher at Garware Bridge U/S- Mutha River and lower (1.12 mg/l) Near Savarkar Bhavan- Mutha River.
- The total phosphorous was highest at Sangam Bridge-Mula Mutha River (3.77mg/l). Total sulphate was maximum Opposite Chhatrapati Sambhaji Udyan- Mutha River (30.0mg/l) and minimum at Garware Bridge U/S- Mutha River (8.00 mg/l).
- The chloride was observed maximum (140 mg/l) at Sangam Bridge- Confluence of Mula Mutha River and minimum (102.28 mg/l) at Panchaleshwar Temple - Mutha River.

It was observed that the water quality of Mutha River is polluted. Major sources of pollution ofriver Mutha are presence of dissolved salts and carbonates of the surrounding soil & disposal ofsewerage waste which is mainly organic matter, and other solid waste in to the water body.Samples collected from River shows the higher organic load with high BOD and CODconcentration.

B. Physico-chemical Characteristics of Mutha River in last five years

Physico-chemical study of Mutha River at six different locations i.e. Vitthalwadi, Mhatre Bridge,Erandwane, Joshi Bridge, Omkareshwar and Railway Bridge were carried out by the PuneMunicipal Corporation (PMC) in the last five years (2011-2016). Information towards the datafrom secondary sources was collected from Environment Status Report (2016-2017) published byPune Municipal Corporation. The study included measurement of BOD, COD, DO and many other parameters; however BOD, COD and DO results are reproduced in the following Table 7.7.

Table 7.7: Water Quality of Mutha River

S. No.	Locations on Mutha River	2011	2012	2013	2014	2015	2016
BOD (mg/l)							
1.	Vitthalwadi	22.90	18.33	22.00	27.00	28.00	38.00
2.	Mhatre Bridge	25.60	19.24	27.00	25.00	32.00	49.00
3.	Erandwane	32.60	20.33	39.00	26.00	36.00	44.00
4.	Joshi Bridge	38.00	21.85	17.00	21.00	39.00	39.00
5.	Omkareshwar	41.50	22.40	27.00	24.00	44.00	42.00
6.	Railway Bridge	38.70	18.28	42.00	48.00	43.00	49.00
COD (mg/l)							

S. No.	Locations on Mutha River	2011	2012	2013	2014	2015	2016
1.	Vitthalwadi	57.80	64.45	76.50	92.00	102.20	133.00
2.	Mhatre Bridge	61.00	64.55	105.00	84.00	91.00	171.00
3.	Erandwane	90.10	68.87	122.00	81.00	102.00	148.00
4.	Joshi Bridge	101.60	74.07	54.00	66.00	83.00	139.00
5.	Omkareshwar	99.50	77.43	77.90	76.00	87.00	134.00
6.	Railway Bridge	98.40	61.82	138.00	158.00	156.00	172.00
DO (mg/l)							
1.	Vitthalwadi	2.40	2.56	2.71	2.80	2.70	2.70
2.	Mhatre Bridge	2.30	1.69	2.50	2.90	2.20	2.30
3.	Erandwane	0.80	1.20	2.10	2.20	1.60	2.60
4.	Joshi Bridge	0.60	0.93	1.90	2.10	1.50	2.70
5.	Omkareshwar	0.60	0.97	2.00	2.30	1.60	2.80
6.	Railway Bridge	0.80	1.27	2.50	2.40	1.50	2.60

C. Ground Water Quality

Ground water samples from 7 representative areas were taken along the alignment near Mutha River and results were given in Table 7.8. Among them three locations were for Bore wells andfour locations for Open wells. The interpretation of the test results were given below.

Table 7.8: Physico-chemical Characteristics Ground Water

S. No	Parameter	Units	Chhatrapati Sambhaji Udyan – Open Well	Subhadra Bhavan , Apte Road- Bore Well	Shri Mahila Griha Udyog Lijjat papad – Bore well	David Sasoon Anath Pangu Griha Niwara- Open Well	Tilakwada – Open well	Parchure wada – Open well	DIC, Pune – Bore well	Acceptable limit – IS 10500:2012
1.	Colour	Hazen	<5	<5	<5	<5	<5	<5	<5	5
2.	Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
3.	pH	-	7.4	7.55	7.49	7.74	7.80	7.6	6.9	6.5 to 8.5
4.	Temperature	0C	24	24	23	24	24	23	24	NS
5.	Electrical Conductivity	µS/cm	532	445	434	794	645	592	365	NS
6.	Turbidity	NTU	<1	<1	<1	2.3	<1	<1	<1	1
7.	Total Dissolved Solids	mg/l	320	292	285	480	416	360	235	500
8.	Total Solids	mg/l	323	288	288	486	420	364	238	NS
9.	Total Suspended Solids	mg/l	<5	<5	<5	6	<5	<5	<5	NS
10.	Acidity as CaCO3	mg/l	<5	<5	<5	<5	<5	<5	<5	

S. No	Parameter	Units	Chhatrapati Sambhaji Udyan – Open Well	Subhadra Bhavan , Apte Road- Bore Well	Shri Mahila Griha Udyog Lijjat papad – Bore well	David Sasoon Anath Pangu Griha Niwara- Open Well	Tilakwada – Open well	Parchure wada – Open well	DIC, Pune – Bore well	Acceptable limit – IS 10500:2012
11.	Total Alkalinity as CaCO3	mg/l	124.8	160	114.4	260	140	145	99.84	
12.	Carbonate as CaCO3	mg/l	<5	<5	<5	<5	<5	<5	<5	
13.	Bicarbonate as HCO3	mg/l	124.8	160	114.4	260	140	145	99.84	
14.	Chemical Oxygen Demand	mg/l	<5	<5	<5	<5	<5	<5	<5	
15.	Total Hardness as CaCO3	mg/l	184.14	164.13	164.13	320.25	220.17	208.16	138.11	200
16.	Calcium as Ca	mg/l	36.87	41.68	46.49	40.08	41.68	57.71	22.44	75
17.	Magnesium as Mg	mg/l	22.36	14.58	11.66	53.48	28.19	15.55	19.33	30
18.	Chloride as Cl-	mg/l	38	24.48	34	44.02	45	38	31	250
19.	Sulphates as SO4	mg/l	40	20.36	30	36	38	34	25	200
20.	Nitrate as NO3	mg/l	5.6	1.47	3.5	7.72	13.29	9.38	4.43	45
21.	Nitrite as NO2	mg/l	0.04	0.06	0.06	0.03	0.05	0.03	0.06	
22.	Ammonical Nitrogen as NH3-N	mg/l	<0.1	<0.1	<0.1	0.13	<0.1	<0.1	<0.1	
23.	Total Kjeldahl Nitrogen	mg/l	1.56	2.56	6.72	1.12	2.24	1.12	1.12	
24.	Fluoride as F	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1
25.	Total Phosphorous	mg/l	<2	<2	<2	<2	<2	<2	<2	
26.	Silica as SiO3	mg/l	17.95	18.6	18.31	17.98	22.73	15.2	15.47	
27.	Boron	mg/l	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.5
28.	Potassium as K	mg/l	5	1.2	1.3	1.2	1.5	2	1.2	
29.	Hexavalent Chromium (as Cr6+)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
30.	Iron (as Fe)	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.3
31.	Copper (as Cu)	mg/l	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.05
32.	Manganese as Mn	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1
33.	Zinc as Zn	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	5
34.	Nickel as Ni	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02
Biological Parameter										
35.	Total Coliforms	No/100	110	12	11	90	140	26	14	Absent

S. No	Parameter	Units	Chhatrapati Sambhaji Udyan – Open Well	Subhadra Bhavan , Apte Road- Bore Well	Shri Mahila Griha Udyog Lijjat papad – Bore well	David Sasoon Anath Pangu Griha Niwara- Open Well	Tilakwada – Open well	Parchure wada – Open well	DIC, Pune – Bore well	Acceptable limit – IS 10500:2012
		ml								
36.	E. coli	No/100 ml	09	02	04	07	11	08	04	Absent

- The pH values ranged from 6.9 to 7.80 indicating the water is slightly alkaline.
- Electrical Conductivity was maximum at David Sasoon Anath Pangu Griha Niwara-Open Well (794 µS/cm) and minimum at DIC, Pune – Bore well (365 µS/cm)
- Turbidity count ranges from <1 to 2.3 NTU.
- Total Dissolved Solids was observed maximum (480 mg/l) at David Sasoon Anath Pangu Griha Niwara- Open Well and minimum (235 mg/l) at DIC, Pune – Bore well.
- Total Solids was observed maximum (486 mg/l) at David Sasoon Anath Pangu Griha Niwara- Open Well and minimum (238 mg/l) at DIC, Pune – Bore well. Similarly, Total Suspended Solids count ranged from <5 to 6 mg/l.
- Total alkalinity ranged from 99.84 mg/l to 260 mg/l. Maximum calcium 57.71 mg/l was found at Parchure wada – Open well. Minimum calcium 22.44 mg/l was found at DIC, Pune – Bore well.
- Similarly, maximum magnesium 53.48 mg/l was found at David Sasoon Anath Pangu Griha Niwara- Open Well and minimum magnesium 11.66 mg/l was found at Shri Mahila Griha Udyog Lijjat Papad – Bore well.
- The hardness (320.25 mg/l) was higher at David Sasoon Anath Pangu Griha Niwara-Open Well and lower (138.11mg/l) at DIC, Pune – Bore well.
- Concentration of Sodium ranged between 6.0 mg/l and 9.0 mg/l. Similarly, concentration of potassium ranges between 1.2 mg/l and 5.0 mg/l.
- Maximum amount of nitrate (13.29mg/l) was found at Tilakwada – Open well and minimum amount (1.47mg/l) was found at Subhadra Bhavan, Apte Road-Bore Well.
- Total Kjeldahl Nitrogen ranges from 1.12 mg/l to 6.72 mg/l.
- The total phosphorous was <2 mg/l in all the sampling sites. Total sulphate wasmaximum at Chhatrapati Sambhaji Udyan – Open Well (40.0mg/l) and minimum at Subhadra Bhavan, Apte Road-Bore Well (20.36 mg/l).
- The chloride was observed maximum (44.02 mg/l) at David Sasoon Anath Pangu Griha Niwara- Open Well and minimum (24.48 mg/l) at Subhadra Bhavan, Apte Road-Bore Well.

Most of the physico-chemical parameters are found well within prescribed limits of IS10500:2012. However, presence of Total Coliforms and E coli indicate that the ground waterin the study area is not suitable for drinking purpose.

7.2.5. Ambient Air Quality

Ambient air quality of the study area has been assessed for two weeks, at seven locations as given in Table 7.9 and in Figure 7.5.The concentrations of PM10, PM2.5, SO_2 and NO_X samples were collected as 24 hourly averageby drawing air at the rate of 1.0 -1.5 m^3/min through glass fiber filter paper and analyzing bythe gravimetric method. Pre-calibrated fine dust particulate samplers were used for monitoringof PM10 & PM2.5. Concentrations of SO_2 and NO_X were analyzed by Modified West and Gaeke& Jacob and Hochheiser method respectively.

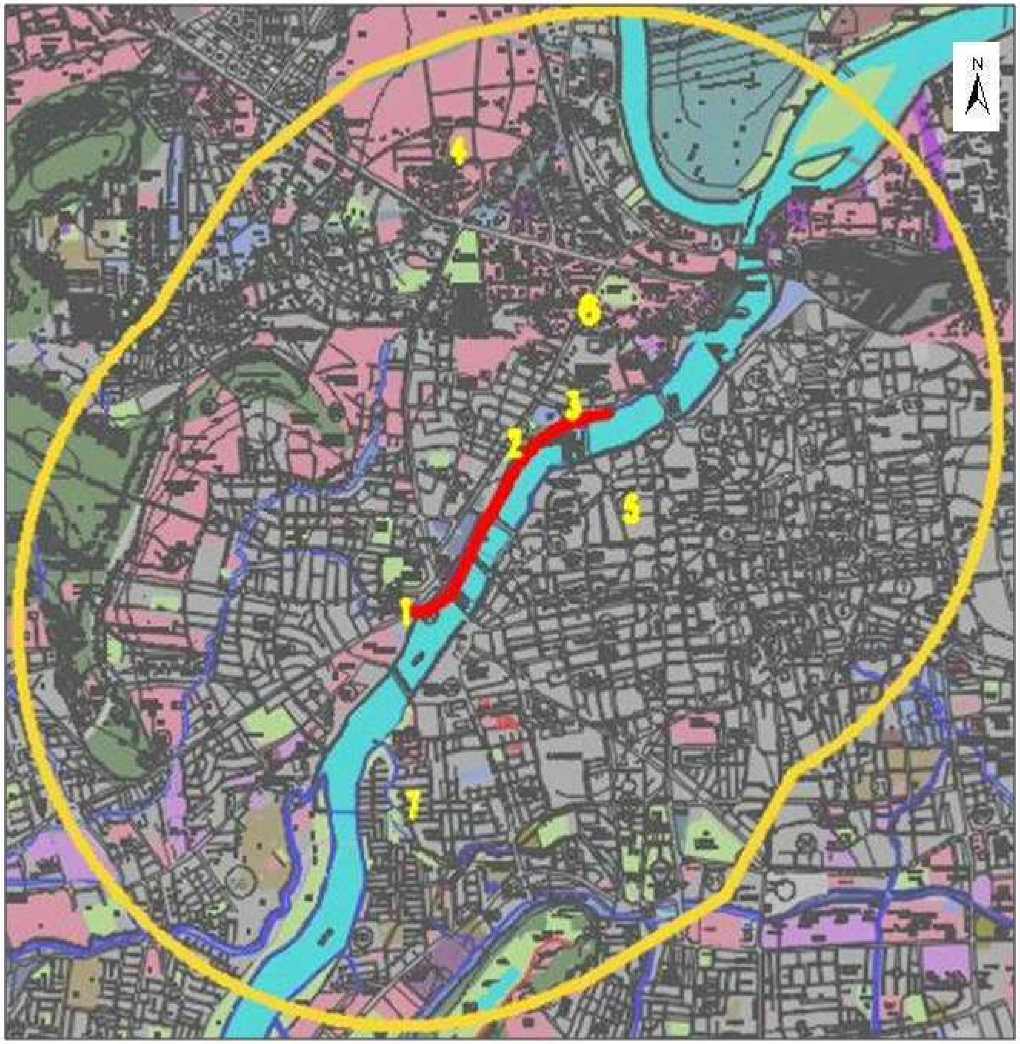
Table 7.9: Ambient Air and Noise Quality Monitoring Locations

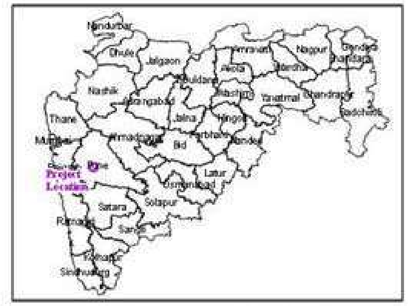
S. No.	Name of the Location	Latitude	Longitude
1.	KarveRoadKshetriyaKaryalaya	18° 30.767'N	73° 50.415'E
2.	Chhatrapati Sambhaji Udyan	18° 31.143'N	73° 50.781'E
3.	Savarkar Bhavan	18° 31.314'N	73° 50.992'E
4.	DIC, Pune	18° 31.986'N	73° 50.719'E
5.	Parchure Wada	18° 31.045'N	73° 51.189'E
6.	Kalaniketan	18° 31.741'N	73° 51.176'E
7.	Rajendranagar	18° 30.247'N	73° 50.417'E

Results of the ambient air quality are given in Table 7.10. From the results, it was observed that concentration of PM10 minimum at DIC Pune (42.1 µg/m^3) & Maximumat Kalaniketan (89 µg/m^3). Higher values recorded due to heavy traffic at Kalaniketan duringthe study. The drop down in the concentration of PM10 at DIC Pune may be due to goodvegetation cover and less traffic density.

The concentration of PM2.5 in the study area was minimum at DIC Pune (21.5 µg/m^3) andmaximum at Karve Road Kshetriya Karyalaya (60 µg/m^3). Recorded values of SO_2, wereminimum at DIC Pune (12.6 µg/m^3) and maximum at Savarkar Bhavan (30.2 µg/m^3). Observedvalues of NO_2, were minimum at DIC Pune (23.2 µg/m^3) and maximum at Karve RoadKshetriya Karyalaya (45.7 µg/m^3).

Figure 7.5: Ambient Air and Noise Quality Monitoring Location Map





Ambient Air Quality Monitoring Locations			
Sr.No.	Name of the Location	Lattitude	Longitude
1	Karve Road Kshetriya Karyalaya	18° 30.767N	73° 50.415E
2	Sambhaji Udyan	18° 31.143N	73° 50.781E
3	Savarkar Bhavan	18° 31.314N	73° 50.992E
4	DIC, Pune	18° 31.986N	73° 50.719E
5	Pachhse Wada	18° 31.045N	73° 51.189E
6	Kalanketan	18° 31.741N	73° 51.176E
7	Rajendranagar	18° 30.247N	73° 50.417E

Table 7.10: Results of Analysis of Ambient Air Parameter (µg/m3)

S. No	MonitoringLocations	Date of Monitoring	22/05/2017	26/05/2017	29/05/2017	2/6/2017
1.	KarveRoad, Kshetriya Karyalaya	PM10	95	102	89	91
		PM2.5	60	79	55	57
		SO2	25	32	28	26.5
		NO2	45.7	50.5	41	47
		CO	0.8	0.9	1.4	1.2
2.	ChhatrapatiSambhaji Udyan	PM10	65.1	62.6	76.2	70.5
		PM 2.5	34.5	35.6	34.5	30.6
		Sox	20.4	21.5	20.2	22.8
		NO2	37.5	34.6	33.9	34.5
		CO	0.3	0.4	0.3	0.2
3.	SavarkarBhavan	PM10	83.2	88.2	98.9	109.5
		PM2.5	56.5	55.6	62.5	64.5
		SO2	30.2	36.2	38.3	37.9
		NO2	45.8	41.4	44.5	45.3
		CO	0.9	1	1.2	1.1
4.	DIC, Pune	PM10	42.1	54.6	64.5	59.3
		PM2.5	21.5	23.9	24.1	25.2
		SO2	12.6	9.8	10.2	9.2
		NO2	23.2	20.1	24.5	23.5
		CO	0.4	0.3	0.5	0.6
5.	Parchure Wada	PM10	78.9	85.2	90.2	85.2
		PM2.5	43.5	52.2	50.1	51.5
		SO2	20.3	23.6	21.2	22.4
		NO2	31.2	38.3	32.5	31.2
		CO	0.4	0.5	0.4	0.3
6.	Kalaniketan	PM10	89	98.7	115	80
		PM2.5	51.5	56	62	48
		SO2	28	37	25	29.6
		NO2	43.5	51.2	40.6	43
		CO	2.1	1.8	1.8	2
7.	Rajendranagar	PM10	57.8	50.2	62.5	64.5
		PM2.5	32.5	30.2	33.2	35.2
		SO2	24.6	21.2	20.3	22.8
		NO2	31.2	35.2	32.2	33.2
		CO	0.4	0.2	0.1	0.2

Similarly CO concentration was minimum at Rajendranagar (0.4 µg/m^3) and maximum atKalaniketan (2.1 µg/m^3).Under the NAMP, MPCB conducted Ambient Air Quality Monitoring at five locations in thePune and Pimpri Chinchwad. The data of the same has been referred.

It is concluded that concentrations of PM10 and PM2.5 was found beyond permissible limits ofNational Ambient Air Quality Standards of CPCB at Karve Road Kshetriya Karyalaya, SavarkarBhavan and Kalaniketan sampling stations. However all the concentrations of SO_2,

NO_2, PM10,PM2.5 and CO found well within standards of NAAQ at Chhatrapati Sambhaji Udyan,Parchurewada and Rajendra nagar.

7.2.6. Ambient Noise Level and Vibration

A. Ambient Noise Levels

Noise levels monitoring were carried out at residential zone, silent zone and commercial zone located within the study area as presented in Table 7.9 and shown in Figure 7.5. The noise monitoring has been carried-out by deploying a digital noise meter having a noise level measuring range of 35 dB (A) to 100 dB (A). At each selected location, noise monitoring was conducted for 15 minutes continuously, during day and night. In this monitoring, at each location, the maximum and the minimum values of noise levels, and the equivalent noise levels were monitored. Results of Analysis of Ambient Noise Level at various locations were given in Table 7.11.

Table 7.11: Results of Analysis of Ambient Noise Level at Various Locations

S. No.	Location	Day	Night
		Levels in dB(A)	
1.	Karve Road Kshetriya Karyalaya	84.6	70.3
2.	Chhatrapati Sambhaji Udyan	45.6	34.8
3.	SavarkarBhavan	75.9	56.2
4.	DIC, Pune	64.1	53.8
5.	Parchure Wada	45.2	35.8
6.	Kalaniketan	86.5	71.6
7.	Rajendranagar	43.5	38.2

Noise levels recorded at various stations were higher than the permissible level of 65db (day)and 55db (night) for commercial areas. Maximum noise levels up to 110 dB (A) reported duringGanapati festivals.

B. Ambient Vibration Levels

The vibration measurement has been carried-out by portable Vibration Meter 2040 at variouslocations as given in Table 7.12. At each selected location, vibration measurement wasconducted for 15-20 minutes continuously during peak period of the traffic. In this monitoring,at each location, measurements were performed in accordance with currently applicablestandards, viz IS 11724 or International standards ISO 2372, VDE 2056 or BS 4675 whichspecify the manner in which the vibration is to be measured. Vibration Monitoring results were given in Table 7.13.

Table 7.12: Vibration Monitoring Locations

S.No.	Name of the Location	Latitude	Longitude
1	Panchaleshwar Temple	18°30'50.14"N	73°50'32.10"E
2	Sambhaji Bridge (Lakdi Pul)	18°30'50.86"N	73°50'33.97"E

S.No.	Name of the Location	Latitude	Longitude
3	Kakasaheb Gadgil Bridge (Z Birdge)	18°30'54.07"N	73°50'36.45"E
4	Baba Bhide Bridge	18°30'56.59"N	73°50'38.46"E
5	Maharshi Vitthal Ramji Shinde Bridge	18°31'16.88"N	73°50'57.58"E
6	Vridheshwar Temple	18°31'17.95"N	73°51'1.24"E

Table 7.13: Vibration Monitoring Results

S. No.	Monitoring Locations	Vibration in mm/sec (Maximum)
1	Panchaleshwar Temple	0.1
2	Sambhaji Bridge (Lakdi Pul)	0.3
3	Kakasaheb Gadgil Bridge (Z Birdge)	0.2
4	Baba Bhide Bridge	0.1
5	Maharshi Vitthal Ramji Shinde Bridge	0.2
6	Vridheshwar Temple	0.1

Maximum vibration levels were recorded at Sambhaji Bridge (Lakdi Pul). These higher values(0.3 mm/sec) were recorded during peak hours of the traffic. However at Panchaleshwar Templeand Vridheshwar temple and at Baba Bhide bridge vibration levels measured were from 0.1 to0.2 mm/sec.

7.3. HYDROLOGY OF MUTHA RIVER

7.3.1. Site Description

Mutha River has undergone several man-made modifications over the years. The major impacton the river was breach of the Khadakwasla Dam on 12 July 1961. Residential houses andbusinesses on both the banks of river were completely washed away. New flood zones had tobe defined to avoid any new construction within the flood zone. The width of critical part ofriver, which flows through the city, was divided in two parts. The central part was confined tosmall width by constructing walls on both sides. Tall retaining walls were built on both sidesfor confining the river within a wider reach.

Few bridges have been constructed across the river and details are given in Table 7.14. In addition, few causeways have also been constructed forpedestrian traffic. The bridges as well as the causeways are under extensive public use.Existing Bridges, Landfill Areas and Obstructions to River Flow in the Project Area of 1.45 km metro stretch along Mutha River is shown in Figure 7.6.

Table 7.14: Data on Elevations of Existing Bridges within the Study Area

S. No.	Name of the Bridge	Levels	
1.	Chavan Bridge(Shivram Mhatre Road)	Ex. Road Top Level Ground Level	551.502 m 545.37 m
2.	Sambhaji Bridge(Lakdi Pool)	Road Level	552.274 m

		Ground Level *Proposed Metro Rail Level*	543.510 m *563.2 m*
3.	Gadgil Bridge	Road Level Ground Level	544.544 m 542.374 m
4.	Baba Bhide Bridge	Road Level Ground Level	552.274 m 542.284 m
5.	Maharshi Vitthal Ramji Shinde Bridge (Bal Gandharve bridge)	Road Top Level Ground Level *Proposed Metro Rail Level*	553.221m 544.009 m *563.2 m*
6.	Jayantrao Tilak Pul (PMC Bhavan Bridge)	Causeway Level River Invert Level	541.858 m 539.280 m
7.	Shivaji Bridge(Nava Pool)	Road Level Ground Level	547.532m 541.829 m

Figure 7.6: Existing Bridges, Landfill Areas and Obstructions to River Flow in the Project Area

(a) (b)

(a) Low levelcauseway onMutha River
(b) Floatingvegetation anddebris causingobstruction toflow at thebridge piers.Also shows thehighly pollutedquality of riverwater.

(c) (d)

(c) Stepsproviding easyaccess to useriver water formultiple uses

(d) Low levelconcrete wallfor restrictingriver widthduring lowflow anda tall retainingwall on theextreme rightside forrestricting highriver flow overfull width

(e) (f)

(e) View ofanother lowlevel causewayon river near atemple

(f) Photo showingfull width ofriver duringlow flow,bounded bylow heightconcrete wallson both sides

(g) (h)

(g) Full river widthand severalstructures onright sidebuilt fordischargingstorm water in the river

(h) Steps foraccess to riverwater andguiding wall &Floatingvegetation

(i) (j)

(i)Another accessramp andsteps, largediameterconcrete pipe,Storm waterflow structure,Concrete pipeoutlet ofeffluentdrainage intoriver water

(j)Busy road onthe left bank ofriverunderneath abridge

(k)

(l)

(k) Obstructions inriver waterflow in theform of rockoutcrop, largeconcretepipeline, densevegetationand grassdirectly in theriver under oneof the bridgespans. Bridgepier and floguidestonewall are seen.
(l) Physiographyof left bank ofMutha River

(m)

(n)

(m) Pedestrian roadin the riverbasin
(n) Large diameterconcretepipeline aboveground levelalong the river

7.3.2. General Description

Hydrology of the river can be studied by using various mathematical calculations. It is easy to make calculations and study Hydrology of a river, which has no control structures and obstructions on it. Hydrology of river without control structure can be easily calculated by using parameters such as catchment area, landfill & land use, rainfall distribution. It needs data on several parameters such as size and shape of catchment area, daily rainfall, (referTable 7.15 and 7.16) infiltration properties of the catchment, land use area, area occupied by forests, residential and industrial area, meteorological data on air speed and direction, daily air temperature, humidity, rate of evaporation and so on.

Another most important function of a Dam is flood moderation. High floods cause enormous loss of life and destruction of property. This is avoided by controlling the outflow from the dam through gated spillway.

Table 7.15: Rainfall during Rainy season of Mutha River sub division

Year	Warasgaon Rainfall (mm)	Panshet Rainfall (mm)	Khadkwasla Rainfall (mm)	Hadapsar Rainfall (mm)	Loni Rainfall (mm)
1981	2075.90	1974.15	841.55		
1982	1492.40	1322.00	690.40		
1983	2081.90	2085.90	953.90		
1984	1983.90	1867.00	757.50		
1985	1662.40	1437.00	626.00		
1986	1664.40	1704.40	695.00		
1987	1292.60	1326.20	802.60		
1988	2294.00	2370.00	993.50		
1989	1494.00	1488.80	734.20		
1990	2429.00	2470.40	853.80		
1991	2254.40	2290.20	899.00		
1992	1827.30	1950.40	737.30		
1993	2033.40	2068.50	708.40	596.80	522.00
1994	3549.10	3390.40	1161.20	604.10	469.00
1995	1544.00	1676.00	865.90	459.00	336.00
1996	2947.00	2228.40	1115.50	649.00	605.00
1997	2448.50	2554.00	1358.40	555.40	533.00
1998	2908.00	2044.60	810.80	456.60	342.00
1999	1983.00	1899.00	674.00	471.50	429.00
2000	1350.00	1334.40	632.00	563.0	409.00
2001	1663.00	1590.20	691.00	344.00	329.00
2002	1406.00	1329.00	505.00	228.00	224.00
2003	1834.00	1802.80	505.00	166.00	156.00
2004	2374.00	2259.00	9024.00	603.00	497.00
2005	3616.00	3545.00	1587.00	871.00	689.00
2006	4032.00	3910.00	1265.00		
2007	2916.00	2821.00	701		
2008	2230.00	2119.00	783.00		
2009	2273.00	2299.00	927		

Table 7.16: Khadakwasla Dam Total Rainfall (mm) Year 2008-2015

Year	June	July	August	September	October	Total
2015	291	76	35	104	118	**624**
2014	25	332	345	83	47	**832**
2013	268	223	55	282	36	**864**
2012	38	111	255	86	155	**645**
2011	220	232	156	198	115	**921**
2010	154	276	164	182	74	**850**
2009	24	412	71	126	80	**713**
2008	95	75	211	310	92	**783**

7.3.3. Obstructions to River Flow in Study Area

Biswas S. K. (2010) concluded numerical model studies for Surma River in Bangladesh fordetermining the effect of bridge pier on waterways constriction. He concluded that if the waterways become constricted, bank erosion and scour may happen much more than expectedvalues. To avoid this drastic situation, river training work from 1 km upstream to 1 kmdownstream may be recommended and continuous monitoring should be conducted during and after construction of such type of structure at stated situation.

There are different ways to find out the minimum waterway or opening of bridge dependingon the shapes. Considering the aesthetical point of view, pier may occupy more waterways andit is the engineers challenge to suggest suitable and substantial remedial measures for makingthe construction possible with nominal adverse effect on river morphology. Bridge pierconstruction was already completed before the present study and some severe morphologicalresponse has been observed. At the bridge location both for the upstream and downstream it isaffected by severe bank erosion, which was not terminated with usual protective measures.

7.3.4. Dams for Pune City

Dams are mandatory structures constructed for storage and supply of water for irrigation anddomestic consumption for large towns and cities. It may be noted that more than seventypercent of water stored in dams is needed for agriculture. The remaining is used for thedomestic use and industrial use. Khadakwasla Dam was the oldest dam built on the MuthaRiver to meet the needs of Pune City. Three more large dams were built during the subsequentyears to store more water for the increasing needs of irrigation, population and industry. As oftoday, four dams exist upstream of the city of Pune, namely Khadakwasla, Panshet, Varasgaonand Temghar.

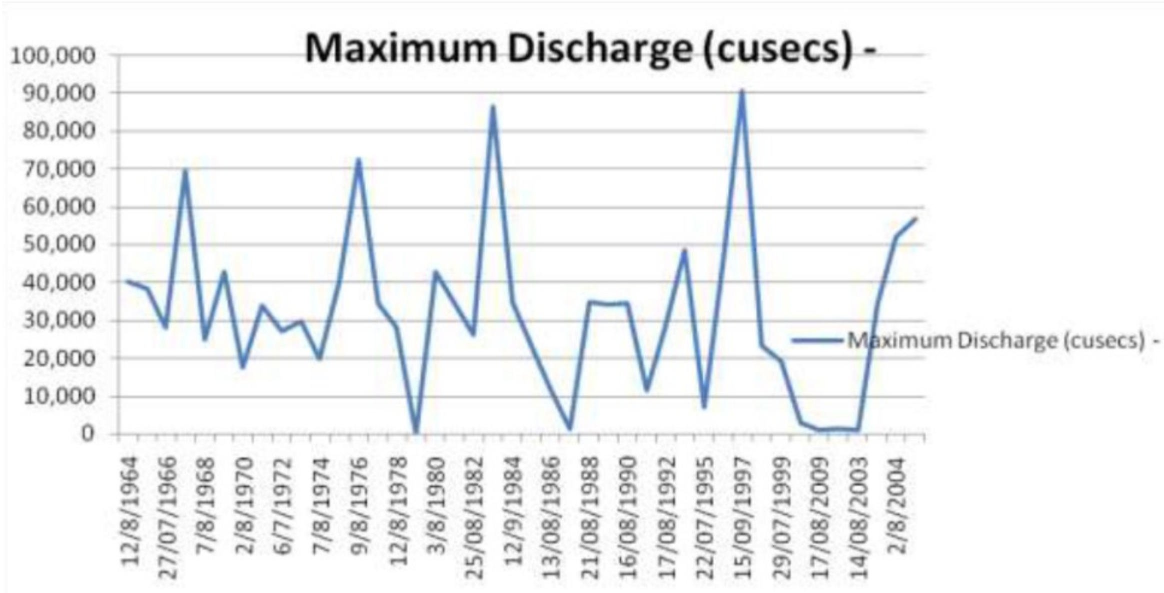
Water from the three dams is released into Khadakwasla Dam as and when needed and it issupplied to Pune city through closed pipes for drinking and through open canal for irrigationthroughout the years. Under these conditions hydrological calculations for the river dischargebecome meaningless because the river discharge is fully controlled manually.

Since the discharge in Mutha River is not a function of natural parameters, there is no need toget any data on rainfall, infiltration etc. Data on actual volume of water released into MuthaRiver daily through Khadakwasla Dam is available from the Irrigation Department. It isbelieved that gauges are installed along the Mutha River from the Dam up to Sangam Bridge.Thus data on river water level corresponding to the water released from the dam are availableand presented in Annexure 7.1 and maximum discharge to Mutha River is shown in Figure 7.7.

7.3.5. Estimation of Maximum Flood Frequency

While discussing river floods, the word Return Period is often used. The amount of waterflowing through each year often has large variation. It dependspredominantly on the quantity of rain during monsoon season, which has a large spatial andtemporal variation. The magnitude of maximum or the peak discharge also has a large variation.For designing a new dam, it is necessary to estimate the current and projected need of waterfor determining the storage capacity of dam in order to meet the annual requirement of water.

Figure 7.7: Maximum Discharge (Cusecs)



If it is too small, the intended purpose will not be served. If it is too large, major part of thedam will remain empty and money for constructing larger dam will be wasted. Hence everydam has to be built for optimum storage capacity. The same consideration applies to theMaximum River Discharge in each year. Taking into account the geometry of the river on itsboth banks, the value of maximum flood discharge is used to decide the area of flood plain. Allconstructions need to be kept beyond the flood line. Analysis of maximum flood discharge dataenables us to decide the Flood Frequency and its volume, which is expressed as the ReturnPeriod. The magnitude of flood is expressed as once in Ten years, once in fifty years, once inhundred years and so on.Affected structures / places due to discharge of Mutha River in the vicinity ofproject site are given in Table 7.17.

Table 7.17: Affected structures/places around Project Site due to discharge in Mutha River

S. No.	Discharge in Cusecs	Affected structure/place
1.	18,000	Baba Bhide Bridge submerges
2.	28,000	Water enters into the Khilare Wasti, near Abasaheb Garware College
3.	33,000	Shitaladevi Temple at Deccan submerges
4.	54,000	Jayantrao Tilak Pul (PMC Bhavan Bridge) submerges
5.	60,000	Water enters into Patil Estate slum area

Source: Flood Control and Disaster Management Action Plan, 2017-18, Pune Municipal Corporation

7.3.6. Estimation of Afflux

The maximum water surface change just upstream of a bridge is termed the afflux in hydraulicengineering. If the Afflux is large, its magnitude needs to be taken into account for calculationof hydraulic forces on bridge piers. H. Liua et al have used the lattice Boltzmann method(LBM) to study afflux. Three configuration parameters, namely, blockage ratio, skewness andeccentricity, are investigated in the LBM method. Afflux calculations are important for bridgeswith multiple spans and large sizes of piers. In the case of present project, there will be a singlepier causing negligible obstruction to the river flow.

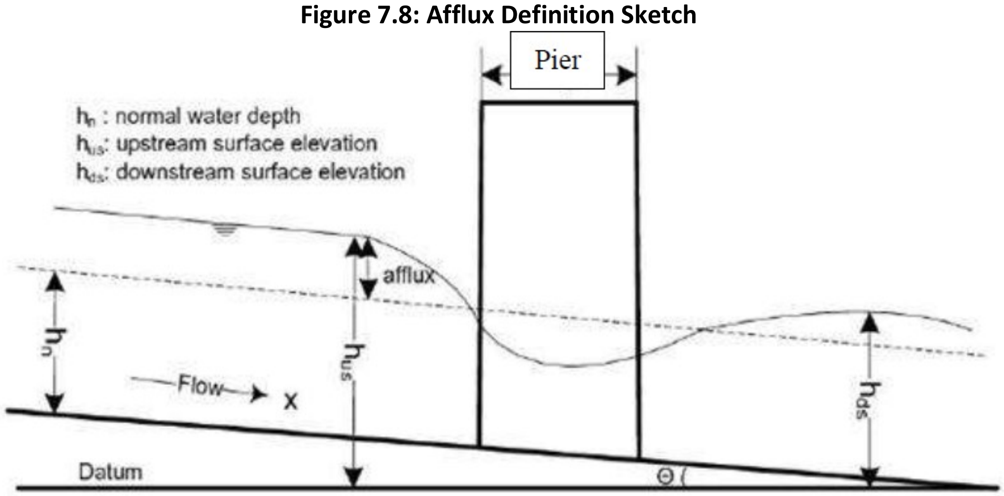
A. Afflux Computations

Afflux is defined as the difference in water levels upstream and downstream of a structure suchas a bridge pier, measured at a location unaffected by high local flow velocities caused by theconstriction of flow. A sketch of Aflux definition is shown in Figure 7.8.

Afflux is the local rise in water level on the upstream side of obstacles to river flow. It mainlyresults from the obstruction to river flow caused by the series of bridge piers, particularly whenthey have large width in the direction of river flow. Afflux also results from other obstructionssuch as trees and islands.

There is no single method for prediction of Afflux caused by Bridge Piers. The method given by the Indian Standards has been adopted for the present project, assuming that it would be more appropriate and reliable for the Indian conditions.

Figure 7.8: Afflux Definition Sketch



B. Afflux Calculations Using Empirical formula

When the area of obstruction is not very large compared to the original unrestricted area, thefollowing formula gives reasonably good results:

$$h = \{V^2/17.85 + 0.0152\}\{A^2/a^2 - 1\}$$

Where

h = afflux in m,

V = velocity in the unobstructed drainage channel in m/s,

A = the unobstructed sectional area of the drainage channel in m^2, and

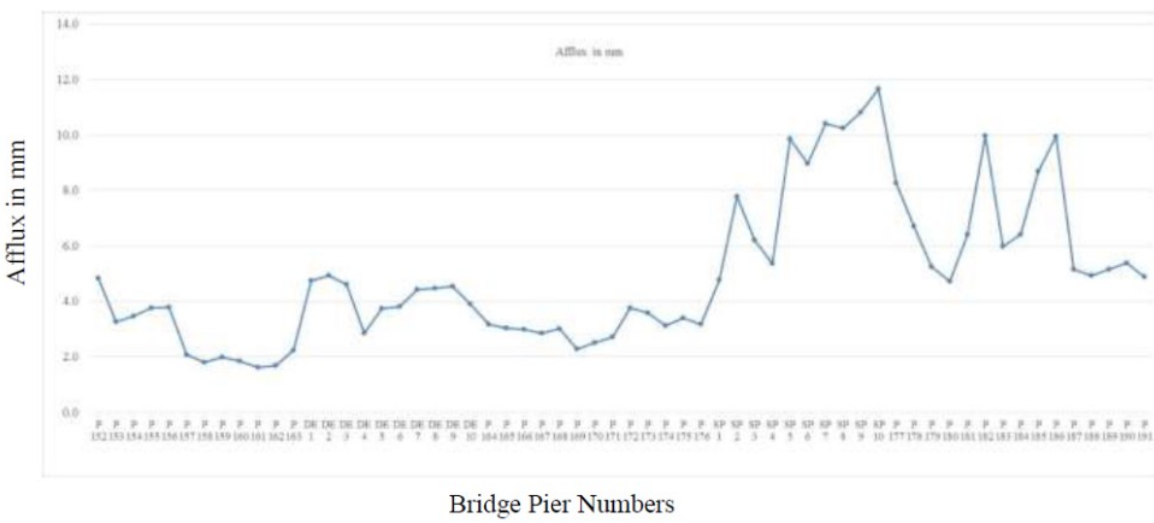
a = sectional area of the drainage channel provided in the construction in m^2.

The site conditions of Mutha River for the project reach under study have the followingconditions:

1. The river does not get flood water due to natural rains. Controlled discharge is released from the Khadakwasla Dam located about 20 km upstream of Pune city. This flow remains constant for a period varying between one to four days. Hence the flow is assumed to be steady and uniform.
2. Out of the total length of about 31 km, only 1.45 km reach is located within the river basin.
3. The alignment of Metro Rail does not cross the river at right angle.
4. The entire Metro rail is located on the left bank of the Mutha River, which consists of un-compacted landfill area.
5. The distance between adjacent piers is variable. Also the size of piers is variable.
6. The afflux has been calculated only for the 100,000 cusecs discharge in the river. These values are very small compared to water depth. Values of lesser discharge will be even smaller and would be insignificant.

The results of calculated Afflux by joining the values of afflux at each consecutive pier alongthe alignment of Pune Metro are presented in Figure 7.9and Annexure 7.2.

Figure 7.9: Plot Showing Afflux along the Metro Pier Alignment



C. Effect of Afflux on River Width at Water Surface (Submergence)

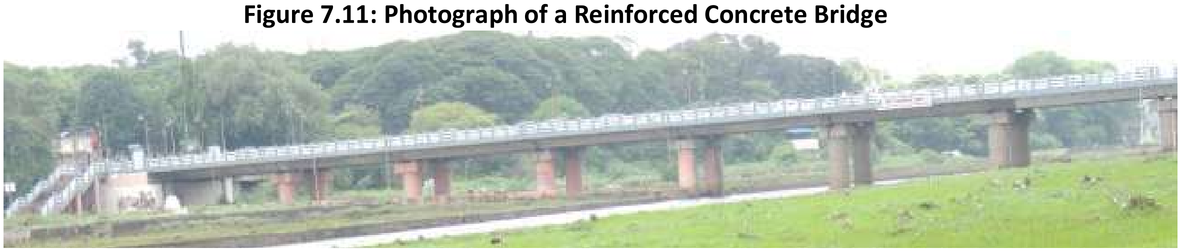
During the past years the only strong material for building bridges was stone. Due to severalstructural limitations, the span of arches for the stone bridges had to be kept small and the sizeof bridge piers and their foundations had to be kept large (refer Figure 7.10).

After invention of steel, larger spans for bridges became possible. This reduced the number ofspans for a bridge and the size of bridge piers also became smaller. This resulted in a reductionin the area obstructed by a bridge on rivers. However, several bridges have slender piers butthe foundations submerged below water surface have very large diameter. Such bridges alsocause large obstruction to flow.

Figure 7.10: Photograph of a Stone Bridge with Arches

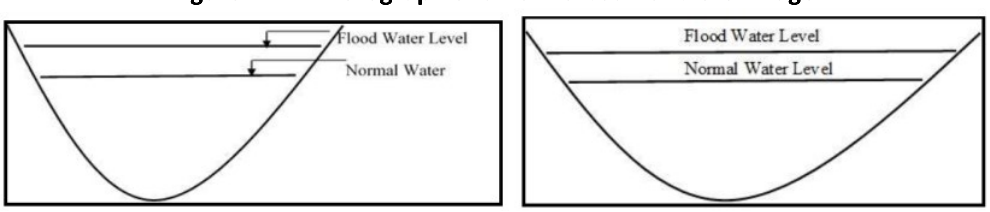
Introduction of Reinforced Concrete was the next step in bridge construction. The spansbecame much larger and arches were on longer necessary. They got replaced by beams (refer Figure7.11). The bridge piers are slender and fewer in number. Such bridges cause very littleobstruction to river flow and have a very small Afflux.

Figure 7.11: Photograph of a Reinforced Concrete Bridge

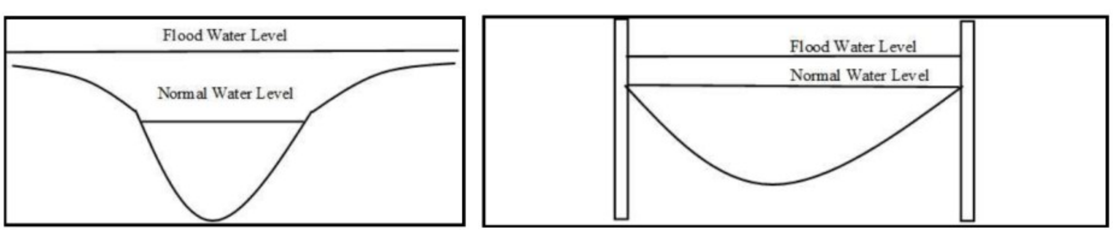


River Section and Bank Inundation: As the water level in a river rises, area on both banks ofthe river gets submerged. This canhave significant environmental as well as socio-economic impact.The cross-section of river and the geometry of both banks have a significant impact on the landsubmergence. Differenttypes of river cross-sections are shown in Figure 7.12.

Figure 7.12: Photograph of a Reinforced Concrete Bridge



Type 1: Deep Gorge River Type 2: Commonly Existing River Section



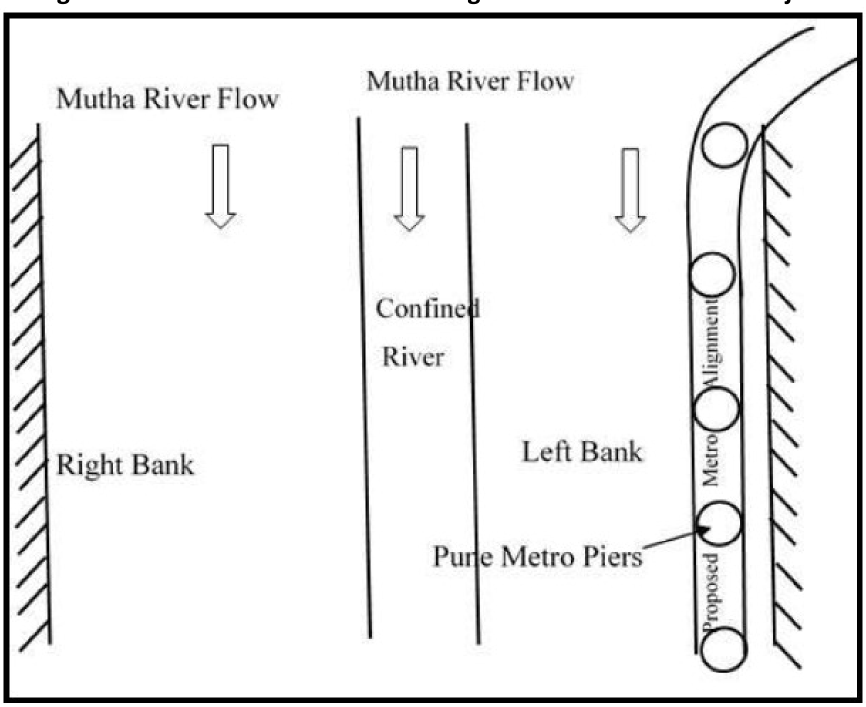
Type 3: River with Flat Banks on both sides Type 4: River with Retaining Walls or Flood Embankments

Under Type 1 the flood water does not have any scope to spread on the banks. Under Type 2only a strip of land parallel to the river flow gets inundated. Type 3 has a regular river channelwithin which the normal flow is restricted. However, there is a large flat area above a certainelevation. Hence a large area over both the banks gets inundated under floods. Type 4 hasretaining walls or flood embankments on both banks of river. Hence the water spread remainsconstrained. Only the depth of water changes depending upon the river flow volume.

Type 2 Commonly Existing River Section and Type 4 River with Retaining Walls or FloodEmbankments are applicable to present study.

An important feature of Pune Metro is its alignment with respect to the river. The alignment ofPune Metro within the Mutha River basin is not at right angles to the river flow. The entirealignment is located on the left bank as shown schematically in Figure 7.13. Theobstruction caused to the flow is only one percent of the river section, which is insignificant.

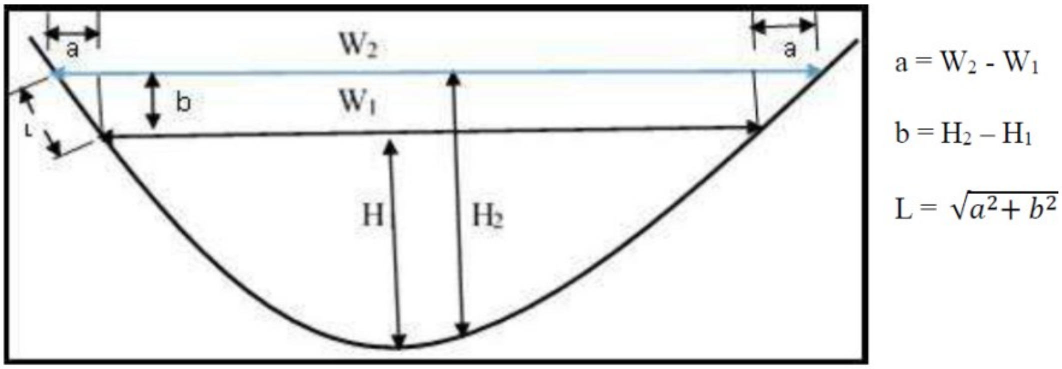
Figure 7.13: Plan View of Circular Bridge Piers for Pune Metro Project



The type of flow, namely critical, supercritical or subcritical, between the two adjacent piersalso matters. The Metro piers are not in one line normal to the flow and the river flow is alsofound to be subcritical. Hence large Afflux cannot occur.

Effect of Afflux on River Width at Water Surface (submergence): Regarding the effect of Afflux on water level between the two banks of the river, the flow pattern generated at the pier needs to be considered. This is shown schematically in Figure 7.14. It is assumed that the afflux will be spread uniformly over the entire river width.

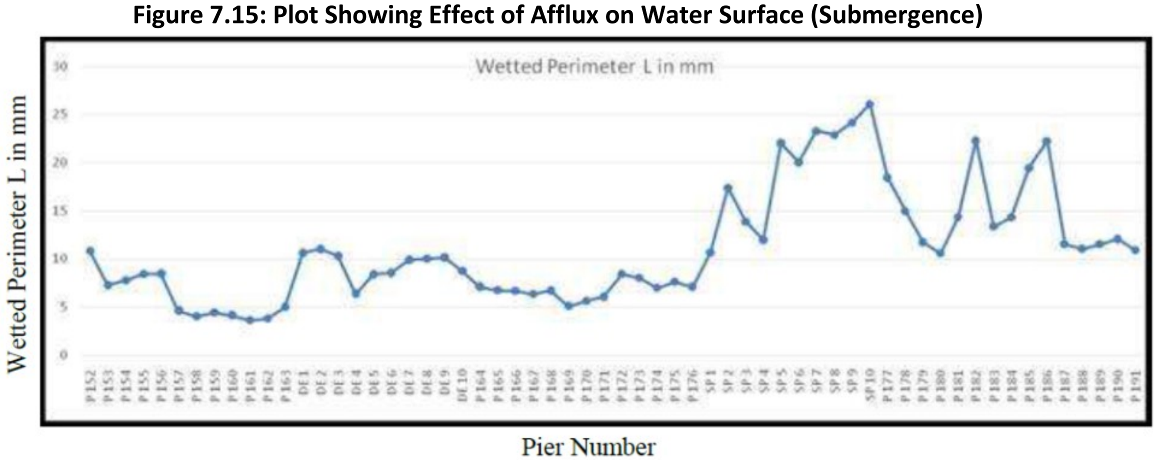
Figure 7.14: Inundation of River Bank caused by Afflux



The afflux b will result in increasing the river width from W1 to W2. This will increase thewetted perimeter (increased submergence), which is shown by L in above figure. Values of Lare plotted in Figure 7.15.

Computation of Pier wise afflux and wetted perimeter concludes that the transverse dimension of bridge piers varies from 2.0 m to 3.0 m. Water spread at maximum discharge of 100,000 cusecs within study reachof 1.45 km along Mutha River varies from 169 m to 255 m.Mathematical calculations depicts the obstruction to the river flow is insignificant due to proposed construction of metro rail alignment piers. Themagnitude of afflux (increase in water level) works out to from 1.6 mm to 11.7 mm. Similarly, increase in submergence will be 3.24mm to 23.32mm at Pier No. 161 and Chatrapati Sambhaji Udyan Metro Station Pier No. 10 respectively.

Figure 7.15: Plot Showing Effect of Afflux on Water Surface (Submergence)



7.3.7. Estimation of River Bed Erosion

Reasons for severe scour and siltation at the bridge site:

1. Water area of river at bridge site was constricted severely (about 33 % due to consumption of four bridge piers) due to use of pier of great width compared to usual bridge pier.
2. It is observed that the sediment samples under study exhibit wide range of grain size classes ranging from <-2.0 Phi to > 4.50 Phi. The grain size frequency curves of three samples from the trench are broadly falling in sand-gravel size fraction. The samples from the trench show significant variations in their grains sizes. The pebble content in the sediments varies from 85.57 gm (TBH5_B), 0.57 gm (TBH5_M) to 57.10 gm (TBH5_T). The coarse sand varies from 35.21 gm (TBH5_B), 17.42 gm (TBH5_M) to 30.66 gm (TBH5_T). In contrast the fine sand varies from 23.49 gm (TBH5_B), 74.20 gm (TBH5_M) to 30.88 gm (TBH5_T). The silt and clay varies from 3 to 4 gm. The granulometric analysis of the interflow sediments shows the characteristics of the sediments and their environment of the deposition. These sediments are mostly poorly to very poorly sorted with unimodal (TBH5_B), trimodal (TBH5_M) and bimodal (TBH5_T) characteristics. The sediments are represented by sandy fine gravels with lenses or beds of gravelly sand and fine sand. The sediments show two modes of deposition i.e. saltation and suspension with minor traction indicating the fluvial environment of deposition.
3. Obstruction is generated when bridges are located across a river. In the immediate vicinity of the project three bridges are located close to each other, namely Sambhaji Bridge (Lakdi Pul), Kakasaheb Gadgil Bridge (Z Birdge) and Baba Bhide Bridge. These bridges cause significant obstruction. Distance between Sambhaji Bridge (Lakdi Pul) to Kakasaheb Gadgil Bridge (Z Birdge) is 146 m and Kakasaheb Gadgil Bridge (Z Birdge) to Baba Bhide Bridge is 102 m. However, proposed metro rail alignment is parallel to river and along blue and red line which envisage non-significant impacts.

7.3.8. Estimated Erosion at Viaduct Pillar Foundation

Biswas S. K. (2010) reported that at downstream of the bridge, bed scouring ranges from 1 to5 meter associated with the thalweg movement from middle to left bank. Such changes i.e. bedscouring along the left bank extends approximately 1 km downstream from the bridge. Atimmediate upstream along the right bank, scouring was more severe than that at downstream.

Another important factor is the river bed sediment. If the sediment consists of fine clay, it getseroded at a very small bed shear stress and gets in suspension. The suspended sediment moveswith the river flow and gets carried away elsewhere. This deficit of sediment causes local scour,which can be a serious problem. At some sites, local scour occurred up to 8 meters below theriver bed, exposing the foundation of piers. In respect of the present project, the flow magnitude and hence the bed shear stress is low. The river bed material consists of sand and disintegratedrock.

7.3.9. Flow Pattern at Viaduct Piers

If a hydraulically smooth transition is provided by bridge pier, eddies on the downstream ofthe pier can be eliminated and local scour shall be prevented.

7.3.10. Conclusions of Hydraulic and Hydrological Aspects

- A part of the Pune Metro Rail having a length of 1.45 km passes through the flood plain of Mutha River. This part is aligned along the length of the river and does not cross the river at any location.
- The proposed alignment is on the left bank of the Mutha River which is a straight course that begins to bend towards the Vitthal Ramji Shinde Bridge. However, our field studies record that a 2-3 m thick alluvium (sediment) cover is present on the northern bank indicating that this stretch of the river is a non-erosive, but depositional and therefore of an aggradational nature. Hence, this bank is much preferred/ suitable for the proposed alignment.
- The geophysical data presented previously concentrated on the suitability of the deeper strata from the foundation and hydrogeological point of view. While the data was of good quality and very nicely depicted, it did not concentrate on the shallow horizons, so did not pick up the sediment-bedrock signatures. Our surveys have focused on this aspect and a 2-5 m sedimentary layer overlying weathered vesicular bedrock has been proven. This augments our field observation and strengths our case.
- The well inventory indicates presence of alluvium (0-9 m thick) overlying weatheredbasalt. Hydro geologically, the area is underlain by an unconfined aquifer consistingof shallow alluvium-weathered vesicular basalt. Most of the dug wells are used fordomestic purposes and as an alternative to tap water. However, a few hotels usegroundwater for commercial purposes.
- As such the aquifer has shallow water table (1-9.3 m below ground level) with 1-3 m seasonal water table fluctuation and has limited groundwater abstraction. Hence, the aquifer is not stressed due to over-exploitation.
- It is also inferred that the water table of the shallow aquifer is above the level of bedrock in the channel. Hence, the hydraulic head is higher thereby negating the possible contamination of surface river water into the groundwater system. The confining/retaining walls along the river channel can be reinforced to minimize surface water spread overflow from left bank during floods/peak discharge.
- Water flowing through the Mutha River is very carefully controlled at the Khadakwasla Dam, which is about 20 km upstream of the area of study. The river has mainly two flows in it. The first one is over the entire non-monsoon season. This discharge is very low, almost close to the Environmental Flow, only to keep the river away from drying and also to supply some water to the villages and towns located downstream of Pune City. Higher river water flows are released through the Khadakwasla Dam on very few occasions of heavy rainfall in the catchments upstream of Khadakwasla Dam. Such flow may last for only one to four days at one occasion and they are also spread widely apart. Thus the socalled Flood situation in Mutha River is very different from other rivers, which have completely different site conditions.
- In view of the above situation, the maximum hydraulic forces on the piers are very low. Since the piers will be designed for many other forces, they will have no adverse effect due to flood in Mutha River.

- The bridge pier foundations will be below the river bed until hard rock is met. Hence they will have no fear of failing due to shear force acting under water flow.
- There will be no adverse flow-structure interaction. That means the bridge piers will have no adverse action on the flow and the river flow will not have any adverse action on the bridge piers.
- The bridge piers as well as the foundations have streamlined shape. Hence there will be no eddy formation at the bridge piers and hence no local scour. If any scour is locally noticed at any of the piers, mitigation measures for the same are available.
- The river flow at bridge piers will be steady because the discharge released from the Khadakwasla will be constant over a period of time. Also there will be no pulsating flow at the pier. Hence the piers will not experience any vibrations caused by the flow. Every time a Metro passes over the bridge, vibrations will be experienced. However, their mitigation is expected to be taken into account in the structural design.
- The distance of adjacent piers varies from 13m, 13.9m, 17.9m, 20m, 21m, 22m, 25m, 27m, 28m, 31m, 46m, 47m etc. This distance is adequate for avoiding any effect due to nearness of adjacent bridges.
- Bridges currently existing on the river are also sufficiently away from the proposed elevated alignment. Hence there is no reason to have any adverse interaction.
- At any cross-section of the river, the area blocked by the width of the pier is negligible compared to the cross-sectional area of river. Hence there will be insignificant afflux or blockage of flow due to construction of viaduct piers. Photographs of existing bridges are given for comparison with the piers of Pune Metro. While conventional bridges shown in the photographs have a series of piers normal to the river flow, the metro bridge has only one pier in the river bed at every cross section.
- Some of the openings of the existing bridges contain construction debris, rocky outcrops, concrete pipelines, and vegetation. These cause obstruction to flow and increase of flow velocity at other locations. If the flow velocity increases beyond the permissible bed shear strength, it will increase the scour. It has been mentioned earlier that lose landfill has been dumped on both banks of the river and large areas have been created. Since the material is not compacted, erosion of these areas is likely to occur.
- Periodic monitoring is recommended for river bed scour. Careful data collection is recommended at curvature in the river because there is likely to be siltation on one side and erosion on the opposite side.
- There are many obstructions to river flow, which have been created by the construction activities in the past. Also floating vegetation within the river and grass on the landfill exists, which affects flow as well as water quality.
- There are many locations along the length of river where untreated municipal sewage and industrial effluent is released into river through pipes, which are visible from the road.
- As hydrology of Mutha River is dependent upon controlled water flow of Khadakwasla dam, no impacts are envisaged on hydrology of Mutha River i.e. flow up to 60,000 cusecs. However due to orientation of piers, locations and shape minimum impacts are predicted beyond discharge of 60000 cusecs. Discharge data

obtained from Irrigation department depicts that, in seventy years time span, on 12 occasion discharge of water recorded more than 60000 cusecs.

- The transverse dimension of bridge piers varies from 2.0 m to 3.0 m. On the other hand, water spread at maximum discharge of 100,000 cusecs within study reach of 1.45 km along Mutha River varies from 169 m to 255 m.
- Mathematical calculations depicts the obstruction to the river flow is insignificant due to proposed construction of metro rail alignment piers. The magnitude of afflux (increase in water level) works out to from 1.6 mm to 11.7 mm. Similarly, increase in submergence will be 3.24mm to 23.32 mm at Pier No. 161 and Chatrapati Sambhaji Udyan Metro Station Pier No. 10 respectively.
- The reasons for insignificantly small value of Afflux and small value of river bank submergence are
  - The alignment of Pune Metro within the Mutha River basin is not at right angles to the river flow.
  - The entire alignment is located on the left bank
  - The distance between adjacent piers is more than 13 meters. Hence they do not have any hydraulic interaction.

7.3.11. Recommendation

- The Bank selected for construction is non erosive side and hence safer for construction
- Tests indicates that construction of piers are not likely to damage existing aquifers
- As the hydraulic head is higher, the surface water will not contaminate the ground water

7.4. ECOLOGY AND BIODIVERSITY

Natural flora and fauna are inseparable part of the environment. They are organized into naturalcommunities and are sensitive to any change in their surroundings. Ecological system showscomplex inter-relationships between biotic and abiotic components including interdependence,competition and mutualism. Biological communities, being dependent on thecondition and resources of its location may change, with these changes in the environment.Hence, observations on the status of flora and fauna are primary requirement of environmentalimpact assessment studies, in view of the need for conservation of environmental quality andbiodiversity. The biological environment includes mainly terrestrial and aquatic ecosystems.Information on the impact of environmental stress on the community structure serves as aninexpensive and efficient early warning system to check the damage to a particular ecosystem.

Biological Communities exhibit a strong relationship with their surroundings and climaticvariables like temperature, humidity, rainfall, soil characteristics and topography. Diversity andrichness of biological communities depend on the environmental conditions and availableresources of the location. The animal and plant community exist in their natural habitat in awell-organized manner and their natural settings can be disturbed by any external factors,including anthropogenic activities. So, once natural setting is disturbed it becomes practicallyimpossible or takes longer time to come back to its original status.

Plants and animalscommunities are reflected by changes in distribution pattern, density, diversity, frequency,dominance and abundance of natural species of flora and fauna existing in a particularecosystem. These changes over a span of time can be quantified and related to the existingenvironmental factors. The sensitivity of animals and plants species to the changes occurringin their existing ecosystem can therefore, be used for carrying out Environmental ImpactKeeping this in view, Environmental Assessment Studies of any given area require informationon the present status of flora and fauna. This information was collected within the study areaand the relevant details on aquatic life were also collected. Ecology and biodiversity studieswere conducted during May to December 2017 (Pre Monsoon, Monsoon and Post Monsoon).

7.4.1. Floral Diversity

A. Phytosociological Study

To obtain the baseline information of theherbaceous flora, detailed phytosociologicalstudies were undertaken. Sampling stationswas spread along the proposed alignmentpassing through Mutha River. For theherbaceous study, stratified quadrantsampling method was applied. Thevegetation sampling was carried out at 10different locations. For each location 7 to 9quadrants of size 1 X 1 m were taken. TheQualitative and Quantitative informationsuch as species richness and diversity,abundance and density and diversity indices were obtained. (John G. Rau and David C.Wooten: Environmental Impact Analysis handbook, 1980, pp1-44).Photographs of herbaceous diversity at project site are shown in Figure 7.16.Phytosociological study of the project area is given in Table 7.18.

Figure 7.16: Photographs of herbaceous diversity at Project Site


Abutilon indicum (Link) Sweet


Cardiospermum halicacabu L


Datura stramonium L.


Sida acuta Burm.f


Acalypha indica L


Ipomea sps.


Eclipta prostrate (L) L


Chromolaena odorata (L.) King & H.E. Robins.



Colocasia esculenta (L.) Schott *Portulaca oleracea* L. *Eichhornia crassipes* (Mart.) Solms



Phyllanthus amarus Schumach. &Thonn *Withania somnifera* (L.) Dunal *Solanum torvum* Sw



Cleome rutidosperma DC *Alternanthera sessilis* (L) RBr ex DC *Cyperus rotundus* L



Phyla nodiflora (L.) Greene *Chrozophora rottleri* (Geiseler) A.Juss. ex Spreng. *Asclepias curassavica* L.

Cleome viscosa L.

Tinospora cordifolia (Willd.) Miers

Senna occidentalis (L.) Link

Amaranthus spinosus L.

Sida acuta Burm.f

Euphorbia hirta L.

Table 7.18: Phytosociological Study

S No	Species name	Freq.Class	Freq.	Density	Aund.
1.	Acalypha ciliata Forssk.	B	22.22	0.58	2.75
2.	*Achyranthes aspera L.*	C	38.89	1.82	4.93
3.	*Alocasia macrorrhizos (L.) G.Don.*	A	11.11	0.63	6.00
4.	*Alternanthera triandra Lam.*	C	50.00	4.21	8.89
5.	*Amaranthus cruentus L.*	C	55.56	1.63	3.10
6.	*Amaranthus spinosus L.*	C	58.33	2.21	4.00
7.	*Amaranthus polygamus L.*	C	55.56	2.74	5.20
8.	*Asclepias curassavica L.*	B	22.22	1.16	5.50
9.	*Hygrophila auriculata (Schumach.)Heine.*	B	22.22	1.00	4.75

10.	*Cardiospermum helicacabum L.*	A	16.67	0.68	4.33
11.	*Senna occidentalis (L.) Link*	C	50.00	1.84	3.89
12.	*Senna tora (L.) Roxb.*	B	38.89	2.53	6.86
13.	*Chrozophora plicata (Vahl) A.Juss.ex Spreng.*	B	27.78	2.11	8.00
14.	*Cleome gynandra L. Sp. Pl. ed.*	B	27.78	1.42	5.40
15.	*Cleome viscosa L. Sp. Pl.*	A	11.11	0.74	7.00
16.	*Commelina forsskalaei Vahl.*	B	38.89	2.05	5.57
17.	*Croton gibsonianus Nimmo*	A	16.67	0.89	5.67
18.	*Cucurbita maxima Duchesne.*	B	22.22	0.37	1.75
19.	*Cynodon dactylon (L.) Pers*	B	33.33	8.47	26.83
20.	*Cyperus compressus L.*	C	50.00	3.13	6.61
21.	*Cyperus rotundus L.*	B	22.22	0.84	4.00
22.	*Datura metel L.*	B	22.22	1.58	7.50
23.	*Eclipta prostrata (L.)*	B	22.22	0.95	4.50
24.	*Eichhornia crassipes (Mart.) Solms*	B	27.78	0.63	2.40
25.	*Eleusine coracana (L.) Gaertn.*	B	38.89	3.47	9.43
26.	*Euphorbia hirta L.*	B	22.22	1.11	5.25
27.	*Ludwigia octovalvis (Jacq.)P.H.Raven.*	A	16.67	0.26	1.67
28.	*Ocimum tenuiflorum L.*	B	36.11	0.68	2.00
29.	*Parthenium hysterophorus L.*	C	47.22	3.42	7.65
30.	*Passiflora foetida L.*	B	22.22	0.26	1.25
31.	*Phyla nudiflora (L.) Greene*	C	55.56	3.97	7.55
32.	*Phyllanthus amarus Schum &Thonn.*	B	27.78	0.53	2.00
33.	*Portulaca oleracea L.*	A	16.67	1.42	9.00
34.	*Cullen corylifolium (L.) Medik.*	A	11.11	0.68	6.50
35.	*Ricinus communis L.*	A	11.11	0.53	5.00
36.	*Sesuvium portulacastrum (L.) L.*	B	22.22	2.42	11.50
37.	*Setaria glauca Kunth*	B	38.89	2.00	5.43
38.	*Setaria intermedia Roem. & Schult.*	B	33.33	2.58	8.17
39.	*Sida acuta Burm. f.*	C	44.44	3.16	7.50
40.	*Sida rhombifolia L.*	A	11.11	0.58	5.50
41.	*Tinospora sinensis (Lour.) Merr.*	A	16.67	0.21	1.33
42.	*Tridax procumbens (L.) L.*	A	11.11	0.95	9.00
43.	*Cyanthillium cinereum (L.) H.Rob.*	B	22.22	1.53	7.25
44.	*Xanthium strumarium L.Sp.*	B	27.78	1.63	6.20

Frequency: *Amaranthus spinosus* L. shows 58.33 % frequency and listed under the class CNext are *Phyla nudiflora* (L.) Greene, *Amaranthus polygamus* L., *Amaranthus cruentus* L., Cyperus *compressus* L., *Senna occidentalis* (L.) Link., *Alternanthera triandra* Lam. having55.56 & 50 % frequency respectively under the class B.

Density: The density of the species Cynodon dactylon (L.) Pers. is 8.47, which is the highestamong all other species. Alternanthera triandra Lam. is the next dense species with a densityvalue 4.21.

Abundance: Cynodon dactylon (L.) Pers. is the most abundant species with a value 26.83.Among the other species most abundant were Sesuvium portulacastrum (L) L., Eleusinecoracana (L.) Gaertn. Tridax procumbens L., Portulaca oleracea L. with values 26.83, 11.50,9.43 & 9 respectively.

Density, diversity and abundance of the herbaceous flora is due to availability of open andfertile land along the Mutha River.

Diversity Indices

Co-existence and competition amongst various species are affected directly by the number ofindividuals in the community. Therefore, knowing the quantitative structure of the communitybecomes essential. Various diversity indices including Simpson's Diversity Index give acomparative and quantitative picture of the community existing in the study area.

To characterize herbaceous vegetation in the study area, the primary data was collected andanalyzed for describing the characteristics of vegetation with reference to species compositionand structural attributes. The diversity measurements reflect as to how many diverse speciesare present, while the density measurements indicate number of individuals of a species in thestudy area. Species diversity is the best measure of community structure and it is sensitive tovarious environmental stresses.

Simpson's Index (D): Simpson's Index (D) basically measures the probability that twoindividual randomly selected from a sample belonging to the same category (Simpson 1949)and hence as index increases, diversity decreases. It was therefore, transformed as 1-Indexwith value ranging from 0 to 1. Values near zero correspond to highly diverse or heterogeneousecosystems and values near one correspond to more homogeneous ecosystems. As per studySimpson's index (D) is 0.03. Hence, project area are has heterogeneous ecosystem.

Shannon Index (H): Shannon diversity index (H), also referred to as a Shannon – Weaverdiversity index, takes into account both number and evenness of categories considered and canbe increased either by greater evenness or more unique species. Normally, the Shannon's indexranges between 1.5 to 3.5 and rarely goes to 4.5. Shannon Diversity Index (H) in the study areais 3.49.

Species Richness: Species Richness is a measure of species found in a sample. Since, thelargerthe sample, more the species we would expect to find, the number of species isdivided by thesquare root of the number of individuals in the sample. This particularmeasure of speciesrichness is known as D, the Menhinick's Index.

Formula: $D = s/\sqrt{N}$

Where

s = number of different species represented in the sample.

N= Total number of individual organism in the sample

Herbaceous study shows value of Species richness D, (i.e. Menhinick's index D) 1.59.

B. Riverine and Aquatic Vegetation of Mutha River

Macrophytes are aquatic plants, growing in or near water that are either emergent, submerged,or floating. Aquatic macrophytes may be native to an area or they may be exotic.

Free floating aquatic weeds such as Eichhorina crassipes Solms (Pontederiaceae), Pistiastratiotes L. (Araceae), Azolla pinnata R.Br. ssp. Asiatica (Azollaceae) and Lemna minor L.(Lemnaceae) were recorded in Mutha River during study period. Excessive growth of theseweeds itself points out the increased nutrient levels in the water body.

Floral Diversity

Individual species were identified including trees, shrubs and herbs by observing the speciesrandomly from the study area. The species encountered during transect survey were also notedseparately.

Primary data were generated by preparing a general checklist of the trees around 500m studyarea. Total 15128 tree individuals were recorded. The area shows overall 309 species whichincluded 196 Tree species, 80 Herbs and 33 Shrubs species. No flora was enlisted under theIndian Forest Act (1927). List of Floral Diversity recorded in the study area are given in Annexure 7.3 and Checklist of Herbs and Shrubs are given in Annexure 7.4.

C. Likely to be affected Trees due to Proposed Alignment

Likely to be affected trees are identified and certified by Botanical Survey of India,Government of India, Ministry of Environment, Forest and Climate Change vide Letter No.BSI/WRC/IDEN.CER./2017/H3-38 dated 24.11.2017. Please refer Table 7.19& 7.20 and Figure 7.17.

Table 7.19: List of Trees likely to be Affected

S. No	Local Name	Scientific Name	Lattitude and Longitude	GrithM	Height M	Canopy DiaM
1.	Rain Tree	Albizia saman (Jacq.) Merr.	18°30'48.48"N 73°50'29.17"E	0.6	6	4
2.	Villayati Chinch	Pithecellobium dulce (Roxb.)Benth.	18°30'48.65"N7 3°50'29.43"E	0.9	12	6
3.	Rain Tree	Albizia saman (Jacq.) Merr.	18°30'48.81"N 73°50'30.24"E	1.7	16	12
4.	Rain Tree	Albizia saman (Jacq.) Merr.	18°30'48.90"N 73°50'30.35"E	3	18	16
5.	Villayati Chinch	Pithecellobium dulce (Roxb.)Benth.	18°30'48.92"N 73°50'30.54"E	0.7	8	6
6.	Villayati Chinch	Pithecellobium dulce (Roxb.)Benth.	18°30'49.04"N 73°50'30.47"E	1	6	4

7.	Rain Tree	Albizia saman (Jacq.) Merr.	18°30'49.08"N 73°50'30.59"E	3.3	16	16
8.	Umber	Ficus racemosa L.	18°30'49.28"N 73°50'31.12"E	0.7	6	6
9.	Villayati Chinch	Pithecellobium dulce (Roxb.)Benth.	18°30'49.38"N 73°50'31.25"E	0.3	8	2
10.	Rain Tree	Albizia saman (Jacq.) Merr.	18°30'49.50"N 73°50'31.60"E	0.7	10	4
11.	Villayati Chinch	Pithecellobium dulce (Roxb.)Benth.	18°30'50.02"N 73°50'32.62"E	0.8	10	6
12.	Villayati Chinch	Pithecellobium dulce (Roxb.)Benth.	18°30'50.14"N 73°50'32.86"E	0.8	10	10
13.	Rain Tree	Albizia saman (Jacq.) Merr.	18°30'51.12"N 73°50'34.29"E	1.8	12	10
14.	Rain Tree	Albizia saman (Jacq.) Merr.	18°30'51.32"N 73°50'34.24"E	1.3	12	10
15.	Jangali Badam	Sterculia foetida L.	18°31'12.52"N 73°50'50.62"E	1.3	8	6
16.	Jangali Badam	Sterculia foetida L.	18°31'12.81"N 73°50'51.48"E	1.6	10	8
17.	Jangali Badam	Sterculia foetida L.	18°31'13.23"N 73°50'51.23"E	1.2	10	6
18.	Jangali Badam	Sterculia foetida L.	18°31'13.45"N 73°50'51.52"E	1.2	12	8
19.	Jangali Badam	Sterculia foetida L.	18°31'13.56"N 73°50'51.72"E	1.4	12	8
20.	Jangali Badam	Sterculia foetida L.	18°31'13.78"N 73°50'51.92"E	1.1	10	6
21.	Jangali Badam	Sterculia foetida L.	18°31'13.95"N 73°50'52.21"E	1	8	6
22.	Jangali Badam	Sterculia foetida L.	18°31'14.12"N 73°50'52.43"E	1	8	6
23.	Babool	Acacia nilotica (L) Delile	18°31'14.08"N 73°50'52.86"E	1.8	10	10
24.	Babool	Acacia nilotica (L) Delile	18°31'16.37"N 73°50'55.13"E	0.8	8	6
25.	Karanj	Pongania pinnata (L.) Pierre	18°31'16.87"N 73°50'56.74"E	0.8	6	6
26.	Villayati Chinch	Pithecellobium dulce (Roxb.)Benth.	18°31'17.33"N 73°50'59.28"E	0.3	4	4
27.	Villayati Chinch	Pithecellobium dulce (Roxb.)Benth.	18°31'17.38"N 73°50'59.61"E	0.3	4	4
28.	Babool	Acacia nilotica (L) Delile	18°31'17.41"N 73°50'59.97"E	0.3	5	6
29.	Subabul	Leucaena leucocephala (Lam.)de Wit	18°31'17.64"N 73°51'1.43"E	1.4	6	8
30.	Pimpal	Ficus religiosa L.	18°31'17.67"N 73°51'1.57"E	0.8	6	8

31.	Vad	Ficus benghalensis L.	18°31'17.74"N 73°51'1.69"E	1.4	8	8
32.	Jambhul	Syzygium cumini (L.) Skeels	18°31'17.80"N 73°51'1.82"E	0.7	6	4

Table 7.20: List of Trees likely to be affected trees - Species Count

S. No.	Scientific Name	Local Name	Number
1	Acacia nilotica (L) Delile	Babool	3
2	Ficus benghalensis L.	Vad	1
3	Ficus racemosa L.	Umber	1
4	Ficus religiosa L.	Pimpal	1
5	Leucaena leucocephala (Lam.) de Wit	Subabul	1
6	Syzygium cumini (L.) Skeels	Jambhul	1
7	Pithecellobium dulce (Roxb.) Benth.	Villayati Chinch	8
8	Albizia saman (Jacq.) Merr.	Rain Tree	7
9	Sterculia foetida L.	Jangali Badam	8
10	Pongania pinnata (L.) Pierre	Karanj	1
		Total	**32**

Figure 7.17: Details of Trees within 1.45 km stretch of Metroalong the Left bank of Mutha River

Sr. No.	Local Name	Scientific Name	T/C	Girth_M	Height_M	Canopy_Dia_M
1	Rain Tree	*Albizia saman* (Jacq.) Merr.	T	0.6	6	4
2	Villayati Chinch	*Pithecellobium dulce* (Roxb.) Benth.	T	0.9	12	6
3	Rain Tree	*Albizia saman* (Jacq.) Merr.	C	1.7	16	17
4	Rain Tree	*Albizia saman* (Jacq.) Merr.	C	3	18	16
5	Villayati Chinch	*Pithecellobium dulce* (Roxb.) Benth.	T	0.7	8	6
6	Villayati Chinch	*Pithecellobium dulce* (Roxb.) Benth.	T	1	6	4
7	Rain Tree	*Albizia saman* (Jacq.) Merr.	C	3.3	16	16
8	Umber	*Ficus racemosa* L.	T	0.7	6	6
9	Villayati Chinch	*Pithecellobium dulce* (Roxb.) Benth.	T	0.3	8	2
10	Rain Tree	*Albizia saman* (Jacq.) Merr.	T	0.7	10	4
11	Villayati Chinch	*Pithecellobium dulce* (Roxb.) Benth.	T	0.8	10	6
12	Villayati Chinch	*Pithecellobium dulce* (Roxb.) Benth.	T	0.8	10	10
13	Rain Tree	*Albizia saman* (Jacq.) Merr.	C	1.8	12	10
14	Rain Tree	*Albizia saman* (Jacq.) Merr.	C	1.3	12	10
15	Jangali Badam	*Sterculia foetida* L.	T	1.3	8	6
16	Jangali Badam	*Sterculia foetida* L.	T	1.6	10	8
17	Jangali Badam	*Sterculia foetida* L.	T	1.2	10	6
18	Jangali Badam	*Sterculia foetida* L.	T	1.2	12	8
19	Jangali Badam	*Sterculia foetida* L.	T	1.4	12	8
20	Jangali Badam	*Sterculia foetida* L.	T	1.1	10	8
21	Jangali Badam	*Sterculia foetida* L.	T	1	8	6
22	Jangali Badam	*Sterculia foetida* L.	T	1	8	6
23	Babool	*Acacia nilotica* (L.) Delile	C	1.8	10	10
24	Babool	*Acacia nilotica* (L.) Delile	C	0.8	8	6
25	Karanj	*Pongamia pinnata* (L.) Pierre	T	0.8	6	6
26	Villayati Chinch	*Pithecellobium dulce* (Roxb.) Benth.	T	0.3	4	4
27	Villayati Chinch	*Pithecellobium dulce* (Roxb.) Benth.	T	0.3	4	4
28	Babool	*Acacia nilotica* (L.) Delile	C	0.3	5	6
29	Subabul	*Leucaena leucocephala* (Lam.) de Wit	C	1.4	6	8
30	Pimpal	*Ficus religiosa* L.	T	0.8	6	8
31	Vad	*Ficus benghalensis* L.	T	1.4	8	8
32	Jambhul	*Syzygium cumini* (L.) Skeels	T	0.7	6	4

T: Transplant & C: Cut

7.4.2. Faunal Diversity

The checklists of Butterflies, Dragonflies, Damselflies, Amphibians, Reptiles and Mammalwhich are present in the study area, are discussed as below.

A. Butterfly Diversity

The distribution patterns of 30 butterfly species recorded during thestudy period are given in Table 7.21. Nymphalidae was most dominant followed by Papilionidae. Common Rose,LimeButterfly, Common Jay, Common Emigrant, Common Grass Yellow, Small Grass Yellow,
Blue Tiger, Plain Tiger, Lesser Grass Blue etc, (refer Figure 7.18) are common inthe study area. Butterfly diversity in the study area is due to presence of herbaceous flora.

Table 7.21: Checklist of Butterflies in and around Study Area

S.No	Scientific Name	Common Name	IWPA Status	IUCN Status
Nymphalidae				
1.	Ariadne ariadne	Angled Castor	Not Enlisted	Not Enlisted
2.	Danaus chrysippus	Plain Tiger	Not Enlisted	Not Enlisted
3.	Euploea core	Common Indian Crow	Sch-IV	Least Concern
4.	Hypolimnas misippus	Danaid Eggfly	Sch-II	Not Enlisted
5.	Junonia almana	Peacock Pansy	Not Enlisted	Least Concern
6.	Junonia atlites	Grey Pansy	Not Enlisted	Not Enlisted
7.	Junonia hierta	Yellow Pansy	Not Enlisted	Least Concern
8.	Junonia iphita	Chocolate Pansy	Not Enlisted	Not Enlisted
9.	Junonia lemonias	Lemon Pansy	Not Enlisted	Not Enlisted
10.	Junonia orithya	Blue Pansy	Not Enlisted	Not Enlisted
11.	Melanitis leda	Common Evening Brown	Not Enlisted	Not Enlisted
12.	Neptis hylas	Common Sailer	Not Enlisted	Not Enlisted
13.	Parantica aglea	Glassy Tiger	Not Enlisted	Not Enlisted
14.	Phalanta phalantha	Common Leopard	Not Enlisted	Not Enlisted
15.	Tirumala limniace	Blue Tiger	Not Enlisted	Not Enlisted
16.	Vanessa cardui	Painted Lady	Not Enlisted	Not Enlisted
Pieridae				
17.	Eurema hecabe	Common Grass Yellow	Not Enlisted	Not Enlisted
18.	Eurema brigitta	Small Grass Yellow	Not Enlisted	Least Concern
19.	Eurema laeta	Spotless Grass Yellow	Not Enlisted	Not Enlisted
Papilionidae				
20.	Papilio polytes	Common Mormon	Not Enlisted	Not Enlisted
21.	Pachliopta	Common Rose	Not Enlisted	Not Enlisted
22.	Papilio demoleus	Lime Butterfly	Not Enlisted	Not Enlisted
23.	Graphium doson	Common Jay	Not Enlisted	Not Enlisted
24.	Graphium agamemnon	Tailed Jay	Not Enlisted	Not Enlisted
25.	Catopsilia pomona	Common Emigrant	Not Enlisted	Not Enlisted
26.	Delias eucharis	Common Jezebel	Not Enlisted	Not Enlisted
27.	Pareronia valeria	Common Wanderer	Not Enlisted	Not Enlisted
28.	Colotis fausta	Large Salmon Arab	Not Enlisted	Not Enlisted
29.	Colotis etrida	Small Orange Tip	Not Enlisted	Not Enlisted
Lycaenidae				
30.	Zizina otis	Lesser Grass Blue	NotEnlisted	Not Enlisted

Figure 7.18: Photographs of Common Butterflies observed in the study area

Plain Tiger

Indian Leopard

Lesser Grass Blue

Common Jay

B. Dragonflies and Damselflies

Eight species of dragonflies and four species of damselflies were found in the study area.Species like Trithemis aurora, Orthetrum sabina and Acisoma panorpoides were commonlyseen throughout the project area while damselfly Ischnura aurora was common in theperiphery of the project site. Please refer Table 7.22 and Figure 7.19.

Table 7.22: Checklist of Dragonflies and Damselflies in and around Study Area

S. No.	Scientific Name	Common Name	IWPA Status	IUCN Status
Dragonflies				
1.	Trithemis aurora	Crimson Marsh Glider	Not enlisted	Not enlisted
2.	Brachythemis contaminata	Ditch Jewel	Not enlisted	Not enlisted
3.	Acisoma panorpoides	Asian Pintail	Not enlisted	Not enlisted
4.	Trithemis pallidinervis	Long Legged Marsh Skimmer	Not enlisted	Not enlisted
5.	Rhyothemis variegata	Common Picture Wing	Not enlisted	Not enlisted
6.	Pantala flavescens	Globe Skimmer	Not enlisted	Least Concern
7.	Ictinogomphus rapax	Common Clubtail	Not enlisted	Least Concern
8.	Orthetrum sabina	Green Marsh Hawk	Not enlisted	Least Concern
Damselflies				
9.	Ischnura aurora	Golden Dartlet	Not enlisted	Not enlisted
10.	Ischnura senegalensis	Senegal Golden Dartlet	Not enlisted	Not enlisted
11.	Pseudagrion decorum	Three Striped Blue Dart	Not enlisted	Not enlisted
12.	Ceriagrion rubiae	Orange Marsh Dart	Not enlisted	Not enlisted

Figure 7.19: Photographs of Common Dragonflies observed in the Study Area

Crimson Marsh Glider

Asian Pintail

Common Picture Wing

Green Marsh Hawk

C. Amphibian Diversity

Our present survey reveals 6 species of frogs belonging to 3 families, dominated by CommonIndian Toad and Skipper Frog(refer Table 7.23).

Table 7.23: Amphibians Observed in the Study Area

S. No.	Scientific Name	Common Name	IWPA Status	IUCN Status
Ranidae				
1.	Euphlyctis ehrenbergii	Skipper Frog	Sch-IV	Least Concern
2.	Hoplobatrachus tigerinus	Indian Bull Frog	Sch-IV	Least Concern
3.	Fejervarya limnocharis	Grass Asian Frog	Sch-IV	Least Concern
Rhacophoridae				
4.	Polypedatus maculatus	Common Tree Frog	Not Enlisted	Least Concern
Bufonidae				
5.	Duttaphrynus melanostictus	Common Indian Toad	Not Enlisted	Least Concern
6.	Euperdon globulosus	Indian Balloon Frog	Not Enlisted	Not Enlisted

D. Reptile Diversity

During site visits the following four reptiles were observed. Please refer Table 7.24.

Table 7.24: Checklist of Reptiles within Study Area

S. No	Common name	Scientific name	IWPA Status	IUCN Status
1.	Hemidactylus frenatus	Common house gecko	Not Enlisted	Least Concern
2.	Calotes versicolor	Indian garden lizard	Not Enlisted	Not Enlisted

S. No	Common name	Scientific name	IWPA Status	IUCN Status
3.	Chamaeleo zeylanicus	Chameleon	Sch - II	Least Concern
4.	Ptyas mucosa	Indian rat snake	Sch-IV	Not Enlisted

E. Mammals

The survey revealed that fourteen species of common mammals were recorded while no wildmammal was observed in this area. Goat, buffalo, cow and squirrel were commonly seen.Please refer Table 7.25 and Figure 7.20.

Table 7.25: Checklist of Mammals

S. No.	Scientific Name	Common Name	IWPA Status	IUCN Status
Pteropodidae				
1.	Rousettus leschenauti	Fulvous Fruit Bat	Sch-V	Not enlisted
2.	Pteropus giganteus	Indian Flying Fox	Sch-IV	Least Concern
Vespertilionidae				
3.	Pipistrellus coromandra	Little Indian Bat	Not Enlisted	Least Concern
Herpestidae				
4.	Herpestes edwardsii	Indian Grey Mongoose	Sch-II	Least Concern
Felidae				
5.	Felis catus	Common Cat	Not enlisted	Not enlisted
Canidae				
6.	Canis lupus familiaris	Common Dog	Not enlisted	Not enlisted
Bovidae				
7.	-	Cow	Not enlisted	Not enlisted
8.	Bubalus bubalis	Domestic Buffalo	Not enlisted	Not enlisted
9.	Capra hircus aegagrus	Goat	Not enlisted	Not enlisted
Equidae				
10.	Equus ferus caballus	Horse	Not enlisted	Not enlisted
Sciuridae				
11.	Funambulus palmarum	Three Striped PalmSquirrel	Sch-V	Least Concern
12.	Funambulus pennantii	Five Striped PalmSquirrel	Sch-IV	Not enlisted
Muridae				
13.	Bandicota bengalensis	Lesser Bandicoot Rat	Not Enlisted	Least Concern
14.	Rattus rattus	Common House Rat	Sch-V	Least Concern

Figure 7.20: Domestic Mammals observed in the Study Area

Goat

Domestic Buffalo


Three Striped Palm Squirrel


Horse (*Equus Ferus Caballus*)

F. Avifaunal Diversity

The checklist of birds is given in Table 7.26. Birds like house crow, common myna, housesparrow, blue rock pigeon, red wattled lapwing, pond heron, white breasted kingfisher etc. Weredominant in the study area (refer Figure 7.21).

Table 7.26: Checklist of Avifauna

S. No.	Scientific Name	Common Name	IUCN Status	IWPA Status
Order - Ciconiformes				
Family - Ardeidae				
1	Egretta garzetta (Linnaeus, 1766)	Little Egret	LC	Schedule IV
2	Ardea alba (Linnaeus, 1758)	Great Egret	LC	Schedule IV
3	Bubulcus ibis (Linnaeus, 1758)	Cattle Egret	LC	Schedule IV
4	Ardeola grayii (Sykes, 1832)	Indian Pond-Heron	LC	-
Order - Falconiformes				
Family - Accipitridae				
5	Milvus migrans (Boddaert, 1783)	Black Kite	LC	-
Order - Charadriiformes				
Family - Charadriidae				
6	Vanellus indicus (Boddaert, 1783)	Red-wattled Lapwing	LC	-
Family - Laridae				
7	Sterna aurantia J.E. Gray, 1831	River Tern	NT	-
Order - Columbiformes				
Family - Columbidae				
8	Columba livia Gmelin, 1789	Rock Dove	LC	Schedule IV
9	Streptopelia senegalensis (Linnaeus, 1766)	Laughing Dove	LC	Schedule IV
Order - Psittaciformes				
Family - Psittacidae				
10	Psittacula krameri (Scopoli, 1769)	Rose-ringed Parakeet	LC	Schedule IV
Order - Cuculiformes				
Family - Cuculidae				
11	Eudynamys scolopacea (Linnaeus, 1758)	Asian Koel	LC	-
12	Centropus sinensis (Stephens, 1815)	Greater Coucal	LC	-
Order - Apodiformes				
Family - Apodidae				
13	Apus affinis (J.E. Gray, 1830)	Little Swift	LC	-
Order - Coraciiformes				

S. No.	Scientific Name	Common Name	IUCN Status	IWPA Status
Family - Alcedinidae				
14	Alcedo atthis (Linnaeus, 1758)	Common Kingfisher	LC	Schedule IV
15	Halcyon smyrnensis (Linnaeus, 1758)	White-breasted Kingfisher	LC	Schedule IV
Family - Meropidae				
16	Merops orientalis Latham, 1801	Small Green Bee-eater	LC	-
Family - Coraciidae				
17	Coracias benghalensis (Linnaeus, 1758)	Indian Roller	LC	Schedule IV
Family - Bucerotidae				
18	Ocyceros birostris (Scopoli, 1786)	Indian Grey Hornbill	LC	-
Order - Passeriformes				
Family - Hirundinidae				
19	Hirundo concolor Sykes, 1833	Dusky Crag-Martin	LC	-
20	Hirundo rustica Linnaeus, 1758	Common Swallow	LC	-
21	Hirundo tahitica Gmelin, 1789	House Swallow	LC	-
Family - Pycnonotidae				
22	Pycnonotus cafer (Linnaeus, 1766)	Red-vented Bulbul	LC	Schedule IV
Family - Laniidae				
23	Lanius vittatus Valenciennes, 1826	Bay-backed Shrike	LC	-
24	Lanius schach Linnaeus, 1758	Rufous-backed Shrike	LC	-
Family - Muscicapidae Subfamily - Turdinae				
25	Saxicoloides fulicata (Linnaeus, 1776)	Indian Robin	LC	-
	Family - Muscicapidae Subfamily - Timaliinae			
26	Turdoides malcolmi (Sykes, 1832)	Large Grey Babbler	LC	Schedule IV
Family - Muscicapidae Subfamily -Sylviinae				
27	Prinia socialis Sykes, 1832	Ashy Prinia	LC	-
28	Orthotomus sutorius (Pennant, 1769)	Common Tailorbird	LC	-
Family - Nectariniidae				
29	Cinnyris asiaticus (Latham, 1790)	Purple Sunbird	LC	Schedule IV
Family - Zosteropidae				
30	Zosterops palpebrosus (Temminck, 1824)	Oriental White-eye	LC	Schedule IV
Family - Passeridae Subfamily - Passerinae				
31	Passer domesticus (Linnaeus, 1758)	House Sparrow	LC	-
Family - Passeridae Subfamily - Ploceinae				
32	Ploceus philippinus (Linnaeus, 1766)	Baya Weaver	LC	Schedule IV
Family - Sturnidae				
33	Sturnus pagodarum (Gmelin, 1789)	Brahminy Starling	LC	Schedule IV
34	Acridotheres tristis (Linnaeus, 1766)	Common Myna	LC	Schedule IV
Family - Dicruridae				
35	Dicrurus macrocercus Vieillot, 1817	Black Drongo	LC	Schedule IV
Family - Corvidae				
36	Corvus splendens Vieillot, 1817	House Crow	LC	Schedule V

IWPA: Indian WildlifeProtection Act
IUCN: InternationalUnionforConservationofNatureand NaturalResources

Figure 7.21: Photographs of Avian Diversity

House Crow | Common Myna | House Sparrow

Blue Rock Pigeon | Red wattled Lapwing | Pond Heron

White Breasted Kingfisher | Black Kite | Little Brown Dove

7.4.3. Wetland Ecology

Wetlands are areas where water is at, near, or just above the surface and where soils are watersaturated for a sufficient length of time such that excess water and resulting low soil oxygenlevels are principal determinants of vegetation and soil development. Wetlands will have arelative abundance of obligate hydrophytes in the vegetation community and soils featuring“hydric” characteristics. From an ecological perspective, either an abundance of hydrophytesor indicators of hydric soil conditions is generally sufficient to indicate a wetland ecosystem.The boundary of the wetland is identified by changes in vegetation structure, loss ofhydrophytes, and wetland soil characteristics. Figure 7.22 showing anthropogenicactivities in the Mutha River.

A. Phytoplankton

Plankton consists of any drifting animals and plants that inhabit oceans, seas, or bodies ofwater. Local abundance varies horizontally, vertically and seasonally. The primary cause ofthis variability is the availability of light. All plankton ecosystems are driven by the input ofsolar energy, confining primary production to surface waters, and to geographical regionsandseasons having abundant light.

Figure 7.22: View of Mutha River & Anthropogenic Activities

Phytoplankton is the autotrophic component of the plankton community. Most phytoplanktonis too small to be individually seen with the unaided eye. However, when present in highenough numbers, they may appear as a green discoloration of the water due to the presence ofchlorophyll within their cells. Phytoplanktons are the foundation of the aquatic food chain.Phytoplankton obtains energy through the process of photosynthesis and must therefore live inthe well-lit surface layer of an ocean, sea, lake, or other body of water. Phytoplankton accountsfor half of all photosynthetic activity on Earth.

Shannon Wiener Diversity Index (SWI): Shannon Wiener Diversity Index (d) is a measure ofdiversity which takes into account the total count and individual count in water sample. Awidely accepted ecological concept is that community with large number of species i.e. withhigh diversity will have stability and thus have the capability to resist adverse environmentinfluences to certain extent. “The Shannon Wiener index” values in the range of 3 andaboveare generally considered to represent healthy conditions of water. The valuesbetween 1 and 3are believed to indicate semi and poor productivity respectively. It is expressed as follows.

$$\text{SWI} = -\sum \frac{ni}{N} \log_2 \frac{ni}{N}$$

Where,

SWI = Shannon Wiener Diversity Index
N = Total number of individuals of species in a sample
n = number of individuals of species in a sample

Palmer Pollution Index (PPI): Palmer (1969) made the first major attempt to identify andprepare a list of genera and species of algae tolerant to organic pollution. According to Palmer(1969), a total score of 20 or more in a sample is an indicator of organic pollution. The valuesbetween 15 and 20 are believed to indicate semi & poor productivity and below 15 is an indicatorof absence of organic pollution respectively. Pollution tolerant genera and species of fourgroups of algae from five sites were encountered. Palmer's (1969) has shown that the generalike Oscillatoria, Euglena, Anabaena, Scenedesmus and Navicula are the species found inorganically polluted waters supported by Gunale and Balakrishnan (1981). Similar genera arerecorded in the present investigation.List of pollution tolerant is represented in Table 7.27.

Table 7.27: Algal Genus Palmer Pollution Index (PPI) (Palmer, 1969)

S.No	Genus	Pollution Index
1.	Anacystis	1
2.	Ankistrodesmus	2
3.	Chlamydomonas	4
4.	Chlorella	3
5.	Closterium	1
6.	Cyclotella	1
7.	Euglena	5
8.	Gomphonema	1
9.	Lepocinclis	1
10.	Melosira	1
11.	Micractinium	1
12.	Navicula	3
13.	Nitzschia	3
14.	Oscillatoria	5
15.	Pandorina	1
16.	Phacus	2
17.	Phormidium	1
18.	Scenedesmus	4
19.	Stigeoclonium	2
20.	Synedra	2

PPI varied between 15 and 22indicating presence of organic pollution. Dominance of Cyanophyceae clearly indicatestendency towards organic pollution. Also, emergence of Euglenophyceae denotes enrichmentof organic pollutants. In Mutha River, occurrence of high pollution indicator species is more.The algae like Anabena, Microcystis, Aphanocapsa and Oscillatoria that were recordedprimarily in Mutha River, are prone to form dense surface water blooms and excreting organiccompounds creating serious problems in the river.

Count: Phytoplankton counts recorded at different sampling stations are presented in Table7.28&7.29 and Figure 7.23 to 7.27. Total algal population varied between 3360 and5530 algal cells ml^{-1}. Garware Bridge U/S showed highest count of phytoplankton. Thephytoplankton population comprised 4 major groups, namely Cyanophyceae, Chlorophyceae,Bacillariophyceae and Euglenophyceae with thirteen genera. Cyanophyceae dominated all thesamples. The SWI values varied between 0.98 and 1.62 that suggest low to medium impact ofpollution or adverse factor.

Table 7.28: Enumeration of Phytoplankton in Mutha River and values of SWI & PPI

Sample No.	Sampling Locations	Phyto-plankton (No/ml)	Percent Composition of algal groups				SWI	PPI
			Cyano-phyceae	Chloro-phyceae	Bacillario-phyceae	Eugleno-phyceae		
1.	Garware BridgeU/S	5530	50	30	10	10	1.19	20
2.	Panchaleshwar Temple Ghat	4320	65	25	10	0	1.62	22
3.	OppositeChhatrapat iSambhaji Udyan	5100	55	30	15	-	1.40	15
4.	Near SavarkarBhavan	3360	45	25	20	10	0.98	17
5.	Shivaji Bridge	3950	60	20	20	-	1.50	19

Significance of Ranges of Shannon Wiener Diversity Index (SWI)

<1: Indicates poor productive water

1 to 3 Indicate medium productive water

>3 Indicates good productive water

Significance of Ranges of Palmer's Pollution index (PPI)

<15: Indicate absence of organic pollution.

15 to <20: Indicate presence of organic pollution

>20: Indicate presence of high organic pollution

Table 7.29: Phytoplankton Genera Recorded in Mutha River

S. No	Phytoplankton Genera	Garware BridgeU/S	Panchaleshwar Temple Ghat	OppositeChh atrapati Sambhaji Udyan	Near Savarkar Bhavan	Shivaji Bridge
Chlorophyceae						
	Closterium sp.	+	-	+	-	-
	Scenedesmus sp	+	+	-	+	+
	Synedra sp.	+	-	+	+	-
	Ulothrix sp	+	+	-	+	+
	Pandorina sp.	+	+	+	-	+
Bacillariophyceae						
	Navicula sp.	+	+	+	-	+
	Fragillaria sp.	-	+	+	+	-
	Gomphonema sp.	+	-	+	-	+
Cyanophyceae						
	Anabaena sp.	+	+	+	+	+
	Oscillatoria sp.	+	+	+	+	+
	Aphanocapsa sp.	+	+	+	+	+
	Microcystis sp.	+	-	+	+	+
Euglenophyceae						
1.	Euglena sp.	+	-	-	-	+

Figure 7.23: Phytoplankton counts observed in Mutha River

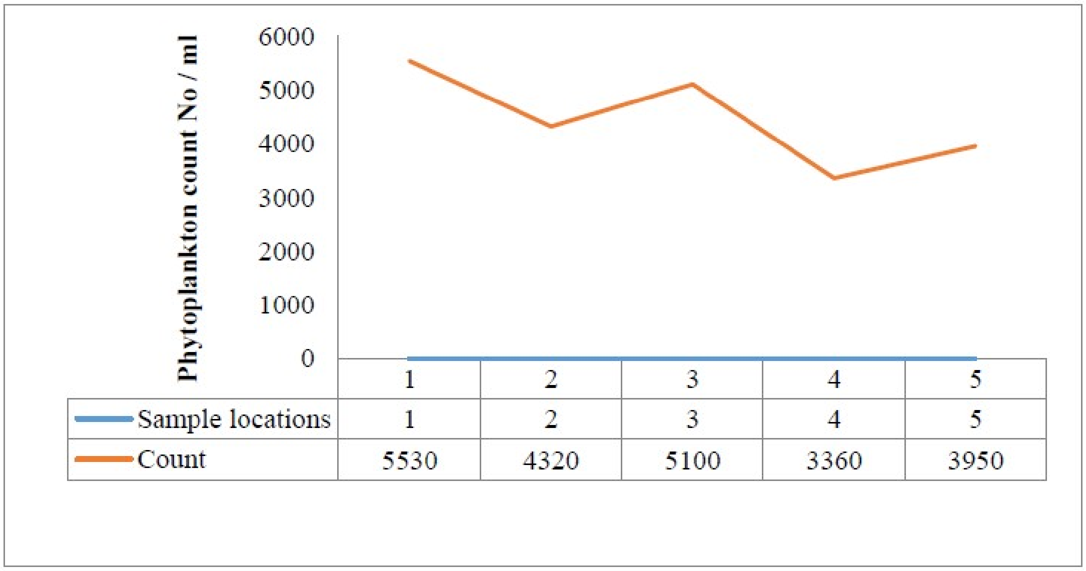


Figure 7.24: SWI counts observed in Mutha River

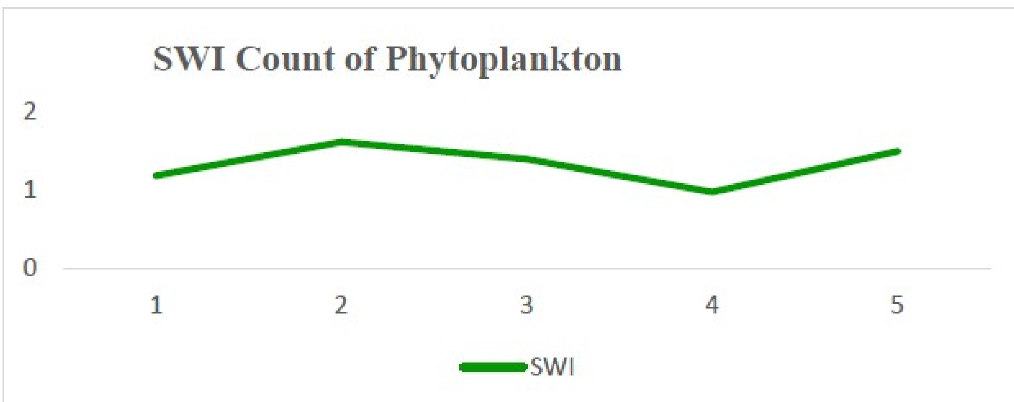


Figure 7.25: PPI counts observed in Mutha River

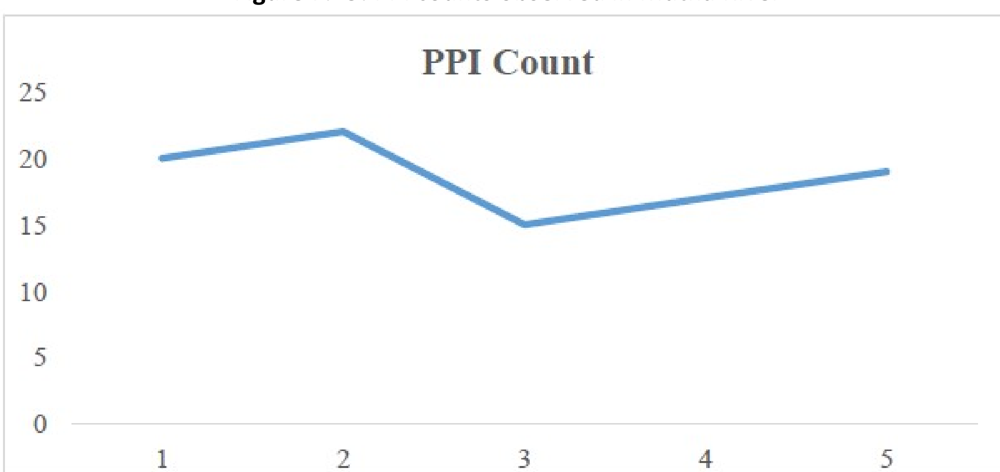


Figure 7.26: Percent composition of algal groups of Phytoplankton observed in MuthaRiver

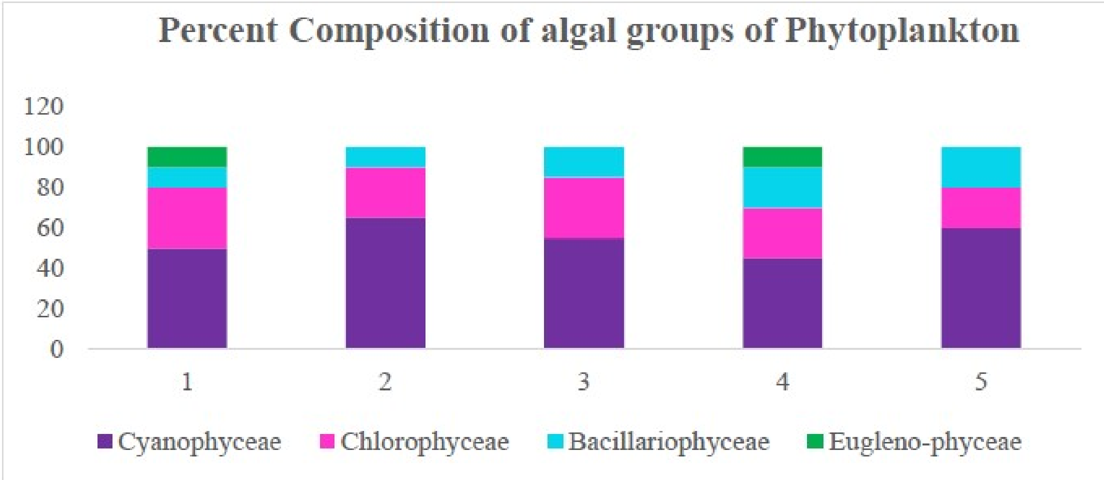
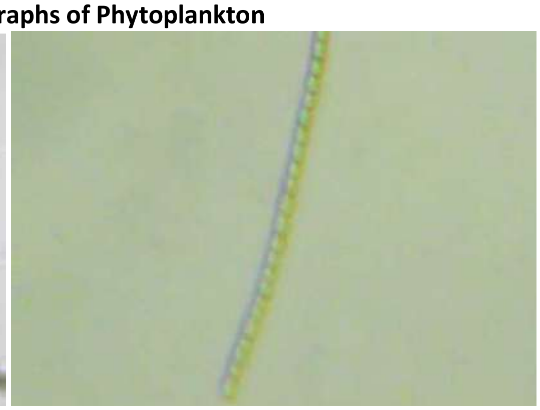


Figure 7.27: Photographs of Phytoplankton

Oscillatoria



Anabaena

Closterium

Chlamyd omonas

A positive correlation was observed between temperature and occurrence of phytoplankton.Similar results were obtained by Wagh et al. (2008) in Assessment of Water Quality of MuthaRiver in Pune City. Several researchers have proposed temperature as a vital factor responsiblefor the growth of algae.

The growth and photosynthesis of algae are influenced by the pH and alkalinity of water. Inthe present study the pH values of Mutha River varied between 6.5 and 7.3. Similar resultswere also observed by Pali Sahu et al. (2015).She reported that the pH values ranged from 6.71to 8.40 in Mula- Mutha River. According to Pali Sahu et al. (2015), the major sources ofpollution of river Mula -Mutha are presence of dissolved salts and carbonates of thesurrounding soil, waste from temples, additional flow of domestic waste and agricultural wastewhich is mainly organic matter, and other solid waste in to the water.

In the present investigation, phytoplankton showed positive correlation with pH, chloride,alkalinity and hardness.

Mutha River surroundings showed that the major sources of pollution are solid waste disposal,religious activities, domestic washing, clothes washing, bathing, cattle wading, run off anddecay of macrophytes.

B. Zooplankton

Zooplankton is microscopic aquatic animals having no resistance to currents, free floated andsuspended in open or pelagic waters. The zooplankton includes animals suspended in waterwith limited powers of locomotion. The distinction between suspended zooplankton is onehaving limited powers of locomotion, and animals capable of swimming independently ofturbulence.

Zooplankton counts, recorded at different sampling stations, are shown in below Table 7.30 & 7.31 and Figure 7.28 to 7.31. Density of Zooplankton varied between 1730 and2610 N/m3. Zooplankton comprised of 3 major group’s i.e. Rotifera, Copepoda and Cladocera with eight different genera. A large number of zooplankton, recorded in Garware Bridge U/S couldbe due to the presence of ample amount of phytoplankton in the respective station. Rotiferadominated all the samples. The SWI, observed to vary from 1.20 to 1.82 indicated low tomedium load of organic pollution or adverse factors. High pollution indicator genera, likeBrachionus, Cyclops and Daphnia were observed in the river.

Table 7.30: Enumeration of Zooplankton in Mutha River

Sample No.	Sampling Locations	Zooplankton Count No/m3	Percent Composition of algal			SWI
			Rotifera	Copepoda	Cladocera	
1.	Garware Bridge U/S	2610	50	30	20	1.35
2.	Panchaleshwar Temple Ghat	2530	60	30	10	1.67
3.	Opposite Chhatrapati Sambhaji Udyan	2210	65	25	10	1.30
4.	Near Savarkar Bhavan	1730	55	35	10	1.82
5.	Shivaji Bridge	2050	55	30	15	1.20

Significance of Ranges of Shannon Wiener Diversity Index (SWI)
<1: Indicate poor productive water
1 to 3 Indicate medium productive water
>3 Indicate good productive water

Table 7.31: Zooplankton Genera Recorded in Mutha River

S. No	Zooplankton Genera	Garware Bridge U/S	Panchaleshwar Temple Ghat	Opposite Chhatrapati Sambhaji Udyan	Near Savarkar Bhavan	Shivaji Bridge
Rotifera						
1	Keratella sp.	+	+	+	+	+
2	Brachionus sp.	+	+	+	+	+
3	Asplancha sp.	+	-	+	-	+
Copepoda						
1	Cyclops sp.	+	+	+	+	+
2	Diaptomus sp.	+	+	+	+	+
3	Bryocamptus sp.	+	-	-	+	+
Cladocera						
1	Daphnia sp.	+	+	+	+	-
2	Moina sp.	+	+	+	+	-

Figure 7.28: Zooplankton count observed in the Mutha River

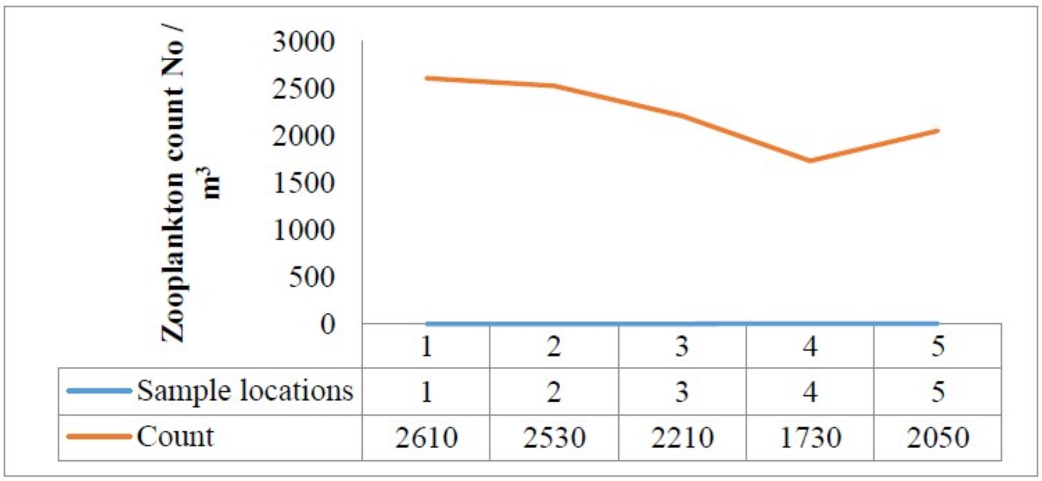


Figure 7.29: SWI Count observed in the Mutha River

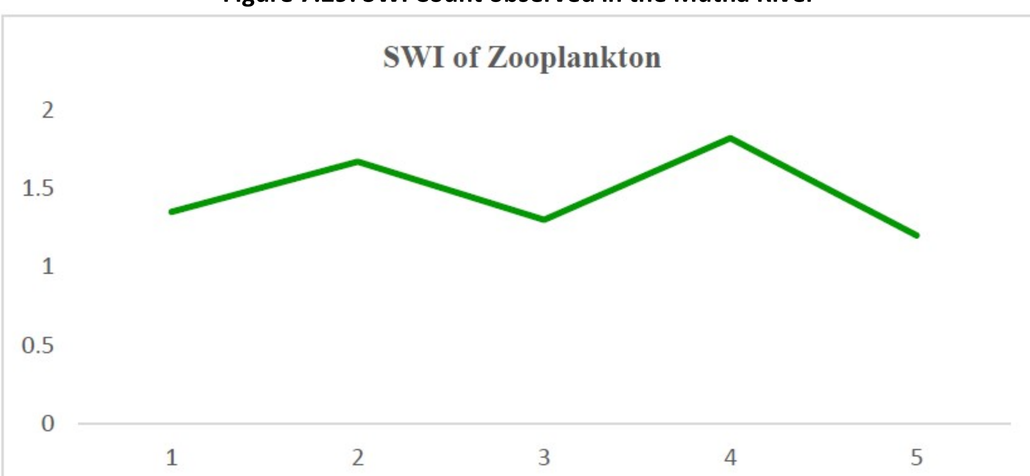


Figure 7.30: Zooplankton Count observed in the Mutha River

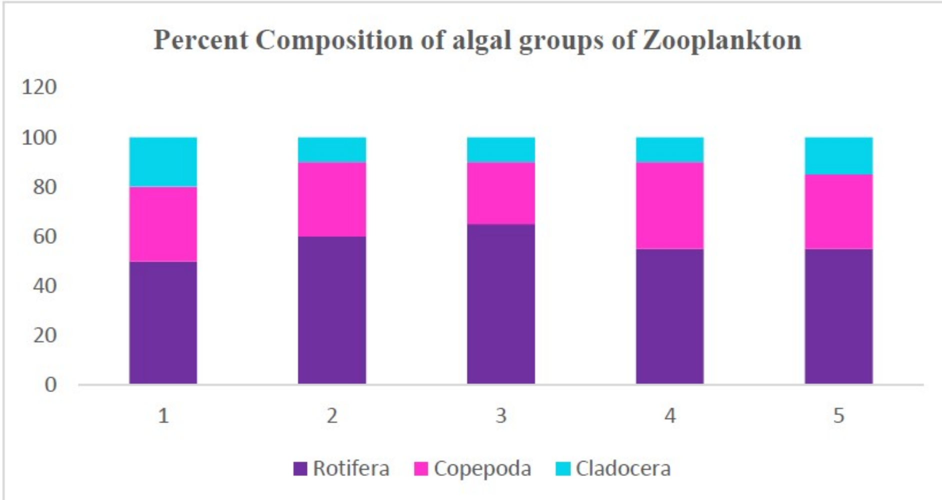


Figure 7.31: Photographs of Zooplankton

Moina Cyclops Brachionus

C. Benthos

The organisms which inhabit the bottom of aquatic body are called benthos. Many of themaresessile; some creep over or burrow in mud and base of water body. The quality and quantity ofanimals found at the bottom is not only related to the nature of substrata but also to depth, thekind and quality of aquatic plants present in such environment. Their number and distributionalso depends upon physico-chemical properties of water and biological complexes such as foodand other factor. The sediments composition and characteristic of the water adjacent to thesediments are also highly variable. Bacteria, fungi and algae may occur in great abundance onsediment. These organism and associated detricial organic matter often provide thepredominant energy sources for the benthic fauna.

Meio and micro fauna are present in and on muddy / coastal / shores water. Therefore, in thepresent study only macro benthos were studied.

Quantitative estimations of benthic fauna require effective sampling procedures, separation oforganisms from the substratum, identification and evaluation of biomass of species and of theirlife history stages.

A number of basic requirements must be met to capture a quantitative sample of the populationliving on and within the sediments. The sampler must penetrate into the sediment to a sufficientdepth to capture all of the organisms inhabiting a defined area. The device should enclose thesame area of sediment each time. As the sampling device is lowered, care should be taken notto disturb the sediments, the sampler should close completely so that sediment and organismsare not lost during retrieval. Please refer Figure 7.32.

Figure 7.32: Benthic Sampling

Sieving of collected sediment for Benthos IsolationInsertion

Insertion of Vanveen grab for sediment collection

Collection of Chironomous larva as benthic organism

A large homogenous sediment sample, collected by the grab sampler, was sieved with a screenmesh of 500 µ sorted out the samples to remove the organisms from the sediment.

One group i.e. Chironomidae was obtained from the 5 sediment samples. Chironomouslarvae are abundant all over the river. The chironomid larvae are known as blood worms, due to thepresence of hemoglobin in their bodies. They represent an abundant group of benthos insectsin freshwater ecosystem. The size of the larva typically ranges from 4 mm to 5mm. The highestcount was 350 m2 Opposite Chhatrapati Sambhaji Udyan. Please refer Table 7.32.

Table 7.32: Benthic fauna recorded at Mutha River

Sample No.	Sampling Locations	Density m^2
1	Garware Bridge U/S	250
2	Panchaleshwar Temple Ghat	200
3	Opposite Chhatrapati Sambhaji Udyan	350
4	Near Savarkar Bhavan	200
5	Shivaji Bridge	250

Note: Only Chironomous larva was observed as benthic fauna

D. Fisheries

Fishes, because of their relatively large size and ease of identification, have long been used asindicators of environmental change. The mobility and sensory perception of many speciesallow them to avoid environmental perturbations, and thus they can show a rapid response toenvironmental changes. Different types of nets having definite meshes, made of nylon twinesare commonly used as gears for fish harvesting.

Preliminary investigation with local fishermen revealed that there are different varieties offishes, viz. Oreochromis mossambicus (Tilapia), Gambusia affinis (Western mosquito fish)Heteropneustes fossilis (Asian stinging catfish), Cyprinus carpio (Common carp) and Ompakbimaculatus (Pabda) normally harvested in the river. It may be mentioned that Tilapia is anexotic hardy fish, breed profusely throughout the year and can tolerate low DO state of water.Since its market price is comparatively less, mostly people from economically weaker sectionslike this fish.

7.5. PUBLIC CONSULTATIONS FOR METRO STRETCH PASSING ALONG MUTHA RIVER

During reconnaissance and field surveys regular interaction was held with the people of varioussections of the society along the project alignment, shopkeepers, pilgrims and influentialpersons of the project area (refer Figure 7.33) Land belong to 1.45 Km of left bankof Mutha river belongs to Irrigation Department. Though, no private land is being acquired forthe Pune Metro alignment, public consultations with pilgrims at various temples, local businesscommunity and Chaupati stall holders were conducted to understand any direct and indirectimpacts on them resulting from the proposed project.

It was observed that most of the stakeholders are aware of the project. Various concerns raisedby the stakeholders along with their valuable suggestions are recorded and presented in Table7.33.

Figure 7.33: Photographs of Public Consultation

Table 7.33: Suggestions of Stakeholders and Mitigation Measures

S. No	Concernsraised	SuggestionofStakeholders	Mitigation Measures
1	TreeCutting	Not to cut the two identicaltrees Couropita guianensis Abul., located at Panchaleshwar Temple. (Pilgrim called Jule, (Twins) Kailaspati, Shivaparvati, Shivalingam)	Alignment is shifted slightly hence thesetwo likely to be affected trees are saved.
2	Access toth e temple	Access to Panchaleshwartemple should not be hamperedduring construction activities.	Existing access to Panchaleshwar &Vridheshwar temple shall be maintained. During construction phase access totemples and Ghats will be given byproviding proper barricades.
3	TrafficMana geme nt	Considering heavy trafficload of two wheelers on river sideroad Traffic should not beaffected during Constructionphase	Traffic management shall be doneeffectively by providing barricades, signage's, signs and all the safety measuresduring construction phase.
4	LaborCamps	Labor camp with all thesanitary facilities should beprovided in construction phase	No labor camp shall be provided in 1.45Km riverside Metro alignment. All the skilled and unskilled labors during constructionphase will have to use the existing facilitiesand designated labor camp from outside ofthe project site.
5	Water,Air Andnoise pollution	Air pollution and noise pollution should be minimized and regular monitoring should be done	Sedimentation of storm water will beminimized by avoiding stockpiling of excavated material. Portable sanitation, treatment and disposal facility shall be provided at construction site. To minimize noise pollution regular maintenance of equipment and vehicles will be done to mitigate noise generation. Roads in the construction area will be sprinkled with water to reduce the uplifting of dust. Tanker water will be used for dustsuppression. Monitoring schedule shall be prepared for monitoring of water, air and noise quality.
6	Socioecono	Local business communityand	No local business community/Chaupatistall

S. No	Concernsraised	SuggestionofStakeholders	Mitigation Measures
	mic Considerations	Chaupati stall holders raised their concerns about displacements and timeline of completion of the Metrorail project.	holder will be affected in 1.45 km Metro rail alignment along the Mutha river. No displacement of Chaupati stall holder is proposed. Construction work of 1.45 km will be completed in six months.

7.6. IMPACT ASSESSMENT

Impact Identification and prediction on the environment due to proposed metro rail projectpassing through Mutha Riverbed have been described below

7.6.1. Impact during Construction Phase

A. Impact on Land Environment

Proposed metro route alignment of approximately 1.45 km passes along the left bank of MuthaRiver from Panchaleshwar temple to Vridheshwar Temple. Land required on left bank of riverfor 39+20 (viaduct + stations) will be 1475 sq.m. for actual construction on ground. The landis belonging to Irrigation Department, Government of Maharashtra.

There is no acquisition of private land proposed for the alignment. However, land other thanMutha River basin of 2500 Sq.m private land shall be acquired for Parking, entry/ exit, 2800 sq.m for Multimodal Hub at Deccan Metro Station. Similarly 1225 Sq.m of Pune MunicipalCorporation land shall be utilized for parking of Chhatrapati Sambhaji Metro Station. Total4425 cubic meter excavated material will be generated. Out of 4,425 cubic meters excavatedmaterial about 295 cubic meter top soil will be generated. Thirty two (32) tress will beaffecteddue to the proposed alignment.

Herbaceous vegetation and Top soil will also disturb due excavation and allied activities.Negative impacts are envisaged due to cutting, leveling and allied construction activities.Overall herbaceous vegetation predominatedwith commonly found weed species. This herbaceous vegetation attract butterfly,dragonfly/damselflies etc. Natural vegetation is much disturbed by anthropogenic pressure.No Rare, Endangered, and Threatened (RET) species of herbaceous flora was observed duringstudy period.

B. Impact on Air Environment

The main source for impact of air quality during construction period is the fugitive dust fromthe activities like excavation, dumping and vehicle movement/ transportation of materials etc.

The overall scenario with predicted concentrations superimposed over the maximum baselineconcentrations is shown in the isopleths (refer Figure 7.34 to Figure 7.36).
Maximum ground level concentrations of dust particles were predicted considering micrometeorological data of the study area obtained during the study period to estimate

theconstruction phase project scenario. It is predicted from the modeling studies that around 50 to500 m area on eastern and north east direction of the proposed metro rail alignment will beimpacted with additional concentration 39.39 µg/m3 of particulate matter to the baselineconcentrations.

Figure 7.34: Predicted GLC Model for Impact of Particulate Matter (Pier No. 1 to 10)

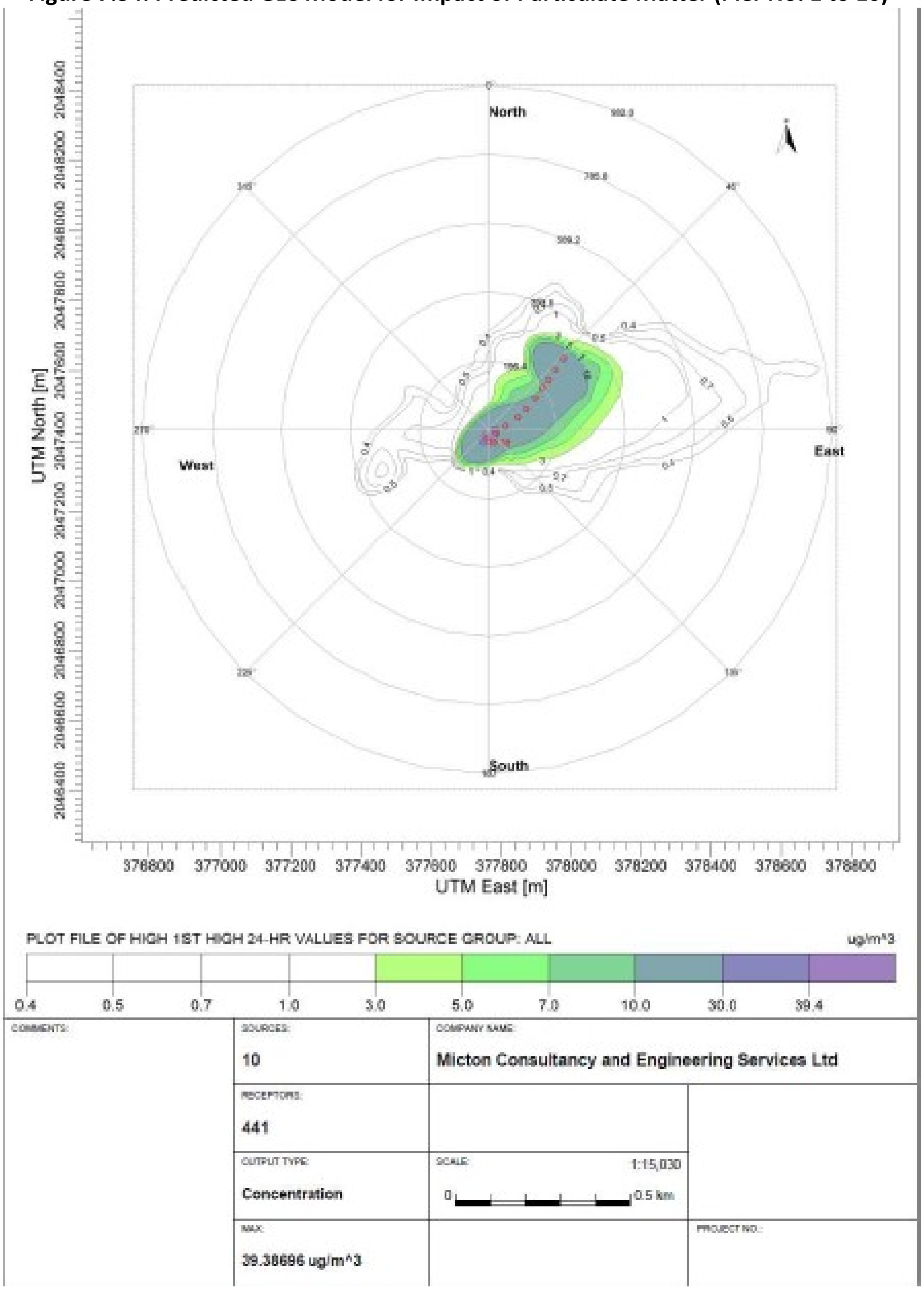


Figure 7.35: Predicted GLC Model for Impact of Particulate Matter (Pier No. 29 to 39)

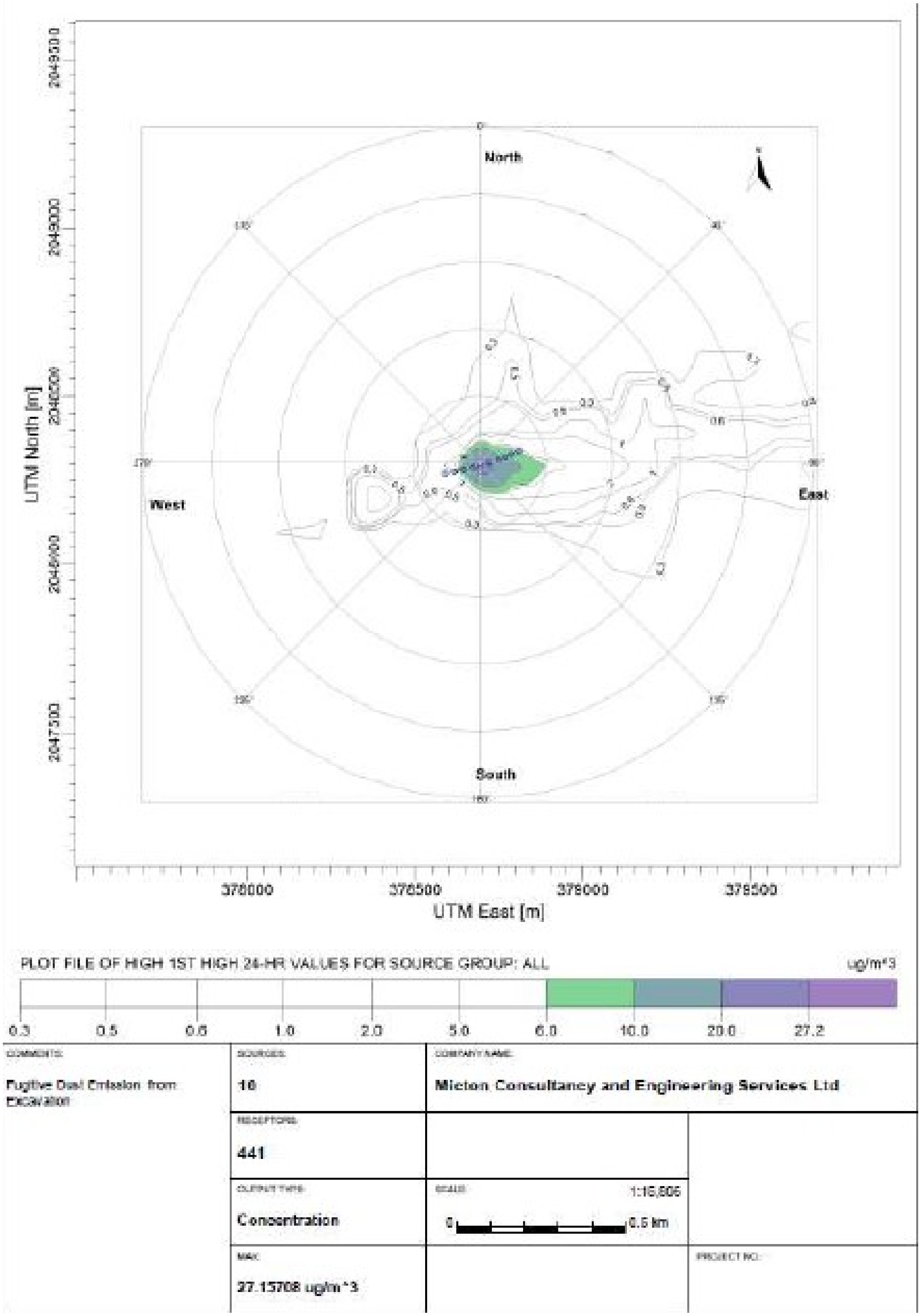
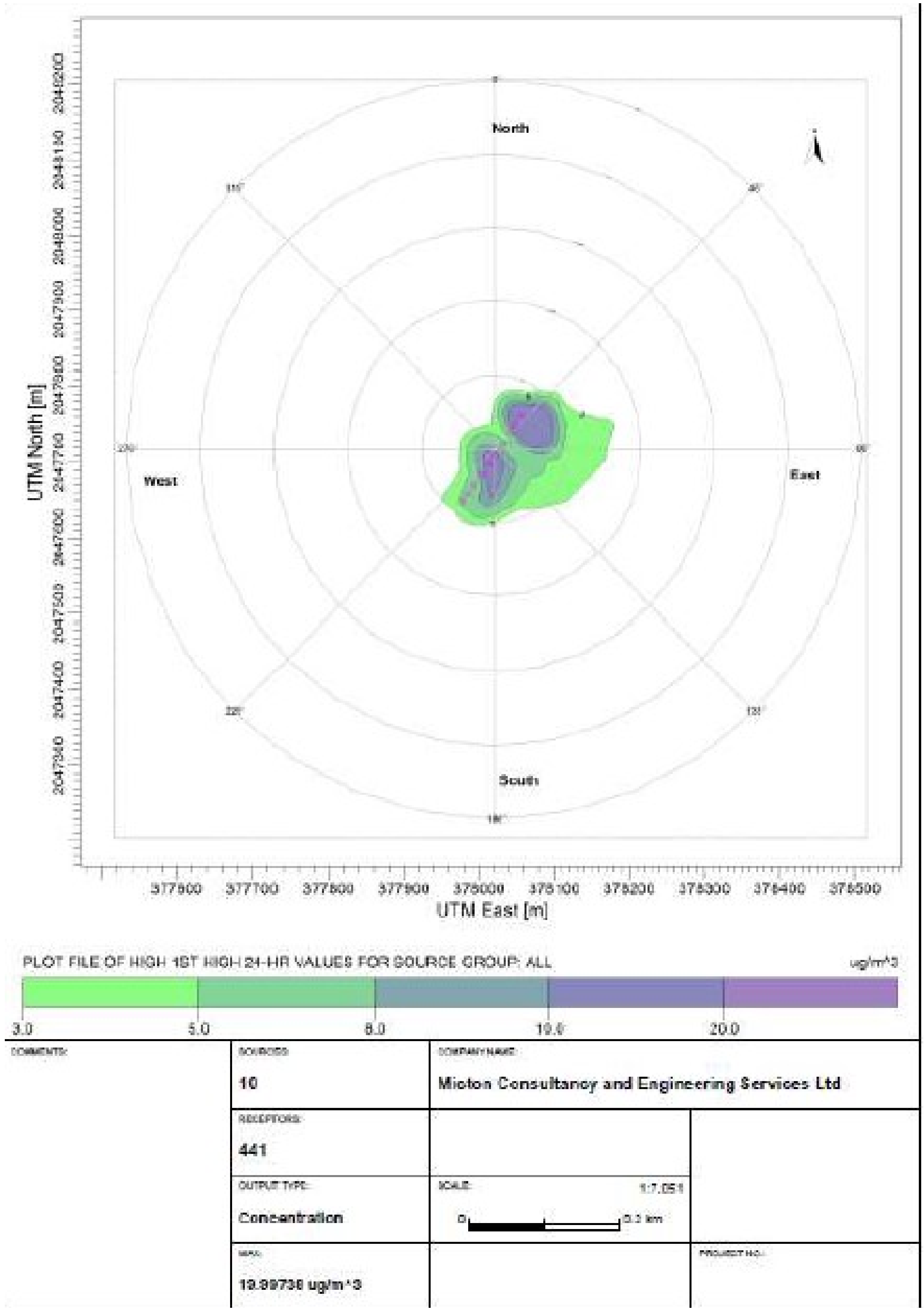


Figure 7.36: Predicted GLC Model for Impact of Particulate Matter (Deccan Metro Station)



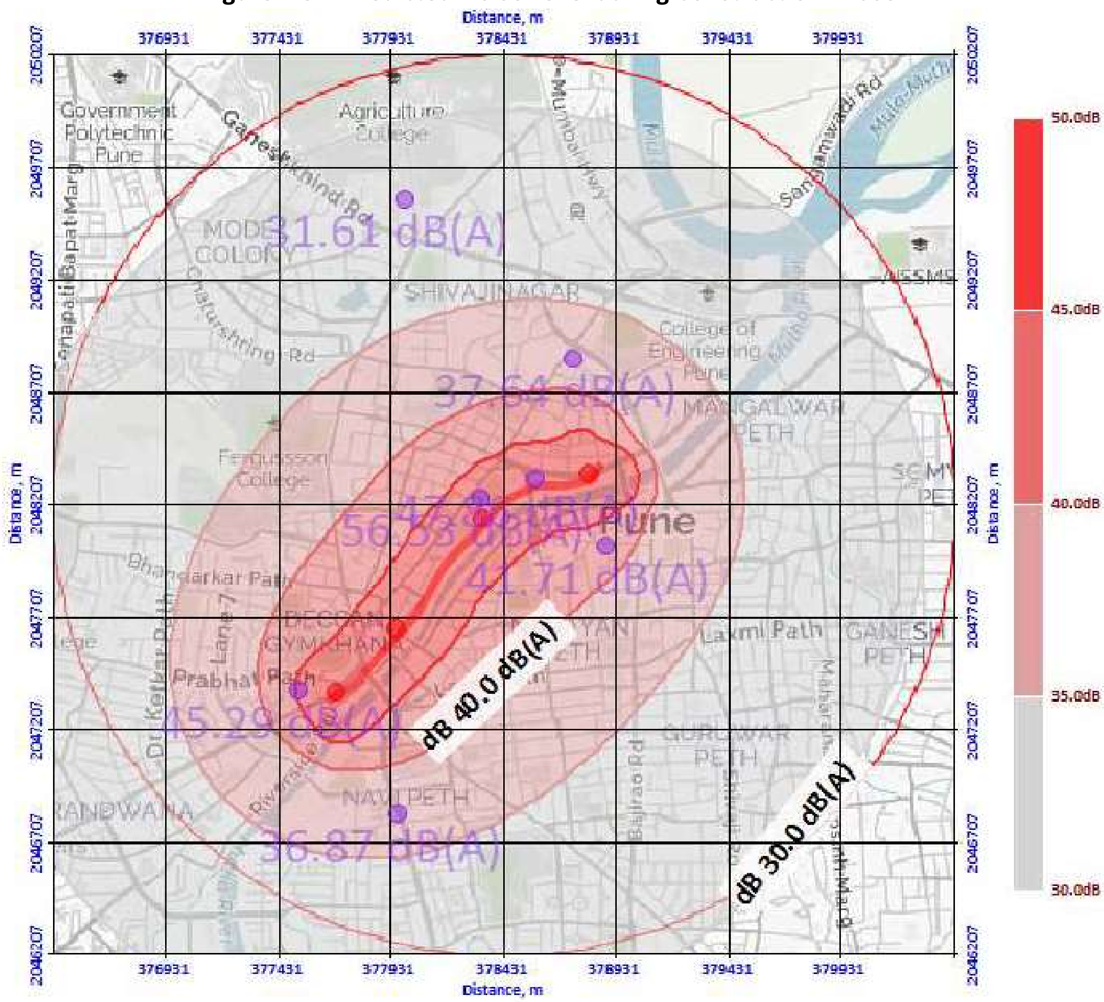
C. Impact on Noise Level and Vibration

The noise likely to be generated during excavation, loading, unloading and transportation ofmaterial is in the range of 90 to 100 dB (A) and this will occur only when all the equipmentoperate together and simultaneously. The workers in general are likely to be exposed to anequivalent noise level of 75-80 dB (A) in an 8 hour shift.

From the dhwaniPRO® sound propagation modelling it is depicted that maximum noise leveldue to construction activity at receptor Chhatrapati Sambhaji Udyan will be 56.87 dB (A), atCommercial zone 47.86 dB (A) and at residential zone 36.87 dB (A)

Vibration level will be increased during excavation and transportation at project site. PredictedNoise Level during construction phase has been shown in Figure 7.37.

Figure 7.37: Predicted Noise Level during Construction Phase



D. Impact on Hydrogeology, Hydrology and Water Quality

The proposed alignment is on the left bank of the Mutha River which is a straight course thatbegins to bend towards the Vitthal Ramji Shinde Bridge. However, our field studies record thata 2-3 m thick alluvium (sediment) cover is present on the northern bank indicating that thisstretch of the river is a non-erosive, but depositional and therefore of an aggradational nature.Hence, this bank is much preferred/ suitable for the proposed alignment.

The geophysical data presented previously concentrated on the suitability of the deeper stratafrom the foundation and hydrogeological point of view. While the data was of good qualityand very nicely depicted, it did not concentrate on the shallow horizons, so did not pick up thesediment-bedrock signatures. Our surveys have focused on this aspect and a 2-5 m sedimentarylayer overlying weathered vesicular bedrock has been proven. This augments our fieldobservation and strengths our case.

The well inventory indicates presence of alluvium (0-9 m thick) overlying weathered basalt.Hydro geologically, the area is underlain by a unconfined aquifer consisting of shallowalluvium-weathered vesicular basalt. Most of the dug wells are used for domestic purposes andas an alternative to tap water. However, a few hotels use groundwater for commercial purposes.

As such the aquifer has shallow water table (1-9.3 m below ground level) with 1-3 m seasonalwater table fluctuation and has limited groundwater abstraction. Hence, the aquifer is notstressed due to over-exploitation.

It is also inferred that the water table of the shallow aquifer is above the level of bedrock in thechannel. Hence, the hydraulic head is higher thereby negating the possible contamination ofsurface river water into the groundwater system. The confining/retaining walls along the riverchannel can be reinforced to minimize surface water spread overflow from northern bankduring floods/peak discharge.

Drinking Water required on construction site for labour is estimated at about 2.25 kld (50Person @ 45 liter per day) as per CPHEEO guidelines May 1999.The water requirement willbe fulfilled through water Tanker supplier.

In addition water will be required during construction phase at about 100 kld for siteactivitiessuch as curing, concrete mixing, dust suppression etc.

The present status of the river water shows that the river is eutrophicated.

E. Impact on Ecology and Biodiversity

Proposed metro route is part of riverine ecosystem. This is habitat for butterfly,dragonfly/damselflies etc.

Herbaceous vegetation will be disturbed due excavation and allied activities. Overall herbaceous vegetation predominatedwith commonly found weed species. This herbaceous vegetation attract butterfly,dragonfly/damselflies etc. Indirect impacts on butterfly, dragonfly/damselflies etc. envisageddue to impact on herbaceous flora. Natural vegetation is much disturbed by anthropogenicpressure. No Rare, Endangered, and Threatened (RET) species of herbaceous flora wereobserved during study period.

Negative impacts are envisaged on terrestrial ecology. No adverse impacts envisaged onaquatic biota.

Total 32 trees belonging to 10 species are liked to be affected. Cutting or transplantation ofthese trees at nesting and perching sites will be affected for avifauna.

F. Impact on Socio Economic Environment

The land will be acquired from Irrigation Department, Government of Maharashtra. There isno acquisition of private land for the alignment. No direct impacts are envisaged on socioeconomic condition from the project area. However, some indirect impacts are envisagedonpilgrims visiting the Temples like Panchaleshwar and Vridheshwar in the project area.Beneficial impacts are predicted on local business community and Chaupati stall holders.

G. Impact on Traffic

Traffic control will be aimed to give adequate warning and clear information to motorists aboutthe nature of works on site. This will translate into correct actions required in order to pass thework site safely. During construction period fugitive impacts are envisaged on existing trafficcondition.

7.6.2. Impact during Operational Phase

A. Land Environment

The proposed project alignment passing through Mutha River will change land use pattern ofthe bank of the river basin. Since the proposed alignment is elevated insignificant land usechange is expected. Hence therefore there will be no irreversible impact of land use change.

B. Air Environment

Metro operation will cause no air pollution in the project area because of electric engines.However, DG set provided for power back at metro station may cause short term air pollution.

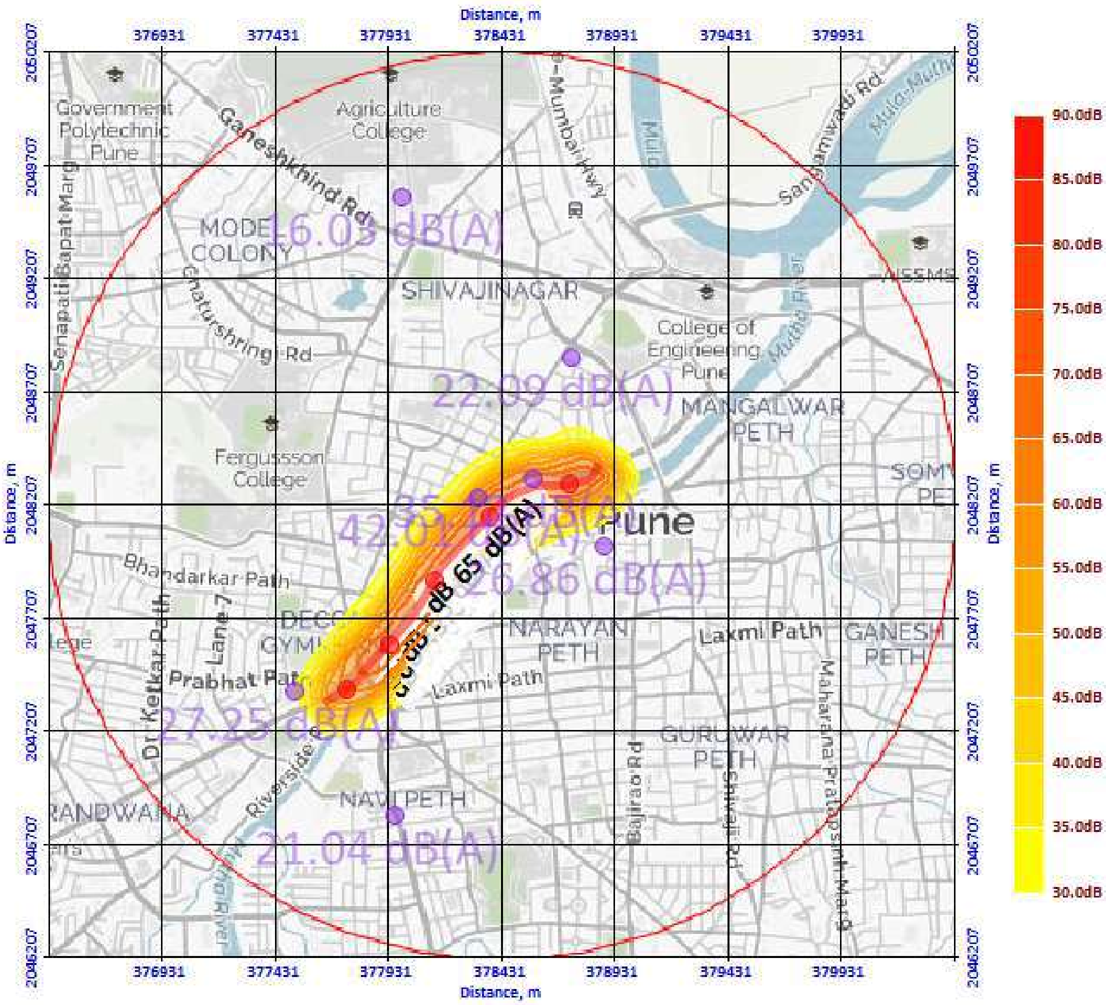
C. Noise Environment and Vibration

The maximum noise level has been estimated as 64 dB (A) including background noise level as20 dB(A) inside the Metro. Noise level at a distance of 12.5m, 25m, and 50m from the alignmenthave been calculated. They worked out to be 57.2, 54.2 and 45.2 dB(A) respectively. (Source:Final Detailed Project Report for Pune Metro Rail Project November 2015).

During the operational phase, the sources of noise are (i) rail-wheel interaction (ii) noisegenerated from equipment like Blower, Compressor, air conditioner, door, Inverter etc. (iii)traction motor in running train.

From the dhwaniPRO® sound propagation modelling it has depicted that maximum noise leveldue to operational phase of the Metro Rail Project at receptor Chhatrapati Sambhaji Udyan willbe 42.01 dB (A), at Commercial zone 27.25 dB (A) and at Residential zone 26.86 dB (A) (refer Figure 7.38).

Figure 7.38: Predicted Noise Level during Operational Phase of the Project



Vibration control:

- 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.
- The lower vibration level has been achieved by provision of bolster less type bogies having secondary air spring.

- From considerations of maintainability, riding comfort and also to contain vibrations andnoise levels, the complete track is proposed to be joint-less and for this purpose even theturnouts will have to be incorporated in LWR/CWR.

D. Hydrogeology and Hydrology

A part of the Pune Metro Rail having a length of 1.45 km passes through the flood plain ofMutha River. This part is aligned along the length of the river and does not cross the river atany location.

Water flowing through the Mutha River is controlled at the Khadakwasla Dam, which is about20 km upstream of the area of study. The river has mainly two flows in it. The first one is overthe entire non-monsoon season. This discharge is very low, almost close to the EnvironmentalFlow. Higher river water flows are released through the Khadakwasla Dam on very fewsporadic occasions of heavy rainfall in the catchments upstream of Khadakwasla Dam. Suchflow may last for only one to four days at one occasion and they are also spread widely apart.Thus the so-called Flood situation in Mutha River is very different from other rivers, whichhave completely different site conditions.

Some of the openings of the existing bridges contain construction debris, rocky outcrops,concrete pipelines, and vegetation. These cause obstruction to flow and increase of flowvelocity at other locations. If the flow velocity increases beyond the permissible bed shearstrength, it will reduce in scour of river bed. It has been mentioned earlier that lose landfill hasbeen dumped on both banks of the river and large areas have been created. Since the materialis not compacted, erosion of these areas is likely to occur.

There are many obstructions to river flow, which have been created by the constructionactivities in the past. Also floating vegetation within the river and aquatic weeds on the landfillexists, which affects flow as well as water quality.

Hydrogeological and hydrological survey conducted concluded that no natural riverine systemexists due to construction of retaining walls, drainage lines, riverside roads, reclamation etc.These structures cause impacts on hydrology of the Mutha River. Alignment of metro isproposed beyond majority of these structures along blue line. No irreversible impact of theproposed Metro Project on hydrology is envisaged.

As hydrology of Mutha River is dependent upon controlled water flow of Khadakwasla dam,no impacts are envisaged on hydrology of Mutha River i.e. flow up to 60,000 cusecs.Howeverdue to orientation of piers, locations and shape only the minimum impacts are predicted beyonddischarge of 60,000 cusecs. Discharge data obtained from Irrigation department depicts that,in seventy years timespan on 12 occasions discharge of water recorded more than 60,000cusecs.

The transverse dimension of bridge piers varies from 2.0 m to 3.0 m. On the other hand, waterspread at maximum discharge of 100,000 cusecs within study reach of 1.45 km along MuthaRiver varies from 169 m to 255 m.

Mathematical calculations depicts the obstruction to the river flow is insignificant due toproposed construction of metro rail alignment piers. The magnitude of afflux (increase in waterlevel) works out to from 1.6 mm to 11.7 mm. Similarly, increase in submergence will be 3.24mm to 23.32 mm at Pier No. 161 and Chatrapati Sambhaji Udyan Metro Station Pier No. 10respectively.

E. Water Environment

Water demand on one station works out to be about 11 kld, out of them 7.5 kld waste waterwill be generated at each station. About 22 kld water will be required for Deccan andChhatrapati Sambhaji Udyan Metro rail station. Rainfall runoff calculated for both the metrostation will be 785 cubic meter per year.

Negative impacts are predicted due to generation of waste water from both the metrostations.

F. Ecology and Biodiversity

The floristic component of the project site does not include any rare or endangered species.No potential impacts are envisaged during operational phase on floristic component.

Majority fauna listed from the study area will be least impacted because habitat requirementfor the reported fauna is general at can be fulfill from adjoining area. However, impacts due toconstruction activity are reversible and cause no further major adverse impact due tooperational phase.

Mitigation measured Proposed for water, air, noise & vibration will minimize negative impactson ecology and biodiversity of the project area. Afforestation, transplantation will have positiveimpacts on biodiversity.

G. Impact of Solid Waste

Floating population for each the station will be around 15000 thousand per day. Considering60gm solid waste generation per capita per day, 900 kg solid waste will be generated duefloating population at each of the metro stations. Waste composition will be 40% organic(approx. 360kg), 33% recyclables (297kg), 2% E-Waste (18kg) and 25% inert/ miscellaneous(225kg).

H. Social Impact Assessment

During reconnaissance and field surveys regular interaction with the people of various sectionsof the society along the project alignment, shopkeepers, pilgrims and influential persons of theproject area were made. Land belong to 1.45 Km of left bank of Mutha river is of IrrigationDepartment.

7.7. ENVIRONMENTAL MANAGEMENT PLAN

7.7.1. Management Plan for Land Environment

Proposed alignment of 1.45 km is passing through Mutha River. Land on left bank of river for 39+20 (viaduct + stations) piers will be 1475 sq.m for actual construction on ground. The landbelongs to Irrigation Department, Government of Maharashtra.

There is no acquisition of private land proposed for the alignment. However, land other than Mutha River basin of 2500 Sq.m. private land shall be acquired for Parking, entry/ exit, 2800 sq.m for Multimodal Hub at Deccan Metro Station. Similarly 1225 Sq.m of Pune MunicipalCorporation land shall be utilized for parking of Chhatrapati Sambhaji Udyan Metro Station.

Total 4425cubic meter excavated material will be generated. Following management practicesshall be followed.

- Out of 4425 cubic meter excavated material about 295 cubic meter top soil will begenerated and same shall be used for plantation.
- Excavated murum and hard rock shall be used for backfilling and remaining quantity willbe disposed at Pune Municipal Corporation authorized site.
- Stockpiling of excessive excavated material will be avoided.
- Existing road will be used for transportation. It is proposed to use existing road network.
- Minimum usage of Kaccha road / un-metaled road at the site where existing road networkis not available with regular water sprinkling for dust suppression.
- Rainy season will be avoided for cutting and filling of earthwork.
- Waste management practices shall be as per Solid Waste Management Rules, 2016
- Degradable waste will be composted through organic waste composter and manure willbe used for landscaping
- Non degradable waste will be handed over to Pune Municipal Corporation for furthertreatment and disposal.
- Out of total 32 affected trees 23 trees will be transplanted at project site. Scientificmethodology for transplantation shall be adapted to minimize mortality.
- Fertile top soil (Top 20 cm of soil i.e. 295 cubic meters) shall be used for plantation.
- Contractor is responsible for identifying, collecting, transporting and disposal of all thewaste produced at the project site by his personnel
- Waste shall be categorized and stored separately prior to dispose from the project site.
- Proposed alignment is elevated, supported on circular piers of 2 m to 3 m in diameter. Henceland area required in the river basin will be minimal.
- No area other than underground foundation and for erection of piers will be used for this project.

- Elevated Metro stations are proposed at Deccan and Chtrapati Smbhaji Udyan. No structureson the ground are required for the metro station other than piers and foundation.

7.7.2. Management of Air Quality

The project will contribute in higher dust levels during construction phase. The concrete willbe made from outside source of Ready Mix Plant. The debris and unutilized constructionmaterial and earth from the construction site shall be removed immediately to recycle withinthe project so that no nuisance dust is generated due to wind. Construction Activities shall notbe allowed at Night.

The site being influenced by winds would result in quick dispersal of the pollutants and therebythe impacts due to NOx and SO2 emissions during the construction will be negligible.Therefore, considering all the air pollutants, it is not expected that air emissions due toconstruction will exceed air quality standards (NAAQS).

Air Quality around the Project site will be impacted during construction stage. To minimizethe occupational health hazard, proper personal protective gears i.e. mask, helmets, face maskshall be provided to the workers who are engaged in dust generation activity. Prevalent Winddirection, spatial distribution, transport and deposition of pollutants will be taken into accountto predict receptor locations for pollutants.

Following measures would greatly reduce the impacts during the construction and operationalphase:

- Regular water sprinkling all over the exposed area using truck-mounted sprinklers.
- Avoid fugitive dust emission by unloading of loose construction materials like sand,cement, aggregate etc. by using ready-mix concrete.
- The nose-mask will be provided to workers in dust prone area.
- All the vehicles used during the construction stage should be maintained and monitoredwith PUC.
- State Pollution Control Board guideline shall be followed for exhaust of DG sets.
- During Operational phase DG set will be used in case of power failure only henceinsignificant impacts are envisaged on air pollution.

7.7.3. Management of Noise Level and Vibration

During construction phase, sources of noise pollution will be due to operation of machinery, earthmoving machinery, Mini Hoist Crane, Hoist Crane, Concrete mini mixer, Weigh batcher etc., as well as transportation vehicles. The project proponents have agreed to take precautionsto control noise pollution as mentioned under:

- Use of equipment that generates noise less than 90 dB (A).
- The noise control measures during the construction phase include provision of acousticshoods wherever possible on the construction equipment and regular maintenance of theequipment.

- Movement of vehicles should be strictly restricted to existing roads and tracks, andcreation of new roads and tracks or off-roading shall be prohibited on the riverbanks.
- Recommend light and sound barriers to proposed activities/working areas.
- The construction workers will be provided with the personal protective equipment likeear muffler, hand gloves etc. to reduce the impact of noise pollution.
- Noise generating activities shall be restricted during day time only.

The following features are incorporated for elimination and reduction of noise.

- Provision of anti-drumming floor and noise absorption material
- Low speed compressor, blower and air conditioner
- Mounting of under frame equipment on anti-vibration pad
- Smooth and gradual operation 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 andpiping holes
- Silent type DG sets with low noise levels are proposed, which do not require a separate room for installation.

Vibration Control

- 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 ofresilient and shock absorbing pad.
- The lower vibration level has been achieved by provision of bolster less type bogies having secondary air spring
- From considerations of maintainability, riding comfort and also to contain vibrations and noise levels, the complete track is proposed to be joint-less and for this purpose even theturnouts will have to be incorporated in LWR/CWR.

7.7.4. Management of Hydrogeology, Hydrology & Water Pollution

From the result of electrical resistivity method and the hydro geological study shows that thestrata below soil are not favorable to form aquifer. However unconfined aquifer reported fromproject area has poor potential. It is envisaged that construction of Piers on the bank are notlikely to cause significant impact on any aquifers. Natural springs are not observed in the areaduring the study period. Hence no adverse impacts during construction phase are envisaged onexisting hydro geological condition.

Water flowing through the Mutha River is controlled at the Khadakwasla Dam, which is about20 km upstream of the area of study. The river has mainly two flows in it. The first one is overthe entire non-monsoon season. This discharge is very low, almost close to the

EnvironmentalFlow. Higher river water flows are released through the Khadakwasla Dam on very fewsporadic occasions of heavy rainfall in the catchments upstream of Khadakwasla Dam. Suchflow may last for only one to four days at one occasion and they are also spread widely apart.

During construction period it is proposed to use tanker water for various construction activities.Considering baseline hydrological condition of Mutha River and proposed project activity noadverse impact envisaged.

Following management measures are suggested to protect the water quality

- Avoid use of ground water for construction activities.
- Sedimentation of storm water will be minimize by avoiding stockpiling of excavated material. Portable sanitation, treatment and disposal facility shall be provided atconstruction site.
- C & D waste and overburden disposed at Pune Municipal Corporation authorized site
- Construction activities shall be restricted to non-rainy days only.
- Mobile Community toilets with STP shall be provided on the site during construction phase to prevent wastewater from entering the water bodies i.e. Mutha River
- The contractor has to take all precautions to minimize the wastage of water in theconstruction process.
- 10 KLD Sewage Treatment plant is proposed at each station.
- Maximum treated water shall be used for flushing and landscaping. Rain water harvesting will be done at each Metro station. No STP shall be constructed on bank of Mutha river basin. Excess treated water shall be discharge to Pune Municipal corporation drainage line.
- Runoff calculated for both the metro station will be 785 cubic meter per year.
- Periodic monitoring is proposed for river bed scour. Data collection is recommended at curvature in the river because there is likely to be siltation on one side and erosion on the opposite side.
- There are many locations along the length of river where untreated municipal sewage and industrial effluent is released into river through pipes, which are visible from the road. These discharges should be stopped immediately for improving water quality.
- It is also inferred that the water table of the shallow aquifer is above the level of bedrock in the channel. Hence, the hydraulic head is higher thereby negating the possible contamination of surface river water into the groundwater system. The confining/retaining walls along the river channel can be reinforced to minimize surface water spread overflow from left bank during floods/peak discharge.
- Disaster Management Plan of Pune Municipal Corporation and Maharashtra Metro Rail Corporation have been followed during flood.
- The Bank selected for construction is non erosive side an hence safer for construction
- Tests indicates that construction of piers are not likely to damage existing aquifers
- The water afflux can further be reduced by reinforcing the retaining wall

- As the hydraulic head is higher, the surface water will not contaminate the ground water
- To minimize number of affected trees from Mutha River basin slight change in alignment is proposed. First alternative considered would affect 155 trees, second alternative consider at 115 trees and current final route passing through Mutha River would affect 32 trees.
- Water and air pollution devices control will be installed
- Elevated metro rail alignment is proposed hence impact on riverine ecosystem will be minimal.

7.7.5. Solid Waste Management Plan

- Waste management practices shall be as per Solid Waste Management Rules, 2016
- Degradable waste will be composted and used for landscaping
- Separate community bins (one for wet waste and one for dry waste) of 240 liters capacity will be placed at each station
- Organic waste composter of 500kg/day capacity will be provided at each metro station
- Degradable (organic) waste of approx. 360 kg will be composted by organic wastecomposter and used for landscaping
- Non degradable waste of approx. 540 kg will be handed over to Pune MunicipalCorporation for further treatment and disposal.

Organic Waste Converter (OWC):

The OWC processes wet organic waste by employing aerobic microbial decomposition. The machineworks in two stages, in the first stage it first crushes the waste and then mixes it homogeneously withthe bio decomposition culture. In the second stage this homogeneous mixture is further mixed & churnwith saw dust, to soak the excess water content from the biomass which ultimately deodorizes it. Thecritical components of the machine should be manufactured in SS304, HSD2& WPS for longer lifeand better results.

Curing: The pre-composted mass is kept for curing and stabilization in the curing bays/drums/Pits forabout 12 days. After the 12th day the container is ready with compost and can be used as fertilizer foronsite use for huge Landscaping within the project area.

Benefits of 'Organic waste converter'

- The total MSW arriving on the site is cleared on the same day.
- Provides a scientific method for the production of organic compost.
- Elimination of foul odour.
- Elimination of Pathogens and weed seeds.
- Problem of rodents and insect pests is avoided.
- Aesthetically acceptable.
- Treatment time is substantially reduced.
- Eco-friendly & Economical
- Requires less space for the treatment.

- Load on the landfill is reduced, thus requires less land for disposal

Organic compost quality parameters:

1.	Moisture	15-20%
2.	Total Organic Carbon	16-20% (min)
3.	C:N	< 20:1
4.	Nitrogen	0.8 (min)
5.	Phosphorus (P_2O_5)	0.5-0.8%
6.	Potassium (K_2O)	1-2%
7.	pH	6.5 – 7.5

7.7.6. Traffic Management Plan

Steps to be taken by Maharashtra Metro Rail Corporation, Pune for smooth flow of trafficduring construction phase

- Install, maintain and work within temporary traffic management (using trafficlights, cones and barriers) to keep the traffic flow safe.
- For transportation of construction material precaution shall be taken to reduce impact of vehicular movement by restricting movement in non-peak hours.
- Use of appropriate sinagaes for smooth traffic movement
- Barricading of the construction site for safety of the civics, traffic and workers.
- Avoid heavy vehicles to ply on the road during peak traffic hours.
- Steps taken for safe pedestrian movement.

7.7.7. Management of Ecology and Biodiversity

To minimize number of affected trees from Mutha River basin slight change in alignment isproposed. First alternative considered would affect 155 trees; second alternative will consider115 trees and current final route passing through Mutha River would affect only 32 trees.

- Out of total 32 affected trees, 23 trees will be transplanted at project site. Scientificmethodology for transplantation shall be adapted to minimize mortality.
- Nine trees will be cut and compensatory afforestation for all the affected trees (Ratio1:3) shall be done at designated plantation area at Pachgaon Parvati.
- To avoid negative impact on herbaceous vegetation, vehicle & Construction machinery movement should restricted to designated roads. Similarly it is suggested to avoid dumping of muck, excessive site clearance, leveling etc. in the river basin.
- Vegetation clearing by chemicals/ herbicides will not be permitted
- Workers should be briefed about do's and don'ts like No hunting/poaching, vegetation burning, no collection of eggs, not to disturb any habitat outside the project area, offroad driving, speeding etc.
- Workers shall report injured animals to the senior persons
- Training cum awareness program shall be conducted for all workers
- Rainy season will be avoided for cutting and filling of earthwork.

- Workers/labour colony not proposed on-site
- Proper management of waste material will be ensured.
- Construction material should not be dumped on bank of river
- Movement of vehicle will monitor for not blowing excessive horn.
- Restriction of construction activity from dawn to dusk.
- Plantation of indigenous plant species to attract fauna like butterflies, bird etc.
- Animals, which are found within the project area and categorized under schedule I to Schedule IV of Wild Life Protection Act 1972 and subsequent amendments are strictly protected and there is a complete ban on their exploitation for any purpose. Care should be taken not to disturb their habitats.
- No area other than underground foundation and for erection of piers will be used for any other project.
- Elevated metro rail alignment is proposed hence impact on riverine ecosystem will be minimal.
- To minimize number of affected trees from Mutha River basin slight change in alignment is proposed. First alternative considered would affect 155 trees, second alternative was consider at 115 trees and current final route passing through Mutha River would affect 32 trees
- Elevated metro rail alignment is proposed hence impact on riverine ecosystem will be minimal.

A. Transplantation of existing trees shall be done as follows:

During the process of transplantation it is necessary to study that the tree responds to a two tierroot system and a new system is then gradually encapsulated in a root ball. The entire methodis divided into the following steps:

- Preliminary root investigation,
- Health diagnosis of the tree,
- Treating the infected trees

B. Root pruning and initiating fresh root growth

Root pruning shall be done systematically to initiate fresh growth of roots and make the plantadapt itself gradually into a new routine whereby after cutting the roots treat the cut parts andfeed it with alternative methods. It is a gradual process and it takes about 3-4 months to actuallyadjust a tree into a new system of living. Before initiating root cutting process, make sure thatthe tree is not infected and if it is we treat accordingly. Certain growth promoter may use forroot initiation.

C. Tree packing, feeding and monitoring for adaptation

This involves packing of trees, timely feeding of the plant with soluble fertilizers and watering.There has to be regular monitoring regarding fertilizer schedules and the chemicals likeinsecticides, pesticides during the course for general treatment. Simultaneously expert staff isneeded to sew packing material properly and tightly according to the root requirement. Planthas to pack in the same environment as before. It needs external support to remain in the sameposition without falling down because of wind pressure. Scaffolding is required for about oneand a half to three months depending upon the condition of the tree for each transplanted treeto give it external support.

D. Transportation of trees

Crane is required to lift the packed tree and usually a trolley or truck is used to transport thetree depending upon its size, from its original location to the place where it is to betransplanted.JCB will be used for digging pits. Pruning may be required depending upon the size of the rootball, the plant canopy, health of the plant, species transplanted or because of overhead wiresand spread of the road while transplantation of the tree.

E. Mechanical Support and Pruning

Mechanical support for trees is necessary when the tree is tall, slow to recover & heavilyfoliaged. Scaffolding is required for about one and a half month for each transplanted treetogive it external support. The support provided to a tree should be removed as soon as the treecan stand alone. It takes about 30 to 45 days in the growing period for the transplanted tree togrow new branches & foliage. The sooner the support will be removed, the faster the tree willbecome stronger.

F. Afforestation and Compensatory Plantation

Criteria for Selection of Species: The choice of vegetative species for planting should bebased on studies of the natural vegetation in the area and on the environmental conditions.List of Tree species suitable for Plantation are given in Table 7.34.

- Plant species which show higher adaptability to local climatic and edaphic conditions
- Tree species should be suitable for natural landscape of surrounding area
- Plants that show vigorous growth, and higher forage value
- Preferably indigenous
- Plant that serves as nesting, feeding and breeding site for fauna
- Plant species having importance in soil binding
- Species tolerant to specific conditions or capacity to endure water stress and climaticextremes after initial establishment

Table 7.34: List of Tree species suitable for Plantation at Pachgaon Parvati

S.No.	Botanical Name	Vernacular Name	Family
1	Adansonia digitata L.	Gorakh chinch	Malvaceae
2	Aegle marmelos (L.) Corr.	Bel	Rutaceae
3	Ailanthus excelsa Roxb.	Maharukh	Simaroubaceae
4	Albizia lebbeck (L.) Bth.	Shirish	Leguminosae
5	Anogeissus latifolia (Roxb. Ex DC)	Dhavda	Combretaceae
6	Areca catechu L.	Supari	Arecaceae

S.No.	Botanical Name	Vernacular Name	Family
7	Artocarpus heterophyllus Lam	Phanas	Moraceae
8	Azadirachta indica A Juss.	Neem	Meliaceae
9	Bambusa bambos (L.) Voss	Bamboo	Poaceae
10	Bauhinia vahlii Wight & Arn	Apta	Leguminosae
11	Bauhinia variegata L.	Kanchan	Leguminosae
12	Bombax ceiba Linn.	Kate – Savar	Malvaceae
13	Butea monosperma (Lam.) Taub..	Palas	Leguminosae
14	Capparis grandis L.f.	Pachunda	Capparaceae
15	Cassia fistula L.	Bahava	Leguminosae
16	Cordia dichotoma G. Forst.	Bhokar	Boraginaceae
17	Couroupita guianensis Aubl.	Kailashpati	Lecythidaceae
18	Dalbergia latifolia Roxb.	Shisav	Leguminosae
19	Putranjiva roxburghii Wall.	Putranjiva	Putranjivaceae
20	Phyllanthus emblica L.	Awala	Phyllanthaceae
21	Erythrina variegata L.	Pangara	Leguminosae
22	Eucalyptus globulus Labill	Nilgiri	Myrtaceae
23	Ficus benghalensis L.	Wad	Moraceae
24	Ficus microcarpa L.f.	Nandruk	Moraceae
25	Ficus racemosa L.	Umber	Moraceae
26	Ficus religiosa L.	Pimpal	Moraceae
27	Ficus virens Aiton.	Piparni	Moraceae
28	Lagerstroemia speciosa (L.) Pers.	Tamhan	Lythraceae
29	Limonia acidissima Groff	Kavath	Rutaceae
30	Melia azedarach L.	Akashneem	Meliaceae
31	Mangifera indica L.	Amba	Anacardiaceae
32	Pongamia pinnata (L.) Pierre	Karanj	Leguminosae
33	Salix tetrasperma Roxb.	Salix/Walunj	Salicaceae
34	Santalum album L.	Chandan	Santalaceae
35	Saraca asoca (Roxb.) Willd.	Sita Ashok	Leguminosae
36	Syzygium cumini (L.) Skeels	Jamun	Myrtaceae
37	Tamarindus indica L.	Chinch	Leguminosae
38	Mimusops elengi L.	Bakul	Sapotaceae

7.7.8. Socio Economic Aspects

The land will be acquired from Irrigation Department, Government of Maharashtra. There isno acquisition of private land for the proposed alignment. No displacement of localshopkeepers, Chaupati stalls holders. No direct impact is envisaged on socio economiccondition from the project area. Opportunity of employment generation for local skilled andunskilled labour is predicted during construction and operational phase. However, someindirect impact is envisaged on pilgrims visiting to Temples like Panchaleshwar andVridheshwar in the project area. Existing access to Panchaleshwar and Vridheshwar shall bemaintained. During construction phase access to temples and Ghats will be given by providingproper barricades.

7.7.9. DMP Provisions at Metro Stations/Other Installations

To prevent emergency situations and to handle effectively in case 'one arises' there needs tobe following provisions for an effective system which can timely detect the threats and helpsuppress the same.

i. Fire detection and suppression system
ii. Smoke management
iii. Environmental Control System (ECS)
iv. Track-way Exhaust System (TES)
v. Station power supply system
vi. DG sets & UPS
vii. Lighting system
viii. Station area lights
ix. Seepage system
x. Water supply and drainage system
xi. Sewage system
xii. Any other system deemed necessary

The above list is suggestive not exhaustive. Actual provisioning has to be done based on siteconditions and other external and internal factors.

A. Preparedness for the Disaster Management

Being a technological complex system worked by new set of staff, with a learning curve toimprove and stabilize with time, intensive mock drills for the staff concerned is very essentialto train them to become fully conversant with the action required to be taken while handlingemergencies.

They also need to be trained in appropriate communication skills while addressing passengersduring incident management to assure them about their well-being seeking their cooperation.

Since learning can only be perfected by 'doing' the following Mock Drills is consideredessential:

a. Fire Drill
b. Rescue of a disabled train
c. Detrainment of passengers between stations
d. Passenger evacuation from station
e. Drill for use of rescue & relief train.
f. Hot line telephone communication with state disaster management
g. Establishment of authentic Passenger Help Line of Telephone, E-Mail, Television and Radio News.
h. Prevention of rumors

B. Occupational Health and Safety

All precautionary methods will be adopted by the company to reduce the risk of exposure ofemployees to occupational safety and health hazards.

For the safety of workers, personnel protective appliances like hand gloves, goggles, aprons,ear mufflers, nose mask etc. will be provided. Nose mask will be provided at places, wherethere is possibility of dust generation. In high noise generation areas ear mufflers will beprovided for the workmen.
Contractor should organize weekly health and safety meeting with the working personnel onrisk associated with the day's tasks and activities ad means of prevention and protection to beimplemented.

C. Energy Saving

Energy charges of any metro system constitute a substantial portion of its operation &maintenance (O & M) costs. Therefore, it is imperative to incorporate energy saving measuresin the system design itself. The auxiliary power consumption of metros is generally more thanthe traction energy consumed by train movement during initial years of operation.Subsequently, traction power consumption increases with increase in trainfrequency/composition in order to cater more traffic. The proposed system of Pune Metroincludes the following energy saving features:

i. Modern rolling stock with 3-phase VVVF drive and lightweight stainless steel coaches have been proposed, which has the benefits of low specific energy consumption and almost unity power factor.
ii. Rolling stock has regeneration features and it is expected that 30% of total traction energy will be regenerated and fed back to 25 KV ac OHE to be consumed by nearby trains.
iii. Effective utilization of natural light is proposed. In addition, the lighting system of the stations will be provided with different circuits (33%, 66% & 100%) and the relevant circuits can be switched on based on the requirements (day or night, operation or maintenance hours etc).
iv. Machine-room less type lifts with gearless drive have been proposed with 3-phase VVVF drive. These lifts are highly energy efficient.
v. The proposed heavy-duty public services escalators will be provided with 3-phase VVVF drive, which is energy efficient & improves the power factor. Further, the escalators will be provided with infrared sensors to automatically reduce the speed (to idling speed) when not being used by passengers.
vi. The latest state of art and energy efficient electrical equipment (e.g. transformers, motors, light fittings etc.) has been incorporated in the system design.
vii. Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control
viii. Solar PV panel are proposed at each metro stations

All property development work including planning, designing & construction of all structuresshall be done as per Indian Green Building Council (IGBC) norms.

7.7.10. Budgetary Provision for EMP

Monitoring and feedback become essential to ensure that the mitigation measures planned byway of environmental protection function efficiently during the entire period of operation. Summary of Budgetary Provision for EMP of Metro Stretch Passing through Mutha River is given in Table 7.35.

Table 7.35: Budgetary Provision for EMP of Metro Stretch Passing through Mutha River

S. No.	Pollution Control & Other EnvironmentInfrastructure	Capital Cost In Rs. Lakhs	Annual O & M Cost in Rs. Lakhs
A.	During Construction Phase:		
1	Water for Dust Suppression	09.00	-
2	Site Sanitation & Safety	05.00	-
3	Environmental Monitoring	10.00	-
4	Noise controlling practices	15.00	-
5	Traffic Management	15.00	-
6	Barricading	20.00	-
7	Health & Sanitation	50.00	-
B.	During Operation Phase:		
1.	Rain Water Harvesting at Metro Station	20.00	0.20
2.	Sewage Treatment Plant	50.00	05.00
3.	Organic Waste Composting	30.00	03.00
4.	Environment Monitoring	-	10.00

7.8. ENVIRONMENTAL MONITORING PROGRAM

A comprehensive monitoring programme is suggested here. Environmental attributes to bemonitored during construction and operational phase are presented in Table 7.36 and 7.37.

Table 7.36: Monitoring Program during Construction Phase

Component	Parameters	Location	Frequency
Ambient AirQuality	PM10, PM 2.5, SO2, Nox,	1. Construction site 2. upstream of site 3. downstream of site	Monthly
DG Sets	Particulates, SO2, NOx, CO, HC	At construction site	Monthly
Noise Level	Leq day, Leq night, dB(A)	1. Construction site 2. upstream of site 3. downstream of site	Monthly
Surface andGround WaterQuality	Physical, Chemical & biological Parameters	1. Construction site 2. upstream of site 3. downstream of site	Monthly
Drinking Water	IS 10500:2012	At construction site	Monthly
Soil Quality	As per standards	1. Construction site 2. upstream of site 3. downstream of site	Quarterly
Health of employees	All relevant parameters	All working areas	Periodical check ups
Solid/	Depending on type of	At the construction area	Quarterly

Hazardouswastes	wastes		
Ecology & Biodiversity	Plantation / Green beltdevelopment, Periodical monitoring of aquatic ecology	Project site and periphery	Monthly
Waste Water (Sewage)	As per SPCB guidelines	Mobile Toilet & STP at Construction site	Monthly

Table 7.37: Monitoring Programduring Operation Phase

Component	Parameters	Frequency
Ambient Air Quality	PM10, PM 2.5, SO_2, Nox,	Quarterly
DG Sets	Particulates, SO_2, NOx, CO, HC	Quarterly
Noise Level	Leq day, Leq night, dB(A)	Quarterly
Surface and Ground Water Quality	Physical, Chemical & biological Parameters	Quarterly
Drinking Water	IS 10500:2012	Quarterly
Health	All relevant parameters	Periodical checkups
Solid/ hazardous wastes	Depending on type of wastes	Quarterly
Ecology & Biodiversity	Plantation / Green belt development, Periodically monitoring of aquatic ecology	Six Monthly
Waste Water (Sewage)	As per SPCB guidelines	Quarterly

Chapter 8 : Environmental Management Plan

8.1. MITIGATION MEASURES

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

- **Location and Design**
  - Compensatory Afforestation
  - Right of Way, Alignment, Track design and Architecture
  - Spatial Planning of stations and Inter-Modal Integration
  - Robust Design
  - Provision for Green Buildingsand solar power
  - Use of Energy and Water
  - Utility Plan

- **During Construction**
  - Supply of Construction Material
  - Pre-casting yards and Material Stockpiling
  - Construction Material Management and Housekeeping
  - Hazardous Waste Management
  - Construction and Demolition Waste management
  - Muck Disposal
  - Energy Management
  - Labour Camp
  - Welfare of Labour
  - Safety of Labour
  - Air Pollution Control Measures
  - Noise Control Measures
  - Vibration Control Measures
  - Increased water demand management
  - Water pollution control measures
  - Traffic Diversion/Management
  - Soil Erosion and Land Subsidence Control
  - Dewatering of underground works

- **During Operation**
  - Noise and Vibration Management
  - Water Supply and Sanitation at stations
  - Management Plan for Depot
- **Training**
- **Establishment of Environment Division**
- **Disaster Risk Management**

8.2. EMP DURING PROJECT LOCATION AND DESIGN

8.2.1. Compensatory Afforestation

Removal of Air Pollutants: Particulate matter in the atmosphere is intercepted by tree canopy. The particulates are retained on the plant surface or washed off by rain or dropped to ground with leaf fall. Urban trees have been found to remove PM10 and PM2.5 from the atmosphere. Removal of PM2.5 is lower than removal of PM10 but the health benefits are higher[9].Ambient concentrations of SO_2 was found to reduce by 39%, NOx by 40%, SPM by 37%, THC by 86%, CO by 93%, VOCs by 87.1% across the green belt and the overall air pollutant removal efficiency was calculated as 63%[10].

Increase in Groundwater Recharge : Quantity of rainfall percolating to a specified depth of soil was found to decrease with distance from canopy edge towards with minimum percolating quantity in open area. Soil infiltration is improved near trees due to litter and tree roots promoting activity of earthworms, insects etc. resulting in increased soil macro porosity. Under conditions where surface runoff of rain water is redistributed towards trees, net water stored in soil near trees increases. In case of trees in which at least 25% of their water intake from soil is from depth greater than 1.5m, 10 trees per hectare with canopy cover 5% provide the highest groundwater recharge: tree density greater than this optimal cover showed reduced groundwater recharge[11].

Location for afforestation will be decided by Maha-Metro, Pune in consultation with PMC as well Forest Department. About 166 trees are likely to be cut and 958 trees are likely to be transplantedfrom the two corridors and two depots. It is proposed to plant three saplings for each tree to be cut and transplanted; hence 3372 trees need to be planted. Estimated compensatory afforestation cost for the proposed corridors is given in Table8.1 by considering Plantation rate of Rs. 852/- per sapling (source: Parks and Garden Department of PMC) and average transplantation rate of Rs. 35000/- per tree (source: based on discussions with transplantation team).

Table 8.1: Cost of Compensatory Afforestation and Transplantation

S. No	Corridor/Depot	Cost in Rs. Lakh			
		Compensatory Afforestation	Transplantation	Add. tree for transplantation	Total Cost
1.	PCMC-RangeHill	3.09	96.25	7.03	106.37
2.	Vanaz - Ramwadi	0.33	67.55	4.93	72.81
3.	Range Hill Depot	0.00	141.05	10.30	151.35
4.	Vanaz Depot	0.82	30.45	2.22	33.49
	Total Cost	**4.24**	**335.30**	**24.47**	**364.01**

[9] Modeled PM2.5 removal by trees in ten US cities and associated health effects, David J Nowak, Satoshi Hirabayashi, Allison Bodine, Robert Hoehn, Elsevier, Environmental Pollution 178 (2013) 395-402

[10] Assessment of Carbon Sequestration Ability of Trees for Adopting in Green Belt of Cement Industries in Karnataka, March 2016, Central Pollution Control Board Zonal Office South

[11] *Intermediate tree cover can maximize groundwater recharge in the seasonally dry tropics, U.Llstedtetal, February 2016, www.nature.com*

The Parks and Garden Department of PMC is responsible for the conservation and management of trees/forests in the project area.The native plant species and miscellaneous indigenous tree species recommended for afforestation.

8.2.2. Right of Way, Alignment, Track design and Architecture

Alignment has been kept elevated where adequate width of right of way on roads is available. Geometric design of the alignment will be such as to optimize curvature. Track design will incorporate welded rails and elastic fittings.Viaduct and elevated stations shall be shaped to minimize visual intrusion.

8.2.3. Spatial Planning of Stations and Inter-Modal Integration

Adequate and well-laid out space shall be designed for concourses and platforms, escalators, elevators and staircases, lighting, turnstiles for normal and abnormal operating conditions; optimal height / depth of the stations, forced ventilation shall be provided. Physical and operational integration of metro with other modes shall be planned. Adequate design of stations and multimodal integration prevents and mitigates congestion at stations and safety is improved.Consumption of energy for climate control, lighting and other facilities at stations is significantly reduced by proper design of passenger flow inside stations, space & facilities inside stations. Use of evaporative cooling process in *air conditioning can reduce water usage (Manual on norms and standards for environment clearance of large construction projects, MoEFCC, 2007).*

8.2.4. Robust Design

The project area lies in Zone III as per revised Seismic Zoning Map of India corresponding to moderate seismic hazard. Engineering construction shall be done so as to meet codal provisions.

8.2.5. Green Buildings

Green building (also known as sustainable building) refers to both a structure and the using of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition. Green buildings help in better preservation of environment as in such structures there are provisions for better saving of energy, water and CO2. Such buildings also have better waste management arrangements. All stations and Depot buildings can be designed as green buildings.

The Indian Green Building Council (IGBC), part of the Confederation of Indian Industry (CII) was formed to enable a sustainable built environment for all and facilitate India to be one of the global leaders in the sustainable built environment by 2025. IGBC has launched green Mass Rapid Transit System (MRTS) rating system for all stations and green Factory Building rating system for Depots.These rating systems are tools to enable new rail based MRTS to apply green concepts during design & construction, so as to further reduce environmental impacts that are measurable.

The proposed metro project is Pune should address the green features under the following categories to get the IGBC green MRTS and green factory building rating system:

- Site Selection and Planning
- Water Efficiency
- Energy Efficiency
- Material Conservation
- Indoor Environment and Comfort
- Innovation in Design & Construction

8.2.6. Solar Power

For the utilization of renewable energy, wherever feasible, installations for solar power can be implemented on the roof of elevated stationsand in Depots. Solar energy generation per year is estimated to be 2.74 Giga-watt-hr for PCMC-Range Hill Corridor and 4.87 Giga-watt-hr for Vanaz-Ramwadi Corridor. Energy potential and cost for installations in Depots has not been estimated in this report because amount of land/structure surface area available for this purpose can be estimated upon evaluation of the Depot layouts. The installation cost for solar system is about Rs 179.60 Lakh for PCMC-Range Hill Corridor and Rs 299.33 Lakh for Vanaz-Ramwadi Corridor. However this cost is not included in estimated cost of EMP since installation and maintenance of solar power infrastructure is proposed to be awarded to developer along with power purchase agreement.

8.2.7. Use of Energy and Water

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

Water supply in stations for air conditioning, cleaning and use of staff and passengers will be procured from municipal supply – this will be supplemented by re-use of treated waste water generated by staff and passengers. Water for depots will be sourced from municipal supply: this will be supplemented by re-use of used water from coach wash.

8.2.8. Utility Plan

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

The Organizations / Departments responsible for concerned utility services are reported in Table 8.2.

Table 8.2: Organizations Responsible for Utilities and Services

S. No.	Organization/ Department	Utility/Services
1.	PWD / NHAI	Road
2.	Pune Municipal Corporation/ MWSSB	Sewerage and drainage lines. Water mains and their service lines, including hydrants and fountains etc, water treatment plants, pumping stations, Roads, surface water drains, nallahs, sewer lines, street lights, high mast lights etc.
3.	Telephone Operators	Tele cables, junction boxes, telephone posts, O.H lines
4.	Power Grid Corporation of India Ltd.	HT towers, cables
5.	Irrigation Dept.	Canal
6.	Oil Corporations	Gas pipe lines
7.	Maharashtra State Electricity Board	HT/other overhead Power lines

8.3. EMP DURING CONSTRUCTION

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

8.3.1. Supply of Construction Material

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

8.3.2. Pre-casting yards and Material Stockpiling

Sites for casting of structural concrete elements and material stockpiling will be decided before start of construction. The sites will be identified by Maha-Metro, Pune such that displacement of persons is not involved to the extent possible.

8.3.3. Construction Material Management and Housekeeping

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

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

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

- All stairways, passageways and gangways shall be maintained without any blockages or obstructions. All emergency exits passageways, exits fire doors, break-glass alarm points, fire-fighting equipment, first aid stations, and other emergency stations shall be kept clean, unobstructed and in good working order.
- All surplus earth and debris shall be removed/disposed off from the working areas to officially designated dumpsites. Trucks carrying sand, earth and any pulverized materials etc. shall be covered while moving.
- Unused/surplus cables, steel items and steel scrap within the working areas shall be removed to identified locations.
- All wooden scrap, empty wooden cable drums and other combustible packing materials, shall be removed from work place to identified locations.
- Empty cement bags and other packaging material shall be properly stacked and removed.
- Proper and safe stacking of material is of paramount importance at yards, stores and such locations for future use. The storage area shall be well laid out with easy access and material stored / stacked in an orderly and safe manner.
- Flammable chemicals/compressed gas cylinders shall be safely stored.

8.3.4. Hazardous Waste Management

It shall be the responsibility of the contractor to ensure that hazardous wastes are labeled, recorded, stored in impermeable containment and for periods not exceeding mandated periods and in a manner suitable for handling storage and transport. The contractor shall maintain a record of sale, transfer, storage of such waste and make these records available for inspection. The contractor shall approach only Authorized Recyclers for treatment and disposal of Hazardous Waste, under intimation to the Project Authority.The treatment and disposal sites will be identified by Maha-Metro, Pune in consultation with PMC such that pollution of water bodies and green areas are not impacted and displacement of persons is not involved.

8.3.5. Construction and Demolition Waste Management

Construction and Demolition (C&D) waste is part of solid waste that results from land clearing, excavation, construction, demolition, remodelling and repair of structures, roads and utilities. C&D waste has the potential to save natural resources (stone, river sand, soil etc.) and energy, reduce transportation over long distances for dumping, and reduce space occupied at landfill sites. C&D waste generated from metro construction has potential use after processing, grading solid waste and recycling.

- Segregation and temporary storage of reusable and recyclable materials at identified locations. Transport recyclable materials to construction sites.
- Sale of metal scrap and other saleable waste
- Identification of intended transport means and route.
- Obtaining permission, where required, for treatment of the hazardous component and its disposal.
- Concrete material shall be brake into coarse size and reutilised in filling.

- The treatment and disposal sites will be identified by Maha-Metro, Pune in consultation with PMC such that pollution of water bodies and green areas are not impacted and displacement of persons is not involved. Before dumping, recyclable material will be removed.The disposal sites will be cleaned and then treated so that leached water does not contaminate the ground water.

8.3.6. Muck Disposal

The excavated material shall be graded such that part can be re-used in construction; balance will be disposed. Before excavation, the Contractor will be required to test the soil quality including heavy metals and the results will be compared with standards. If the soil is contaminated, disposal will be done with due treatment or isolation of such muck.

Disposal sites will be identified by Maha-Metro, Pune in consultation with PMC such that pollution of water bodies and green areas are not impacted and displacement of persons is not involved. The following activities are involved:

- Material will be stock-piled with suitable slopes
- Material will be stabilised each day by watering or other accepted dust suppression techniques. The muck shall be filled in the dumping site in layers and compacted mechanically.
- Once the filling is complete, the entire muck disposal area shall be provided with a layer of good earth on the top and covered with vegetation.

8.3.7. Energy Management

The contractor shall use and maintain lighting, tools and equipment of appropriate specifications so as to conserve energy.

8.3.8. Labour Camp

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

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

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

Health care awareness and clinics: Construction workers are more prone to Infectious diseases such as HIV/AIDS. It should be prevented by following actions: Counselling, community events, clinic, and coordination with local health authorities.

8.3.9. Welfare of Labour on Construction Site

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

Canteen Facilities: A cooked food canteen on a moderate scale shall be provided for the benefit of workers wherever it is considered necessary. The contractor shall conform generally to sanitary requirements of local medical, health and municipal authorities and at all times adopt such precautions as may be necessary to prevent soil pollution of the site.

First aid facilities: At every workplace, a readily available first-aid unit including an adequate supply of sterilized dressing materials and appliances will be provided. Suitable transport will be provided to facilitate taking injured and ill persons to the nearest hospital.

Day Crèche Facilities: At every construction site, provision of a day crèche shall be made so as to enable women workers to leave behind their children. At construction sites where 20 or more women are ordinarily employed, there shall be provided at least one temporary structure with sufficient openings for light and ventilation for use of children under the age of 6 years belonging to such women. There shall be adequate provision of sweepers and maid servants to keep the places clean. These facilities are applicable only if woman workers are employed.

8.3.10. Safety of Labour

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

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

The construction works shall be undertaken in accordance with all applicable legislation and Indian statutory requirements and guidelines-OHSAS 18001-2007: Occupational Health and Safety Management System and ISO 14001-2015: Environmental Management Systems. The key elements of the SHE manual are as follows:

1. Identification of the unit responsible for co-ordinating and monitoring the Contractor’s SHE performance;
2. Procedures for identifying and estimating hazards, and the measures for addressing the same; a list of SHE hazards anticipated
3. SHE training courses and emergency drills
4. SHE inspections to identify any variation in construction activities and operations, machineries, plant and equipment and processes against the SHE Plan and its supplementary procedures and programs: Planned General Inspection, Routine

Inspection, Specific Inspection and Other Inspection

5. Safety Audit: SHE Audit to assess potential risk, liabilities and the degree of compliance of construction Safety, Health & Environmental plan and its supplementary procedures and programs against applicable and current SHE legalisation regulations and requirements of the employer; Electrical Safety Audit; External SHE Audit
6. SHE Communication to communicate the Safety, Occupational health and Environment management measures through posters campaigns / billboards / banners / glow signs being displayed around the work site
7. SHE Reporting – reports, minutes, inspection reports, audit reports
8. Accident reporting and investigation
    - Reports of all accidents (fatal/injury) and dangerous occurrences to the Employer
    - Reporting to Govt. organisations
9. Investigations of Accidents and Dangerous Occurrences, Near misses and minor accidents
10. Prepare an Emergency Response Plan for all work sites including injury, sickness, evacuation, fire, chemical spillage, severe weather and rescue.

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

a) Housekeeping
b) Working at Height and Falling objects and Danger areas
c) Lifting Appliances
d) Launching Operation
e) Construction machinery, tools equipment - Safe worthiness
f) employ qualified electrical personnel on site and requirements of electrical equipment, distribution etc
g) Lighting
h) Exposure of worker to use of exhaust or harmful gases in confined locations
i) Fire prevention, protection and fighting system
j) Corrosive substances
k) Demolition
l) Excavation and Tunnelling
m) Traffic Management
n) Personal Protective Equipment (PPE)
o) Reporting which will contain results of monitoring and inspection programs
p) Process of response to Inquiries, complaints and requests for information from private and government entities
q) Physical fitness of workmen
r) Medical Facilities on site : Occupational Health Centre, Ambulance van and room HIV/ AIDS prevention and control
s) Exposure to Noise – prevention measures
t) Ventilation and illumination

8.3.11. Air Pollution Control Measures

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

- 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.
- Dust control (*Dust Control Manual for Industrial Minerals Mining and Processing, CDC NIOS, RI 9689/2012):*

Processes such as pneumatic filling of silos, transportation by road, drilling and blasting, crushing, screening, bulk/bag unloading generate dust.

Local exhaust ventilation systems (LEVS) as shown in Figure 8.1, capture dust generated and then transport this dust via ductwork to a dust collection filtering device. By capturing the dust at the source, it is prevented from becoming liberated into the processing plant and contaminating the breathing atmosphere of the workers. LEVS possess a number of advantages:

- The ability to capture and eliminate very fine particles that are difficult to control using wet suppression techniques;
- The option of reintroducing the material captured back into the production process or discarding the material so that it is not a detriment later in the process; and
- Consistent performance in cold weather conditions because of not being greatly impacted by low temperatures.

For outdoor areas where potential dust sources are uncontrolled, such as haul roads, stockpiles, and miscellaneous unpaved areas dust suppression by water spraying is required. It is a combination of direct spraying of the material to prevent dust from becoming airborne (prevention) and knocking down dust already airborne by spraying the dust cloud and causing the particles to collide, agglomerate, and fallout from the air (suppression). Water spraying has only a limited residual effect due to evaporation, and will need to be reapplied at various points throughout the process to remain effective. The keys to effective wet spray dust control are proper application of moisture, careful nozzle location, controlling droplet size, choosing the best spray pattern and spray nozzle type, and proper maintenance of equipment.

Good quality haul roads with added petroleum emulsions and adhesives, water spraying with surfactants, speed control, traffic control, load covers are other required dust control measures during transportation. Compaction of topsoil stockpile shall be followed with chemical binder coating and vegetation.

Figure 8.1:Silo top Aero Filter

The drilling process is used on surface and underground for blasting operations which are conducted to fragment the rock. Drilling operations are notorious sources of respirable dust, which can lead to high exposure levels for the drill operator, drill helper, and other personnel in the local vicinity during operation. Therefore, dust controls on drills are necessary and involve both wet and dry methods. Operator cabs are increasingly becoming an acceptable method for protecting the drill operator from respirable dust generated by the drilling operation. The most common method of dust control for underground drilling is using wet drilling techniques. Dry collectors are not commonly used due to the bulkiness of the collectors and their associated maintenance issues.

Blasting occurs infrequently enough that it is not considered to be a significant contributor to PM10. The most common method of dust control is to allow the dust and gases from blasting to be dispersed and removed through the ventilation system in the case of underground operations or through atmospheric dispersion in the case of surface operations. Underground operations generally schedule the blasting during off-shift times to allow sufficient time for the area to ventilate, to disperse, and to remove the dust and gases from the blasting. If off-shift blasting is not feasible, then areas affected by the blasting should be cleared and work should not commence until the dust and gases are removed.

Aggregate crushing and screening operations can be major sources of airborne dust. Worker exposure may be managed through engineering controls to suppress or enclose the dust sources or by isolating the worker from the dust source- Operator Booths, Control Rooms, and Enclosed Cabs and personal protective equipment. The performance of installed dust control systems should be periodically evaluated, maintained, and, when necessary, modified to maximize performance. Wet technique is suitable.

During bulk loading, loading spouts with dust collectors and physical barriers can be used.

8.3.12. Noise Control Measures

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

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

Automation of equipment and machineries, wherever possible, should be done to avoid continuous exposure of workers to noise. The workers employed in high noise level area should be provided with protective devices.

8.3.13. Vibration Management

In underground section the tunnel will be constructed by State of Art Technology i.e. Tunnel Boring Machine (TBM) and stations will be constructed by Cut and Cover method which is widely accepted and the safest technique. In case construction of underground stations or tunnelling by NATM in hard rock which require controlled blasting, estimated vibration levels are within limits.

Methods other than blasting like rock splitters work on principle of wedging (www.stm-ce.com): they are do not produce flying material and therefore do not need evacuation; they are accurate, can work in vertical or horizontal direction and can be mounted on excavators.

At locations where the alignment is close to protected monuments, heritage assets or other sensitive structures, the contractor shall prepare a monitoring scheme including building condition survey prior to construction at such locations. This scheme shall include:

- Monitoring requirements for vibrations at regular intervals throughout the construction period.
- Pre-construction structural integrity inspections of protected monuments, heritage assets or other sensitive structures.
- Information dissemination about the construction method, probable effects, quality control measures and precautions to be used.

Construction activities shall be scheduled such that demolition, earthmoving and ground-impacting operations do not occur in the same time period. Unlike noise, the total vibration produced could be significantly less when vibration sources operate separately. Construction activities shall be avoided during night hours when people are more aware of vibration. The relative merits and demerits of vibratory piles vis-a-vis impact piles are listed in the section under impacts.

A. Blasting

In case construction of underground stations or tunnelling by NATM in hard rock which require controlled blasting, laid down precautions and procedures in accordance with The Explosives Rules 2008 shall be implemented. License and No Objection Certificate from District Magistrate or DGMS as case may be to transport and possess to use explosives; laid down precautions to be observed during transportation, handling, storage, inventory and use; precautions to be observed against fire, accident, loss, pilferage; procedures of disposal or destruction of explosives.

8.3.14. Chance Finds

There is likelihood that chance finds of archaeological or heritage value is discovered during excavation done for the purpose of construction of the Metro.

Article 23 of The Ancient Monuments and Archaeological sites and Remains Act,1958 amended in 2010 covers procedure to deal with antiquities discovered during archaeological excavations. However chance finds discovered during excavation for other purposes are to be dealt in accordance with Indian Treasure Trove Act, 1878, modified up to the 1st September, 1949. Treasure is defined as “anything of any value hidden in the soil, or in anything affixed thereto”.

The steps involved in dealing with chance finds are as follows:

a. Notice by finder of treasure to Collector
b. Notification by Collector requiring claimants to appear
c. When treasure may be declared ownerless, such treasure shall either be delivered to the finder or be divided between him and the owner of the place in which it has been found. When no other person claims as owner of place, treasure to be given to finder.
d. The Collector, may, at any time before delivering or dividing the treasure declare his intention to acquire on behalf of the Government the treasure or any specified portion thereof, by payment to the persons entitled thereto and thereupon such treasure or portion shall be deemed to the property of the Government.
e. Decision of Collector is final.

8.3.15. Increased Water Demand Management

Water requirement for construction of metro will be met through municipal supply or through sewage treated and re-used. Estimated capital cost of treating sewage from municipal STPs to use in construction as alternative to municipal fresh water supply is Rs 54 lakh excluding pipeline cost.This cost is not included in EMP cost.

8.3.16. Water pollution Control

Wastewater generated from the site during the construction contains suspended materials, spillage and washings which can pollute surface and ground water; such washings shall be led through separate drains into precipitation chambers before discharge into the sewage drain to the standards prescribed for disposal.

8.3.17. Traffic Diversion/Management

In order to retain satisfactory levels of traffic flow during the construction period; traffic management and engineering measures need to be taken. They can be road widening, traffic segregation, one-way movements, traffic diversions, acquisition of service lanes, etc.

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

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

8.3.18. Soil Erosion and land subsidence control

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

To manage land subsidence measures including maintaining adequate distance of the trench from existing structures adjacent to the trench, measures to support the walls of the trench as well strengthen soil underneath adjacent structures will be required.

8.3.19. Draining of Water

Water from underground works shall be led by construction drains into sumps and then to trunk sewers or used to recharge groundwater or re-use for construction. Capital and operating cost is included in engineering cost and therefore is not included in EMP.

8.4. EMP DURING OPERATION

8.4.1. Noise and Vibration Management

Use of ballast-less track with elastic and absorbent fittings is a standard provision for noise control. At depots use of green belt with vegetation of thick foliage helps reduce noise; where site layout permits barrier blocks of less-vulnerable buildings can be used; alternatively freestanding barrier walls can be built (*Manual on norms and standards for* *environment clearance of large construction projects, MoEFCC, 2007*).Screening of noise shall be ensured by providing parabolic noise barriers on each side of the track along the curved portion of the viaduct and at sensitive receptors during operation. Polycarbonate noise barriers 15 mm to 25 mm thick are known to reduce noise level by between 30 dB to 33 dB. A budgetary provision of Rs. 98lakh is kept in the cost estimate towards the Noise Barriers for PCMC - Rang Hill Section and Rs. 373.35 Lakh for Vanaz - Ramwadi Corridor.

Vibration can be reduced by proper design and maintenance of track and rolling stock.In case of ballast less track, the following are some measures for vibration damping: resilient soft base plates between rail and track slab; resilient rubber between the base plate and track slab; soft elastic fastening system[12]. Deep and narrow trenches in the ground shall be tested at vibration-sensitive structures.

8.4.2. Water Supply and Sanitation at Stations

The public health facilities such as water supply, sanitation and toilets are much needed at each station.Water supply for air conditioning, cleaning and use of staff and passengers will be procured from municipal supply – this will be supplemented by re-use of treated waste water generated by staff and passengers.Total quantity of waste water generation at all stations of PCMC – Swargate alignment will be 300 KLD; and where as at all stations of Vanaz – Ramwadi alignment will be 196 KLD. The waste water will be treated by installing bio digesters at each stations and depots. Number of Bio Digesters and cost at each station is given in Table 8.3.

Table 8.3: Capacity of Bio Digester at Each Station

S. No.	Station Name	Waste Water in KLD	Capacity of Bio Digester System in KLD	Number of Bio Digesters	Cost of Bio Digester in Rs Lakh
PCMC-Swargate					
1	PCMC	63.0	65	13	5.2
2	Tukaram Nagar	23.6	25	5	2.0
3	Bhosari (Nashik Phata)	13.1	15	3	1.2
4	Kasarwadi	20.4	20	4	1.6
5	Fugewadi	38.7	40	8	3.2
6	Dapodi	7.3	10	2	0.8
7	Bopodi	19.1	20	4	1.6
8	Khadki	3.6	10	2	0.8
9	Range Hill	13.1	15	3	1.2
10	Shivaji Nagar	16.9	20	4	1.6
11	ASI	1.4	10	2	0.8
12	PMC	9.9	10	2	0.8
13	Budhwar Peth	7.3	10	2	0.8
14	Mandai	15.0	15	3	1.2
15	Swargate	47.1	50	10	4.0

[12]Current state of practice in railway track vibration isolation: an Australian overview, SakdiratKaewunruen & Alex M. Remennikov,Jan 2016, Australian Journal of Civil Engineering

S. No.	Station Name	Waste Water in KLD	Capacity of Bio Digester System in KLD	Number of Bio Digesters	Cost of Bio Digester in Rs Lakh
	Total	300	335	67	26.8
Vanaz - Ramwadi					
1	Vanaz	20.8	20	4	1.6
2	Anand Nagar	1.7	10	2	0.8
3	ideal Colony	0.1	10	2	0.8
4	Nal Stop	30.1	30	6	2.4
5	Garware College	5.5	10	2	0.8
6	Deccan	26.9	30	6	2.4
7	ASI	8.8	10	2	0.8
8	Civil Court	25.1	25	5	2.0
9	Mangalwar Peth	13.5	15	3	1.2
10	Pune Railway Station	20.5	20	4	1.6
11	Ruby Clinic	4.6	10	2	0.8
12	Bund Garden	8.0	10	2	0.8
13	Yerawada	8.0	10	2	0.8
14	Kalyani Nagar	15.1	15	3	1.2
15	Ramwadi	7.3	10	2	0.8
	Total	**196**	**235**	**47**	**18.8**

Bio Digesters

Maha-Metro, Pune will install eco-friendly bio-digesters at 36 stations and 2 Depots for onsite disposal of human waste. A memorandum of understanding (MoU) in this regard was signed with Defense Research and Development Organization (DRDO), which had developed this technology. The bio-digester based eco-friendly sanitation technology will convert human faecal waste into water and gas. This technology was developed to solve the sanitation problem faced by soldiers in high altitude.This technology has 2 components

(i) The anaerobic microbial consortium which is formulated from group of bacteria that are very efficient to perform the biodegradation of the human waste in wide range of temperature and in presence of toxic chemicals.
(ii) The vessel in which fermentation is carried out with the help of bacteria is called bio-digester.

The process of bio-degradation of human waste used in the present technology is carried out in strict anaerobic environment (devoid of oxygen) by anaerobic microbial consortium. It involves multiple biochemical steps and is of complex nature. These steps are sequential in nature and interdependent.

Bio-digester technology treats human waste at the source. A collection of anaerobic bacteriathat has been adapted to work at temperatures as low as -5°C and as high as 50°C act asinocula (seed material) to the bio-digesters and convert the organic human waste into water,methane, and carbon-dioxide. The anaerobic process inactivates the pathogens responsiblefor water-borne diseases and treats the fecal matter without the use of an external energysource. The only by-products of the waste treatment process are pathogen-free water,which is good for gardening, and bio-gas, which can be used for cooking. Bio-toilets do notrequire sewage connectivity and because the process is self-contained, bio-toilets are alsomaintenance-free. Anticipated influent & effluent wastewater quality parameters from thebio-digesters are given in Table8.4 and typical cross section of a Bio Digester is shown in Figure 8.2.

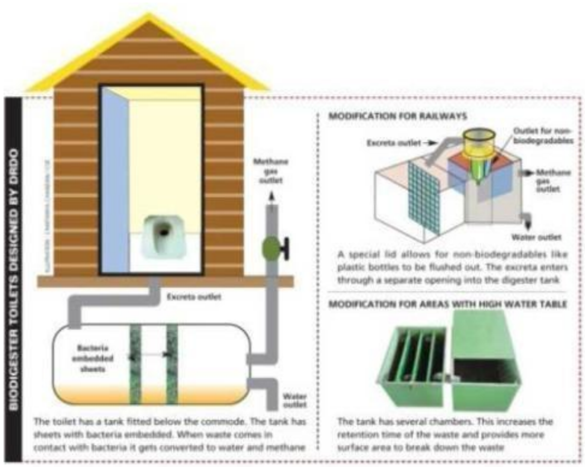
Table 8.4: Wastewater Quality Parameters (Influent & Effluent)

S. No	Parameter	Unit	Characteristics	
			Influent	Effluent
1.	pH	-	7.0 - 7.5	7.0 - 7.5
2.	Turbidity	NTU	70 - 90	2 - 5
3.	Total Suspended Solids	mg/l	90 - 120	50 - 80
4.	Total Dissolved Solids	mg/l	350 - 450	100 - 300
5.	Bio Chemical Oxygen Demand at 5 days and $20^{O}C$	mg/l	70- 120	2-4
6.	Chemical Oxygen Demand	mg/l	250 - 300	15 -25
7.	Coliforms	MPN/100 ml	300 - 350	0 - 12

Source: DRDO Website

Organic waste will be segregated and treated by in-site bio-composter technique.

Figure 8.2:Typical Cross Section of Bio Digester



8.4.3. Rain Water Harvesting

To augment the storage of groundwater, it is proposed to construct rainwater harvesting structure of suitable capacity at the elevated stations and in the elevated alignment. Each pillar can have inbuilt downpipes to collect the rainwater from the viaduct and led into underground tanks; water collected will percolate down to the subsoil through layers of sand and gravel.

Average annual rainfall of Pune is 722 mm. The annual rainwater harvesting potential of elevated stations and viaduct is estimated at 2.07 lakh cubic meters per year. Estimated cost for rainwater harvesting for viaduct and elevated stations is Rs 208.26 Lakh for PCMC-Range Hill corridors and Rs 263.97 Lakh for Vanaz – Ramwadi corridors.

8.4.4. Management Plan for Depots

- Water supply
- Rain water harvesting
- Waste Water Treatment
- Oil Pollution
- Surface Drainage
- Green Belt Development
- Solid Waste Disposal
- Top Soil Preservation, reuse and dust control

a) Water Supply

Water will be sourced from municipal supply.This will be supplemented by re-use of used water from coach wash (10.6 kld for PCMC – Swargate line and 5.80 kld for Vanaz-Ramwadi line).

b) Rain Water Harvesting

To augment storage of groundwater, it is proposed to construct roof top rainwater harvesting structure of suitable capacity in the depots. Rainwater harvesting potential of depots will be estimated upon availability of depot layout plans and cost of rainwater harvesting estimated.

c) Waste water Treatment

Bio Digester with Reed bed (DRDO, India) system which can handle human waste as well as wastewater as proposed by Maha-Metro Pune can be installed at each Depot. Number of Bio Digesters and cost at each station is given in Table 8.5.

Table 8.5: Capacity of Bio Digester at Depots

S. No.	Station Name	Waste Water in KLD	Capacity of Bio Digester System in KLD	Number of Bio Digesters	Cost of Bio Digester in Rs Lakh
1	Range Hill Depot	22.5	25	5	2.0
2	Vanaz Depot	18.8	20	4	1.6

The treated waste water could be reused for horticulture, washing and flushing purpose in the depot area.

d) Oil Pollution

Oil spillage from during change of lubricants, cleaning and repair processes in the maintenance Depot cum workshop for maintenance of rolling stock should be trapped in oil and grease traps and disposed off to authorised collectors, so as to avoid any underground/ surface water contamination. These traps need to be installed before effluent treatment plant.

e) 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.

f) Green Belt Development

The greenbelt development / plantation in the depot area harmonizes the depot with surrounding environment and acts as pollution sink / noise barrier. It will check soil erosion. Compensatory afforestation cost at depot area is included in the Compensatory Afforestation cost of the project as given in Section 7.2.1. In addition to the compensatory afforestation, green belt is recommended around the perimeter of the Depots. Cost will be estimated upon finalisation of area and shape of depot sites. Treated sewage and effluent can be used for green belt development.

g) Solid Waste Disposal

Solid waste generated from the Depots which includes hazardous waste will be taken awayby the cleaning contractor weekly and recycled/treated and disposed of at designated waste disposal sites.

h) Top soil preservation, reuseand dust control

Top soil which is found to be rich in nutrients based on soil sampling shall be preserved during construction and re-used for horticulture post-construction.Permanent plantation on un-paved area shall be done.Complete dust interception can be achieved by a 30 m belt of trees. Even a single row of trees may bring about 25 percent reductions in airborne particulate matter *(Manual on norms and standards for environment clearance of large construction projects, MoEFCC, 2007).*

8.5. DISASTER RISK MANAGEMENT

Hazard is a threat or event which can cause damage; disaster is a major hazard event. Disaster risk is expressed as the likelihood of loss of life, injury or destruction and damage from a disaster.

The recommended approach (UNISDR) is to manage disaster risk rather than managing disasters. Disaster risk is the combination of the severity and frequency of a hazard, the numbers of people and assets exposed to the hazard, and their vulnerability to damage. The main opportunity in reducing risk lies in reducing exposure and vulnerability. Disaster Risk Management includes the following actions:

i. **Reduction and prevention: M**easures to reduce existing and avoid new disaster risks, for instance relocating exposed people and assets away from a hazard area. In case of mass transit like Metro such measures are not actionable.
ii. **Mitigation:** The lessening of the adverse impacts of hazards and related disasters. For instance implementing strict land use and building construction codes. This aspect is accounted for in design and construction of the project.
iii. **Transfer:** The process of formally or informally shifting the financial consequences of particular risks from one party to another, for instance by insurance. This is not yet available.
iv. **Preparedness:** The knowledge and capacities of governments, professional response and recovery organisations, communities and individuals to effectively anticipate, respond to, and recover from the impacts of hazard events or conditions, for instance installing early warning systems, identifying evacuation routes and preparing emergency supplies.

Risk Management process[13] comprises the following stages:

a) Description of the system that is at risk
b) Identify the potential hazards or sources of risk (the list of initiating events or scenarios of events leading to the undesired outcome – technological and human)
c) Risk analysis to estimate the likelihood of the scenarios or events occurring and each scenario's consequence
d) Compare and rank the various risk drivers
e) Action plan in response to the identified major risks
f) Regular monitoring, review and updation of the process.

1) For example, the system at risk needs to be defined as to include inter-modal integration.
2) Examples of potential hazards are fire risk or security alarms or failure of train control or motive power or passenger doors / escalators / platform screen doors on trains or in stations; staff training and work environment; inadequate maintenance.
3) Action plan shall include the following.

Procedures and Records

Evaluation of progress and effectiveness of EMP and EMoP,response to inquiries, complaints and requests for informationsurveillance, incident reporting, corrective and preventive actions, emergencies, training and emergency exercises, response to emergencies,

Identification of resources: Sources of repair equipment, personnel, transport and medical aid for use during emergency will be identified.

Emergency systems: Back-up systems for ventilation, communication and train control, lighting etc shall be established.

Evacuation procedures: Evacuation procedures will be prepared in consultation with local administration and notified. To ensure coordinated action, an Emergency Action Committee shall be constituted.

[13] A. Berrado, Em El-Koursi, A. Cherkaoui, M. Khaddour. A Framework for Risk Management in Railway Sector: Application to Road-Rail Level Crossings. Open transportation Journal, Bentham Open, 2010, 19p. HAL Id: hal-00542424 https://hal.archives-ouvertes.fr/hal-00542424 Submitted on 2 Dec 2010

Communication System: Primary and back-up system shall be put in place

4) **Review and Updation:** Drawing inputs from the incident reporting system the Action Plan shall be reviewed at pre-decided intervals and upon occurrence of defined ``trigger events`` and suitably updated.

8.6. TRAINING

The training for engineers and managers will be imparted by Maha-Metro, Pune on regular basis to a) monitor implementation of approved EMS by Contractor b) monitor environmental status during operation and c) monitor disaster management during operation. The cost is estimated to be Rs 15.00 Lakh for PCMC – Swargate Corridor and Rs 12.50 Lakh for Vanaz – Ramwadi Corridor as the details are listed in Table 8.6.

Table 8.6: Cost for Training Program

S. No	Item	Cost (Rs)	
		PCMC- Swargate	Vanaz-Ramwadi
1	Curriculum Development and course preparation 1 months Rs.50000/month	50,000	50,000
2	Extension Officer (1 year) Rs. 20,000/month	9,60,000	9,60,000
3	Instructor 20 sessions of 10 days each	2,40,000	2,40,000
4	Demonstration/Presentation Aids	1,00,000	-
5	Material etc	1,50,000	-
	Total	**15,00,000**	**12,50,000**

Chapter 9 : Environmental Monitoring Planand Environmental Management System

9.1. ENVIRONMENT MONITORING PLAN

9.1.1. Pre-Construction Phase

The environmental monitoring programme helps in signalling the potential problems resulting from the proposed project activities and will allow for prompt implementation of corrective measures. Pre-construction phase monitoring has been done for the proposed project for air, noise, vibration, water and soil quality as part of this report. The results so obtained are documented in Chapter 4. This will have to be followed by monitoring of afforestation/transplantation.

9.1.2. Construction Phase

Monitoring schedule for the entire period of construction is summarized in Table 9.1. The number of locations could be modified based on need when the construction commences. Monitoring should be carried out by NABL Accredited/MoEFCC recognized private or Government agency. The contractor will be responsible for carrying out monitoring during construction under the supervision of PIU. The results of air quality, water quality, waste water, vibration monitoring will be submitted to management quarterly during construction phase.

Table 9.1:Construction Stage Monitoring Schedule

Parameter	Frequency	Locations (number)*	Reference/Standard	Implementation by / Approval by
Air	Once (24 hours) in Two weeks at four locations for each reach for entire construction period.	4	• Guidelines for Ambient Air Quality Monitoring, CPCB, 2003 • National Ambient Air Quality Standards 2009	Contractor/Maha-Metro, Pune
Noise	Once (24 hours) in Two weeks at four locations for each reach for entire construction period.	4	• Protocol for Ambient Level Noise Monitoring, CPCB, May 2015 • ISO/ TC 108 (vibration)	Contractor/ Maha-Metro, Pune
Vibration	3 ASI Sites, 2 Hospitals and 2 locations vertically above UG section	16		
Water (surface	Once in a season, four seasons in a year	12	• Guide Manual – Water and waste	Contractor/ Maha-Metro, Pune

Parameter	Frequency	Locations (number)*	Reference/Standard	Implementation by / Approval by
and ground water) and waste water			water analysis, CPCB • Drinking water – Specifications IS 10500: 2012 and CPHEEO Manual 2012	
Soil	Once in a season, four season in a year	12	US EPA test protocols	Contractor/ Maha-Metro, Pune
Ecology	Four time each year	Along corridor, at depots and afforestation sites.	As per Forest authorities	Contractor/ Maha-Metro, Pune&Parks and garden Department of PMC.
Worker safety	As per SH&E/EMS			

* The number of locations of Air & Noise may vary depends upon the front site open in each reaches. The number of monitoring location will be decided with prior consent of GC/Maha-Metro.

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

The estimated environmental monitoring cost during construction phase is Rs 568.16 Lakh for PCMC- SwargateCorridor and Rs 81.52 Lakhfor Vanaz-Ramwadi Corridor.The estimated cost towards environmental monitoring during construction will be part of civil contract.

9.1.3. Operation Phase

The monitoring schedule is presented in Table 9.2. The results of air quality, water quality, waste water, vibration will be submitted to management bi-annually during operation phase.

Table 9.2: Operation Stage Monitoring Schedule

Parameter	Frequency	Locations (number)	Reference/Standard	Implementation by / Approval by	Period (years)
Air	2x24 hours in a week for each season, Three seasons in a year	31	• Guidelines for Ambient Air Quality Monitoring , CPCB, 2003 • National	Maha-Metro, Pune	3

Parameter	Frequency	Locations (number)	Reference/Standard	Implementation by / Approval by	Period (years)
			Ambient Air Quality Standards 2009		
Noise	2x24 hours in a week for each season, Three seasons in a year	31	Metro Rail Transit System, Guidelines for Noise and Vibrations, RDSO, Ministry of Railways, September 2015	Maha-Metro, Pune	3
Vibration	24 hours, once a two month	8			
Water (surface and ground water)	Once in a season, Three seasons in a year	12 locations	• Guide Manual – Water and waste water analysis, CPCB • Drinking water – Specifications IS 10500: 2012 and CPHEEO Manual 2012	Maha-Metro, Pune	3
Waste Water	Once in a season, three seasons in a year	2 depots			
Solid Waste	Once a year	2 depots	• Solid Waste Management Rules 2016	Maha-Metro, Pune	3
Soil	Once in a season, four season in a year	12 locations	US EPA test protocols	Maha-Metro, Pune	3
Ecology	Once a year	Afforestation sites	As per Forest authorities	Maha-Metro, Pune/& Parks and garden Department of PMC	3

The estimated environmental monitoring cost during operation phase is Rs 184.15 Lakh for PCMC-Range Hill Corridor and Rs 166.86 Lakh for Vanaz-Ramwadi Corridor.

9.2. ESTABLISHMENT OF ENVIRONMENTAL DIVISION

It is recommended that Project Authority establishes an Environment Division at the initial stage of the project itself. This division should have an Environmental Officer and an Environment Engineer. The task of the division would be to monitor implementation of environmental mitigation measures and environmental monitoring and it should report directly to Chief Engineer of the Project Authority. Progress of the division should be reviewed by an Environmental Advisor once in a year. The Environmental Advisor should be an experienced expert familiar with environmental management in similar projects. Cost for the first ten years (including 10% annual increase) is given in Table 9.3. The estimated cost is

Rs 243.68 Lakh each for PCMC – RangeHillCorridor and Rs 164.92 Lakh for Vanaz - Ramwadi Corridor.

Table 9.3: Environmental Division Cost

S. No	Head	Cost (Rs Lakh)	
		PCMC-RangeHill	Vanaz-Ramwadi
A	**Capital Cost**		
	Office Furnishings (Computer, furniture etc) LS	2.50	2.50
B	**Recurring Cost**		
	Man Power Cost (For 12 months)		
	Environmental Engineer @ Rs. 50,000/month	6.00	0.00
	Environmental Assistant @30000/month	3.60	3.60
	Office Maintenance @ Rs. 15,000/month	1.80	1.80
C	**Sub Total (A+B)**	**13.90**	**7.90**
	Miscellaneous expenses, LS (10 % of C)	1.39	0.79
	Total cost for 1 Year	**15.29**	**8.69**
	Total cost for 10 years @ 10% annual increase	**243.68**	**164.92**

9.3. ENVIRONMENT MANAGEMENT SYSTEM (EMS)

Environment Management System is intended to facilitate implementation, tracking and reporting on Environment Management Plan and Environment Monitoring Planproposed for the project. Clearances/permissions required for the proposed metro corridors are given in Table 9.4 and Roles and responsibilities for preparation and Implementation of Environmental Management Plan (EMP) and Environmental Monitoring Plan (EMoP) are summarized in Table 9.5.

Table 9.4: Clearances/Permissions for Proposed Metro Corridors

S. No	Clearance/Permission	Act/ Rules/ Notifications	Authority
1.	Building Permissions	EIA Notification 2006 with Amendment forIntegration of environmental Conditions in local building byelaws.	Building permission from PMC/PCMC for stations and depots.
2.	Land Use Change	Town Planning Department, Pune Municipal Corporation	PMC/PCMC
3.	Consent to establish and Consent to operate construction yards, labour camps, stations and depots(*sincenon-residential)*	Water (Prevention and Control of Pollution) Act 1974, Air (Prevention and Control of Pollution) Act 1981	State Pollution Control Board (Checklist of information to be submitted along with Application is given in at Annexure 8.1)
4.	Sites to establish labour camps, pre-casting and material yards	Land use Master Plan and DC&PR	PMC/PCMC
5.	Permission for disposal of Construction and Demolition	Construction and Demolition Waste Management Rules, 2016	SPCB; PMC/PCMC for

S. No	Clearance/Permission	Act/ Rules/ Notifications	Authority
	Waste		sites
6.	Permission for Disposal of Hazardous Waste	Hazardous and Other Wastes (Management, and Trans boundary Movement) Rules, 2016	SPCB; PMC/PCMC for sites
7.	Permission for muck disposal	Rules of PMC/PCMC	PMC/PCMC for sites
8.	Permission to excavate land and near utilities	Rules/norms of PMC/PCMC and utility agencies	PMC/PCMC and utility agencies
9.	Permissions for energy, water supply, sewage and solid waste disposal etc		
10.	Permission for felling of trees	Tree Authority Department, Pune Municipal Corporation	PMC/PCMC (Form enclosed at Annexure 8.2)
11.	License and NOC in connection with blasting during construction	The Explosives Act 2008	DGMS and District Collector
12.	Consent for construction near ASI monuments	The Ancient Monuments and Archaeological sites and Remains Act,1958 amended in 2010 The Ancient Monuments and Archaeological sites and Remains (Amendment) Bill 2017	Archaeological Survey of India (Form enclosed at Annexure 8.3)
13.	Proceedings to deal with chance finds	Indian Treasure Trove Act, 1878, modified upto the 1st September, 1949.	District Collector
14.	Consent for construction near Heritage Structures	Conservation of Heritage Buildings/ Precincts/ Natural Features, DCPR-2017 for Pune Municipal Corporation	Municipal Commissioner, Pune
15.	Forest Clearance	Forest (Conservation) Act 1980	Not required
16.	Wildlife Clearance	The Wildlife (Protection) Act, 1972	Not required
17.	CRZ Clearance	Coastal Regulation Zone Notification, 2011	Not required

Table 9.5: Roles and Responsibilities –Preparation and Implementation EMP and EMoP

SN o	Environmental Impact	Mitigation Measure	Implementing Entity	Responsible Entity
EMP during Location and Design Phase				
1	Displacement and private property acquisition, impact of environmentally sensitive areas.	Alignment design to avoid or minimize impact.	DPR and design consultant	PIU
2	Loss of trees and water bodies		DPR and design consultant	PIU
3	Visual intrusion	Capital and operating cost and vibration impact of underground line in trade off with visual intrusion. To design aesthetic	DPR and design consultant	PIU

SN o	Environmental Impact	Mitigation Measure	Implementing Entity	Responsible Entity
		structures of viaduct and stations on elevated sections.		
4	Archaeological monuments	Alignment design to avoid or minimize impact.	DPR and design consultant	PIU
EMP during Pre-construction Phase				
1	Disclosure	Disclose to stakeholders the EMP/EMoP measures proposed to be implemented; upon feedback, revise the measures if necessary	PIU	PIU
2	Displacement and private property acquisition.	Implement R&R Plan	PIU	PIU
3	Loss of trees and water bodies	Implement compensatory afforestation	PMC	PMC
4	Site measures	Prepare Safety, Health and Environment (SH&E) Manual and secure approval.	Contractor	PIU
5	Environmental Management and Monitoring	Implement institutional requirements for implementation of EMP and EMoP.	Contractor	PIU
EMP during Construction Phase				
1	Soil erosion, fugitive dust generation, muck disposal and C&D waste management	Implement suitable construction methods and as per SH&E Manual • Contractor shall dispose the muck/dry soil generated at construction sites at a mutually agreed location by GC/Maha-Metro and Contractor. • Contractor shall carry out the reconciliation for the disposed soil and quantities shall submit to GC/Maha-Metro on quarterly basis. • Dry wheel wash facilities shall beprovided at exit gate from wheresoil disposal shall be carried. • Sufficient staff shall be madeavailable at site to control thedisposal of muck/soil from sitesuch as a supervisor, labors forwheel cleaning, brooms for wheelcleaning and concrete pad wherewheels will be cleaned. • The dumpers carrying the muck/dry soil has to be covered while plying on the roads on the way to disposal location. • Contractor shall take due care that muck generated during piling works does not get contaminated with hydrocarbons or any other contaminant. • The onsite muck shall be monitored	Contractor	PIU

SNo	Environmental Impact	Mitigation Measure	Implementing Entity	Responsible Entity
		quarterly at random location during piling works in progress. In case any polluted muck is produced; the muck shall be handled and disposed as per provisions of hazardous waste handling rules 2016. • Construction and Demolition Waste shall be disposed in accordance with the provisions of C & D waste handling rules 2016.		
2	Air and noise Pollution	Vehicles and machinery are to be maintained to emission standards; machinery noise muffles etc and personal protective gear to workers.	Contractor	PIU
3	Vibration	Implement vibration monitoring and building condition surveys at sensitive structures	Contractor	PIU
4	Water pollution	• Implement measures such as precipitation tanks on site • Contractor shall try and reduce the water consumption through use of energy efficient water fixtures at sites and project offices • Leakage of water should not be • allowed through pipes and valves • Reuse of water used for curing and for other uses to be planned	Contractor	PIU
5	Soil pollution	• Implement measures to prevent ingress of toxic / heavy metals. Suitable storage area for suchmaterials shall be prepared andequipment shall be made availablefor handling of these materials. • Contractor shall take all necessary precautions such that construction material, diesel, grease, waste oil, chemicals etc. does not spill on ground. • Regular monitoring of groundwater and soil leachate shall be conducted in depot areas where possibility of ground water contamination is anticipated	Contractor	PIU
6	Water supply; waste water and solid waste disposal from construction activities	• Arrange for water supply; Implement measures as per SH&E Manual. • The contractor shall prepare the waste management plan and submit to the GC/Maha-Metro for concurrence. • Contractor shall dispose-offhazardous wastes as per theprovisions of SHE manual for Pune Metro. • Contractor shall dispose-off	Contractor	PIU

SNo	Environmental Impact	Mitigation Measure	Implementing Entity	Responsible Entity
		nonhazardoussolid wastes, nonhazardousliquid wastes, biomedical wastes as per theprovisions of SHE manual for Pune Metro.		
7	Labour camp: water supply; sewage and solid waste disposal; healthcare	Implement measures as per SH&E Manual	Contractor	PIU
8	Facilities on site and workplace safety		Contractor	PIU
9	Incident Management	Prepare Incident Management Plan with reporting formats.	Contractor	PIU
10	Environmental Monitoring	Prepare Environmental Monitoring Plan.		
11	Availability of institutional capacity	Implement training and establish environment unit as per SHE manual	Contractor	PIU
12	Tree protection/ Cutting and Disposal	• Contractor shall prepare an action plan for number of trees to be affected/felled (about 1124 trees) and trees proposed to be planted (about 3372 saplings) as per compensatory afforestation norms • The indigenous plants to be planted in the project area such as Neem, Karanj, Pipal, Babul, Mango, Jamun, Kadam, Indian Rain Treeetc. • Other than Contractor, no one is allowed to cut the identified trees which are falling in a ROW • Biomass shall not be stored at site for more than 15 days	Contractor	PIU
13	Energy Management /Conservation	The contractor shall use and maintain lighting, tools and equipment of appropriate specifications so as to conserve energy.	Contractor	PIU
EMP during Operation Phase				
1	Noise Pollution	Wherever required implement and maintain noise barriers on viaduct	PIU	PIU
2	Vibration	Implement vibration monitoring and building condition surveys at sensitive structures, if required	PIU	PIU
3	Water supply, sewage and solid waste disposal at stations and depots	• Implement measures including treatment and reuse of waste water, rain water harvesting to augment ground water. • Organic waste shall be segregated and treated by in-site bio composter technique.	PIU	PIU

SN o	Environmental Impact	Mitigation Measure	Implementing Entity	Responsible Entity
4	Incident Management	Implement Incident Management Plan.	PIU	PIU
5	Environmental Monitoring	Implement Environmental Monitoring Plan as mentioned in Section 8.1 of EIA report.	PIU	PIU
6	Monitoring and Grievances	Implement mechanism to monitor progress of implementation of the EMP/EMoP measures and results achieved. Implement mechanism for project-level grievance redressal	PIU	PIU

The range of documentation required to be generated and maintained as part of SH&E before and during construction and during operation is as follows:

- Controlled documents of mandatory environmental Approvals and clearances along with record extensions thereof
- Controlled documents of approved SH&E Manual, EMP and EMoP with revisions thereof and time schedule of such revisions if any.
- Controlled documents of formats of site inspection checklists with revisions thereof and time schedule of such revisions if any
- Reports of site inspections, monitoring data, reports of internal or external audit, observations of PIU and local statutory agency if any like Pollution Control Board, local municipal authority, Forest Department etc. and subsequent remedial action taken by Contractor if any.
- Records of coordination meetings of PIU/GC and Contractor with subsequent remedial action taken by Contractor if any.
- Records of incident reporting and remedial action taken by Contractor if any and follow-up of such incidents.
- Procedures and Records
  Evaluation of progress and effectiveness of EMP and EMoP, response to inquiries, complaints and requests for information.

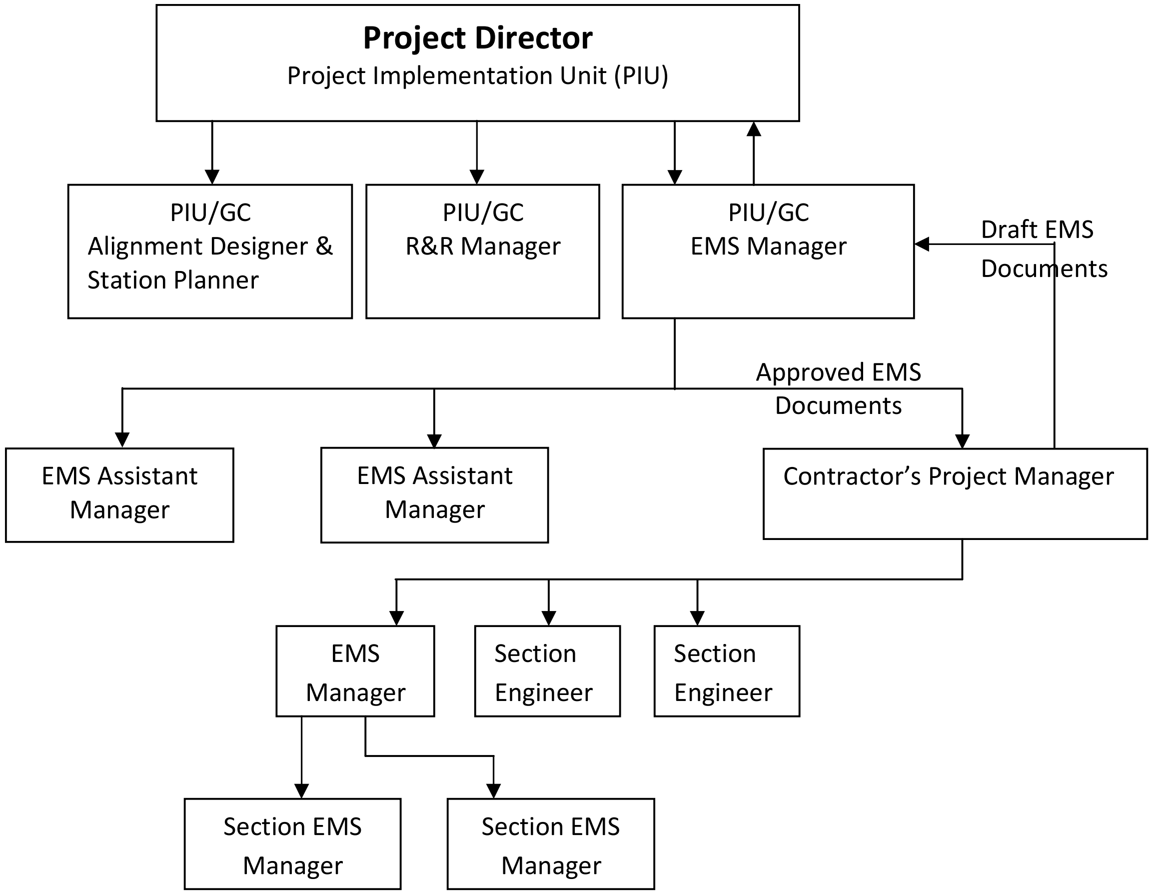
A typical EMS organization is depicted in Figure 9.1.One indicative activity i.e, approval of EMS documents is shown in this organisation chart.

9.4. REPORTING SYSTEM

The monitoring report of environmental parameters (Air, Noise, Water and soil) will be prepared by the environmental engineer and submitted to the Project Management Consultant.

- The contractor will report to Construction Supervision Consultant (CSC) and CSC will report to Maha-Metro, Pune on compliance. Maha-Metro, Pune may disseminate the information to all interested parties.
- Non compliance of the monitoring will be seen by the Maha-Metro, Pune.

Figure 9.1:EMS Organization



* GC: General Consultant as Project Management Consultant

- Photographic monitoring record will be maintained by the contractor. All material source points, disposal locations, plant locations, camp locations, etc should be photographed.
- A full record of construction activities will be kept as a part of normal contract monitoring system under the various stages of construction.
- The reporting format for various activities during construction is given at Annexure 8.4 to Annexure 8.14.

9.4.1. Record Keeping

Monitoring forms will need to be devised for use, focusing attention on environmental issues and providing feedback for future improvement. Mitigation and enhancement measures adopted in the final design will be explicitly under the bill of quantities (BOQ), so that performance and completion is readily documented. Project diaries would record environmental problems (soil erosion, air quality, water quality, noise level etc), as well as safety incidents and will be retained as part of the accepted environmental management.

Chapter 10 : Cost Estimate

10.1. SUMMARY OF COSTS

The total estimated environmental management and monitoring cost for the proposed project is Rs 2744.34 Lakh as indicated corridor wise in Table 10.1.The costtowardsenvironmental monitoring and rainwater harvesting during construction phase will be the part of Civil Contract and remaining cost will be the part of Project Implementation Unit (PIU).

Table 10.1: Cost of Environmental Management Plan

S. No	Item	Amount in Rs. Lakh		Responsibility
		PCMC - Range Hill	Vanaz - Ramwadi	
1.	Compensatory Afforestation	257.71	106.30	PIU
2.	Noise Barriers	97.95	373.35	PIU
3.	Rainwater Harvesting	208.26	263.97	Civil Contract
4.	Environmental Monitoring			
	During Construction	568.16	81.52	Civil Contract
	During Operation	184.15	166.86	PIU
5.	Training and Extension	15.00	12.50	PIU
6.	Environment Division	243.68	164.92	PIU
	Total Amount in Rs. Lakh	**1574.92**	**1169.42**	

ANNEXURE 1.1

DRINKING WATER QUALITY STANDARDS (IS 10500:2012)

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

S. No.	Characteristic	Requirement (Acceptable Limit)	Permissible limit in the absence of alternate source	Remarks
	Max			
21	Mineral oil, mg/l Max	0.5	No relaxation	-
22	Nitrate (as NO_3) mg/l, Max	45	No relaxation	-
23	Phenolic compounds (as C_6H_5OH) mg/l, Max	0.001	0.002	-
24	Selenium (as Se), mg/l, Max	0.01	No relaxation	-
25	Silver (as Ag), mg/l, Max	0.1	No relaxation	-
26	Sulphate (as SO_4) mg/l, Max	200	400	May be extended to 400 provided that Magnesium does not exceed 30
27	Sulphide (as H_2S) mg/l, max	0.05	No relaxation	-
28	Total alkalinity as calcium carbonate, mg/l Max	200	600	-
29	Total Hardness (as $CaCO_3$) mg/l, Max	200	600	-
30	Zinc (as zn), mg/l, Max	5	15	-
31	Cadmium (as Cd), mg/l, Max	0.003	No relaxation	-
32	Cyanide (as CN), mg/l, Max	0.05	No relaxation	-
33	Lead (as Pb), mg/l, Max	0.01	No relaxation	-
34	Mercury (as Hg) mg/l, Max	0.001	No relaxation	-
35	Molybdenum (as Mo) mg/l, max	0.07	No relaxation	-
36	Nickle (as Ni), mg/l, max	0.02	No relaxation	-
37	Polychlorinated biphenyls, mg/l, max	0.0005	No relaxation	-
38	Polynuclear aromatic hydrocarbons (as PAH) mg/l, Max	0.0001	No relaxation	-
39	Total Arsenic (as As), mg/l, Max	0.01	0.05	-
40	Total Chromium (as Cr) mg/l, Max	0.05	No relaxation	-
41	Trihalomethanes Bromoform, mg/l, max Dibromochloromethane, mg/l, max Bromodichloromethane, mg/l, max Chloroform, mg/l, max	 0.1 0.1 0.06 0.2	 No relaxation No relaxation No relaxation No relaxation	-
42	Radioactive materials a) Alpha emitters Bq/l max b) Beta emitters pci/l, Max	 0.1 1.0	 No relaxation No relaxation	-

ANNEXURE 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.	$^{\circ}C$	Shall not exceed 5°C above the receiving water temperature
6	Oil and grease, Max.	mg/l	10
7	Total residual Chlorine, Max.	mg/l	1.0
8	Ammonical Nitrogen (as N), Max.	mg/l	50
9	Total Kjeldah Nitrogen (as N), Max.	mg/l	100
10	Free Ammonia (as NH_3), Max.	mg/l	5
11	Biochemical Oxygen Demand (5 days at 20°C), Max.	mg/l	30
12	Chemical Oxygen Demand Max.	mg/l	250
13	Arsenic (as As), Max.	mg/l	0.2
14	Mercury (as Hg), Max.	mg/l	0.01
15	Lead (as Pb), Max.	mg/l	0.1
16	Cadmium (as Cd), Max.	mg/l	2.0
17	Hexavalent Chromium (as Cr^{+6}), Max.	mg/l	0.1
18	Total Chromium (as Cr) Max.	mg/l	2.0
19	Copper (as Cu), Max.	mg/l	3.0
20	Zinc (as Zn), Max.	mg/l	5.0
21	Selenium (as Se), Max.	mg/l	0.05
22	Nickel (as Ni), Max.	mg/l	3.0
23	Cyanide (as CN), Max.	mg/l	0.2
24	Fluorides (as F), Max.	mg/l	2.0
25	Dissolved phosphates (as P), Max.	mg/l	5.0
26	Sulphides (as S), Max.	mg/l	2.0
27	Phenolic compounds (as C_6H_5OH), Max.	mg/l	1.0
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

ANNEXURE 1.3

TOLERANCE LIMITS FOR INLAND SURFACE WATER QUALITY

Characteristic	Designated Use Class of Inland Waters				
	A	B	C	D	E
pH value	6.5 to 8.5	6.5 to 8.5	6.5 to 8.5	6.5 to 8.5	6.0 to 8.5
Dissolved Oxygen, mg/l, Min.	6	5	4	4	-
Biochemical Oxygen Demand (5 days at 20^0C), mg/l	2	3	3	-	-
Total coliform organisms, MPN/100 ml. Max.	50	500	5000	-	-
Colour Hazen units	10	300	300	-	-
Chlorides (as Cl), mg/l Max.	250	-	600	-	600
Sodium Adsorption ratio Max.	-	-	-	-	26
Boron (as B), mg/l. Max.	-	-	-	-	2
Sulphates (as SO_4), mg/ l	400	-	400	-	1000
Nitrates (as NO), mg/l Max.	20	-	50	-	-
Free Ammonia (as NH_3), mg/l	-	-	-	1.2	-
Conductivity at 25^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	-	-

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

ANNEXURE 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), □m^3	Annual 24 Hours**	50 80	20 80
Nitrogen Dioxide as $NO_{2,}$ □m^3	Annual 24 Hours**	40 80	30 80
Particulate Matter (size less than 10□m) or PM_{10}□m^3	Annual 24 Hours**	60 100	60 100
Particulate Matter (size less than 2.5□m) or PM2.5 □m^3	Annual * 24 Hours**	40 60	40 60
Ozone (O3)□□m^3	8 hours** 24 Hours**	100 180	100 180
Lead (Pb)□□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)□□m^3	Annual * 24 Hours**	100 400	100 400
Benzene (C_6H_6)□□m^3	Annual *	05	05
Benzo (a) pyrene (BaP)particulate phase only nm^3	Annual *	01	01
Arsenic (AS)□□nm^3	Annual *	06	06
Nickle (Ni) nm^3	Annual *	20	20

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

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

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

ANNEXURE 1.5

NATIONAL AMBIENT NOISE STANDARDS

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

Source: Central Pollution Control Board

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

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

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

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

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

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

ANNEXURE 2.1

MAHARASHTRA GOVERNMENT NOTIFICATION ON LARR

REVENUE AND FORESTS DEPARTMENT

Madam Cama Marg, Hutatma Rajguru Chowk, Mantralaya,
Mumbai 400 032, dated the 27 August 2014.

NOTIFICATION

RIGHT TO FAIR COMPENSATION AND TRANSPARENCY IN LAND ACQUISITION REHABILITATION AND RESETTLEMENT ACT, 2013.

No.LQN. 12/2013/C.R. 190/A-2.—Whereas, by Government Notification, Revenue and Forests Department, No. LQN. 12/2013/C.R. 190/A-2, dated the 22nd May 2014 (hereinafter referred to as "the said notification"), the Government of Maharashtra has, published a preliminary draft policy for the observance by the various Departments of the Government of Maharashtra,under section 108 of the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013(30 of 2013), so as to provide higher compensation than calculated under the said Act, in case of the acquisition of land, rehabilitation and resettlement, whose entitlements are overall higher than the Compensation, Rehabilitation and Resettlement package provided under the said Act so as to facilitate the affected persons or his family to opt to avail such higher compensation and rehabilitation and resettlement under any other State laws for the time being in force in the State under which his land is proposed to be acquired.

Now, therefore, the Government of Maharashtra, after considering all the objections or suggestions received by it in respect of the proposed policy published in the said notification hereby publish the policy under section 108 of the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013, as follows, namely :—

Part-1. Land Valuation:—

1. The market value of land to be acquired will be determined by ready reckoner value fixed under the Maharashtra Stamp Act (59 of 1958) and the Maharashtra Stamp (Determination of True Market Value of Property) Rules, 1995.

2. The multiplication factor by which market value of the land is multiplied will be 1.20 in case of rural areas and 1.10 for urban areas. (This factor should be at least 10 percent higher than the State approved multiplier).

3. Compensation of the land to be acquired in rural area: (market value x 1.20) *plus* value of assets attached to land or building)*plus*(100% solatium) = Land Compensation Price;

Compensation of the land to be acquired in urban area: (market value x 1.10) *plus* value of assets attached to land or building) *plus*(100% solatium) = Land Compensation.

4. In case the land is acquired for urbanization purpose, 20% of the developed land will be reserved and offered to the landowner at price equal to cost of acquisition and cost of development. The net land reserved and offered will be excluding the land required for infrastructure development by recovering the cost of acquisition and cost of development gross land i.e. 20%. The land required for infrastructure development and cost of the same as per norms prescribed by Public Works Department or Irrigation Department or Rural Development Department or Municipal Corporations or City and Industrial Development Corporation of Maharashtra (CIDCO) or Mumbai Metropolitan Region Development Authority (MMRDA) or Maharashtra Industrial Development Corporation (MIDC). The actual area required for development of infrastructural facilities will be taken into consideration at the time of calculation of land to be allotted.

The net land to be reserved or offered to land owner will be:—

20% of the gross land-land required for infrastructural development as per norms prescribed by Public Works Department or Irrigation Department or Rural Development

Department or Municipal Corporations or City and Industrial Development Corporation of Maharashtra (CIDCO) or Mumbai Metropolitan Region Development Authority (MMRDA) or Maharashtra Industrial Development Corporation (MIDC) norms-recovery of cost of acquisition as per Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 and cost of development as per norms prescribed by Public Works Department or Irrigation Department or Rural Development Department or Municipal Corporations or City and Industrial Development Corporation of Maharashtra (CIDCO) or Mumbai Metropolitan Region Development Authority (MMRDA) or Maharashtra Industrial Development Corporation (MIDC) for gross 20% land.

Explanation.—As per the City and Industrial Development Corporation of Maharashtra (CIDCO) norms, the area required for infrastructure development considered is 30%.,then the net land to be reserved or offered to land owner will be 20% of the gross land-7% area required for infrastructure development=14% of the land acquired- (recovery of cost of acquisition and cost of development as per City and Industrial Development Corporation of Maharashtra (CIDCO) norms for gross 20% land.

The acquiring body may also give monetary value equivalent of the net developed land in lieu of actually providing the land to the displaced persons or his family.

Part-2. Rehabilitation and Resettlement components:—

1. If a house is lost in rural area, a constructed house shall be provided as per the specifications of *Indira AawasYojana* or Rs. 1.65 lacs in lieu of house.

Explanation.—In case of *Indira AawasYojana*, a house of 25 sq.mt.will be provided. Considering the low specifications, the construction cost will be minimum Rs. 600 per sq.ft.which gives Rs. 1,61,400 excluding the cost of the developed land.

2. If a house is lost in urban area, a constructed house shall be provided of 50 sq.mt.plinth area as per Public Works Department norms or Rs. 5.5 lacs in lieu of house.

Explanation.—Considering the construction cost of Rs. 1000 per sq.ft., the cost of house will be Rs. 5,38,000 excluding the cost of the developed land.

3. One time payment of Rs. 5 lacs to each affected family to those who have eligible candidate for employment.

4. Subsistence allowance to the affected displaced families of Rs. 3000 per month for a year after displacement date. For the families belonging to Scheduled Castes or Scheduled Tribes such families will get additional Rs. 50,000.

5. Transportation cost of Rs. 50,000 per affected displaced families.

6. Those families having cattle shed or petty shops will get Rs. 25,000 one time financial assistance.

7. One time grant for artisans, small traders of Rs. 50,000.

8. One time resettlement allowance of Rs. 50,000 after shifting of house.

9. Stamp duty and registration charges will be borne by Requiring Body for the first transaction of the rehabilitated person only.

10. The Requiring Body will provide the infrastructure in Rehabilitation and Resettlement area, which includes the roads, drainage, *Panchayatghar*, post office, *samajmandir* and other facilities as mentioned in the THIRD SCHEDULE of the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013. However, if the Requiring Body monetize the amenities as per family costs of constructing these amenities as per cost norms developed by Public Works Department or Rehabilitation Department or Irrigation Department or Rural Development Department

or Urban Development Department or Municipal Corporations City and Industrial Development Corporation of Maharashtra (CIDCO) or Mumbai Metropolitan Region Development Authority (MMRDA) or Maharashtra Industrial Development Corporation (MIDC). In such an eventuality, the Requiring Body shall offer 10% plus the total per family cost of all the amenities to be provided under the THIRD SCHEDULE of the said Act.

11. All monetary value fixed above shall be entitled to be increased by 5% on the 1st January of each year unless the rate of inflation index is less than 5 % for that year.

12. Above package will be applicable if the affected person accepts the same through a written consent.

(*Note*.- The explanations provided above are only the supportive information on the basis of City and Industrial Development Corporation of Maharashtra (CIDCO) practice and shall not be included part of the Guidelines)

By order and in the name of the Governor of Maharashtra,

S. K. GAWADE,

Deputy Secretary to Government.

ON BEHALF OF GOVERNMENT PRINTING, STATIONERY AND PUBLICATION, PRINTED AND PUBLISHED BY SHRI PARSHURAM JAGANNATH GOSAVI, PRINTED AT GOVERNMENT CENTRAL PRESS, 21-A, NETAJI SUBHASH ROAD, CHARNI ROAD, MUMBAI 400 004 AND PUBLISHED AT DIRECTORATE OF GOVERNMENT PRINTING, STATIONERY AND PUBLICATION, 21-A, NETAJI SUBHASH ROAD, CHARNI ROAD, MUMBAI 400 004, EDITOR : SHRI PARSHURAM JAGANNATH GOSAVI.

ANNEXURE 2.2

EIB ENVIRONMENTAL AND SOCIAL STANDARDS

TheEIB Environmental Standards *(Environmental and Social Standards Overview, July 2014)* which will be addressed in the EIA Report will be from among the Standards which are listed below.

Standard 1: Assessment and management of environmental and social impacts and risks

The first standard underscores the importance of managing environmental and social impacts and risks throughout the life of an EIB project through the application of the precautionary principle. The standard's requirements allow for the development of an effective environmental and social management and reporting system that is objective and encourages continual improvements and developments. The standard includes requirements for stakeholder engagement and disclosure throughout the life of the project.

Standard 2: Pollution Prevention and Abatement

The objective of the second standard is to avoid and minimise pollution from EIB-supported operations. It outlines a project-level approach to resource efficiency and pollution prevention and control in line with best available techniques and internationally disseminated practices.

Standard 3: Bio Diversity and Ecosystems

The EIB acknowledges the intrinsic value of biodiversity and that its operations may have a potential impact on biodiversity and ecosystems. This standard outlines the approach and measures the promoter has to take to protect and conserve all levels of biodiversity. The standard applies to all habitats (marine and terrestrial) whether or not previously disturbed or legally protected. It focuses on major threats and supports the sustainable use of renewable natural resources and the equitable sharing of benefits from the project's use of natural resources.

Standard 4: Climate Related Standards

EIB financing as a whole is aligned with EU climate policies, which should be taken into account at all stages of the project cycle, in particular regarding the assessment of the economic cost of greenhouse gas emissions and the climate vulnerability context. Specifically, project promoters must ensure that all projects comply with appropriate national and, where applicable, EU legal requirements, including multilateral agreements, related to climate change policy.

Standard 5: Cultural Heritage

Through its projects, the EIB recognises the central role of cultural heritage within individual and collective identity, in supporting sustainable development and in promoting cultural diversity. Consistent with the applicable international conventions and declarations, this standard aims at the identification, management and protection of tangible and intangible cultural heritage that may be affected by project activities. It emphasises the need for the implementation of a "chance-find procedure", which outlines the actions to be taken if previously unknown cultural heritage is encountered.

Standard 6: Involuntary Resettlement

EIB projects sometimes necessitate land acquisition, expropriation and/or restrictions on land use, resulting in the temporary or permanent resettlement of people from their original places of residence or their economic activities or subsistence practices. Standard 6 is rooted in the respect and protection of the rights to property and to adequate housing, and of the standard of living of all affected people and communities. It seeks to mitigate any adverse impacts arising from their loss of assets or restrictions on land use. It also aims to assist all affected persons to improve or at least restore their former livelihoods and living standards and adequately compensate for incurred losses.

Standard 7: Rights and interests of Vulnerable Groups

The EIB seeks to protect all vulnerable project-affected individuals and groups, whilst seeking that these populations duly benefit from EIB operations. The standard requires that there is full respect for the dignity, human rights, aspiration, cultures and customary livelihoods of vulnerable groups including indigenous peoples. It requires the free, prior and informed consent of affected indigenous groups.

Standard 8: Labour Standards

Good labour practices and the use of appropriate codes of conduct are important to ensure the fair treatment, non-discrimination and equality of opportunity of workers. This standard aims at ensuring that promoters of EIB projects comply with the core labour standards of the International Labour Organisation and with national labour and employment laws. The standard also requires the establishment, maintenance and improvement of worker-management relationships.

Standard 9: Occupational and public health, safety and security

The EIB expects promoters to protect and secure public and occupational health, safety and security and promote the dignity of the affected community in relation to project-related activities, with particular attention to vulnerable groups. The standard also requires promoters to adhere to the international norms and relevant human rights principles when using security services.

Standard 10: Stakeholder Engagement

As a public institution, the EIB actively promotes the right to access to information, as well as public consultation and participation. Standard 10 requires promoters to uphold an open, transparent and accountable dialogue with all project affected communities and relevant stakeholders in an effective and appropriate manner. The value of public participation in the decision-making process is stressed throughout the preparation, implementation and monitoring phases of a project. The right to access to remedy, including through grievance resolution, is actively required.

ANNEXURE 4.1

VALUED ENVIRONMENTAL COMPONENTS WITHIN ROW

S. NO	CHAINAGE	VECS	REMARKS
PCMC – Swargate			
1.	7.425	Dargah	Affected
2.	7.520	Temple	Affected
3.	Near VishnupantKushabaBhoslePatil Chowk	Ganesh Temple	U/G section – No impact
4.	Shivaji Nagar Rly Stn Road	St. Francis High School	U/G section – No impact
5.	Near Civil Court Station	Pune Engineering College	U/G section – No impact
6.	Near City Post	Gujarati Primary School	U/G section – No impact
7.	Near Shivaji Road n ShaniparMandai Road	Temple	U/G section – No impact
8.	After MahadevAmbadasWadekar Marg	Temple	U/G section – No impact
9.	Before MandiStn	Temple	U/G section – No impact
10.	At MandaiStn	Temple	U/G section – No impact
11.	After Mandai Station	Temple	U/G section – No impact
Vanaz - Ramwadi			
1.	2.325	Temple	Affected
2.	4.365	Panchalekshar Temple	Partially Affected
3.	4.945	Temple	Affected
4.	5.600	Siddeshwar Temple Ghat	Ghat partially affected during construction
5.	6.400	Temple	Affected
6.	6.840	Temple	Affected
7.	8.250	Temple	Affected

ANNEXURE 5.1

LIST OF TREES ALONG THE CORRIDORS/DEPOTS

PCMC - RANGE HILL

S. No	Location	Common Name	Botanical Name	App. Girth(cm)	App. Height (m)	Cut (C)/ Transplant (T)
1.	Start to PCMC Station	Jamun	*Syzygium cumini*	40	10	T
2.		Kadam	*Neolamarckia cadamba*	50	10	T
3.		Bargad	*Ficus benghalensis*	25	7	T
4.		Kadam	*Neolamarckia cadamba*	70	10	T
5.		Jamun	*Syzygium cumini*	20	8	T
6.		Badam	*Terminalia catapa*	20	10	T
7.		Bargad	*Ficus benghalensis*	25	4	T
8.		Jamun	*Syzygium cumini*	60	12	T
9.		Bargad	*Ficus benghalensis*	40	7	T
10.		Asoka	*Polyalthia longifolia*	20	3	T
11.		Asoka	*Polyalthia longifolia*	20	3	T
12.		Umbar	*Ficus glomerata*	10	2	T
13.		Umbar	*Ficus glomerata*	30	4	T
14.		Dry Tree	-	30	8	C
15.		Gulmohar	*Delonix regia*	80	12	T
16.		Nilgiri	*Eucalyptus sp*	120	12	T
17.		Shubhra chafa	*Plumeria Rubra*	30	3	T
18.		Shubhra chafa	*Plumeria Rubra*	30	3	T
19.		Shubhra chafa	*Plumeria Rubra*	30	3	T
20.		Shubhra chafa	*Plumeria Rubra*	30	3	T
21.		Shubhra chafa	*Plumeria Rubra*	30	3	T
22.		Shubhra chafa	*Plumeria Rubra*	30	3	T
23.		Shubhra chafa	*Plumeria Rubra*	30	3	T
24.		Shubhra chafa	*Plumeria Rubra*	30	3	T
25.		Shubhra chafa	*Plumeria Rubra*	30	3	T
26.		Shubhra chafa	*Plumeria Rubra*	30	3	T
27.		Shubhra chafa	*Plumeria Rubra*	30	3	T
28.		Shubhra chafa	*Plumeria Rubra*	30	3	T
29.		Shubhra chafa	*Plumeria Rubra*	30	3	T
30.		Shubhra chafa	*Plumeria Rubra*	30	3	T
31.		Shubhra chafa	*Plumeria Rubra*	30	3	T
32.		Rain tree	*Samania saman*	40	10	T
33.		Subabul	*Leucaena leucocephala*	40	10	C
34.	PCMC Station	Subabul	*Leucaena leucocephala*	40	10	C
35.		Subabul	*Leucaena leucocephala*	60	4	C
36.		Rain tree	*Samania saman*	60	10	C
37.		Subabul	*Leucaena leucocephala*	60	12	C
38.		Subabul	*Leucaena leucocephala*	80	12	C
39.		Subabul	*Leucaena leucocephala*	40	10	C
40.		Subabul	*Leucaena leucocephala*	40	10	C
41.		Jangal Jalebi	*Pithecellobium dulce*	80	7	T
42.		Bargad	*Ficus religiosa*	40	8	T
43.		Rain tree	*Samania saman*	50	10	T
44.		Subabul	*Leucaena leucocephala*	50	10	C
45.		Rain tree	*Samania saman*	50	12	T
46.		Subabul	*Leucaena leucocephala*	40	10	C

S. No	Location	Common Name	Botanical Name	App. Girth(cm)	App. Height (m)	Cut (C)/ Transplant (T)
47.		Subabul	*Leucaena leucocephala*	40	10	C
48.		Subabul	*Leucaena leucocephala*	50	10	C
49.		Subabul	*Leucaena leucocephala*	50	10	C
50.		Mango	*Mangifera indica*	60	10	T
51.		Rain tree	*Samania saman*	40	10	T
52.		Subabul	*Leucaena leucocephala*	40	10	C
53.	PCMC Station - Tukaram Nagar Station	Asoka	*Polyalthia longifolia*	40	10	T
54.		Imali	*Tamarindus indica*	60	8	T
55.		Subabul	*Leucaena leucocephala*	23	8	C
56.		Bargad	*Ficus benghalensis*	120	10	T
57.		Asoka	*Polyalthia longifolia*	40	10	T
58.		Asoka	*Polyalthia longifolia*	40	10	T
59.		Asoka	*Polyalthia longifolia*	40	10	T
60.		Asoka	*Polyalthia longifolia*	40	10	T
61.		Asoka	*Polyalthia longifolia*	40	10	T
62.		Asoka	*Polyalthia longifolia*	40	10	T
63.		Neem	*Polyalthia longifolia*	40	10	T
64.		Asoka	*Polyalthia longifolia*	40	8	T
65.		Asoka	*Polyalthia longifolia*	40	10	T
66.		Asoka	*Polyalthia longifolia*	40	10	T
67.		Asoka	*Polyalthia longifolia*	40	10	T
68.		Asoka	*Polyalthia longifolia*	40	10	T
69.		Asoka	*Polyalthia longifolia*	40	10	T
70.		Bargad	*Polyalthia longifolia*	23	10	T
71.		Asoka	*Polyalthia longifolia*	40	10	T
72.		Asoka	*Polyalthia longifolia*	40	10	T
73.		Asoka	*Polyalthia longifolia*	40	10	T
74.		Coconut	*Cocos nucifera*	30	12	C
75.		Umbar	*Ficus glomerata*	40	8	T
76.		Shubhra chafa	*Plumeria rubra*	20	3	T
77.		Shubhra chafa	*Plumeria rubra*	20	3	T
78.		Devils Tree	*Alstonia scholaris*	40	8	T
79.		Devils Tree	*Alstonia scholaris*	40	8	T
80.		Devils Tree	*Alstonia scholaris*	40	8	T
81.		Devils Tree	*Alstonia scholaris*	40	8	T
82.		Shisam	*Dalbergia sissoo*	20	03	T
83.	Tukaram Nagar Station	Nil	Nil	Nil	Nil	Nil
84.	Tukaram Nagar Station to Bhosari Station	Rain tree	*Samania saman*	110	12	T
85.		Rain tree	*Samania saman*	110	12	T
86.		Rain tree	*Samania saman*	225	12	C
87.		Rain tree	*Samania saman*	40	7	T
88.		Subabul	*Leucaena leucocephala*	90	10	C
89.		Subabul	*Leucaena leucocephala*	25	7	C
90.		Subabul	*Leucaena leucocephala*	210	10	C
91.		Subabul	*Leucaena leucocephala*	90	10	C
92.		Subabul	*Leucaena leucocephala*	25	8	C
93.		Kadam	*Neolamarckia cadamba*	30	8	T
94.		Subabul	*Leucaena leucocephala*	80	10	C
95.		Kadam	*Neolamarckia cadamba*	50	10	T
96.		Subabul	*Leucaena leucocephala*	50	10	C
97.		Kadam	*Neolamarckia cadamba*	50	10	T

S. No	Location	Common Name	Botanical Name	App. Girth(cm)	App. Height (m)	Cut (C)/ Transplant (T)
98.		Subabul	*Leucaena leucocephala*	50	10	C
99.		Kadam	*Neolamarckia cadamba*	20	7	T
100.		Subabul	*Leucaena leucocephala*	50	8	C
101.		Rain tree	*Samania saman*	210	12	T
102.		Kadam	*Neolamarckia cadamba*	15	3	T
103.		Subabul	*Leucaena leucocephala*	40	8	C
104.		Kadam	*Neolamarckia cadamba*	15	3	T
105.		Subabul	*Leucaena leucocephala*	60	8	C
106.		Kadam	*Neolamarckia cadamba*	30	8	T
107.		Subabul	*Leucaena leucocephala*	60	10	C
108.		Kadam	*Neolamarckia cadamba*	15	4	T
109.		Subabul	*Leucaena leucocephala*	50	8	C
110.		Subabul	*Leucaena leucocephala*	50	8	C
111.		Kadam	*Neolamarckia cadamba*	40	8	T
112.		Subabul	*Leucaena leucocephala*	40	8	C
113.		Kadam	*Neolamarckia cadamba*	30	8	T
114.		Subabul	*Leucaena leucocephala*	50	8	C
115.		Kadam	*Neolamarckia cadamba*	40	7	T
116.		Subabul	*Leucaena leucocephala*	60	8	C
117.		Kadam	*Neolamarckia cadamba*	20	6	T
118.		Subabul	*Leucaena leucocephala*	40	8	C
119.		Subabul	*Leucaena leucocephala*	30	6	C
120.		Subabul	*Leucaena leucocephala*	40	6	C
121.		Rain tree	*Samania saman*	210	12	C
122.		Pipal	*Ficus religiosa*	250	12	C
123.		Subabul	*Leucaena leucocephala*	30	6	C
124.		Subabul	*Leucaena leucocephala*	40	7	C
125.		Subabul	*Leucaena leucocephala*	30	8	C
126.		Rain tree	*Samania saman*	110	10	T
127.		Subabul	*Leucaena leucocephala*	30	7	C
128.		Subabul	*Leucaena leucocephala*	40	7	C
129.		Subabul	*Leucaena leucocephala*	50	8	C
130.		Kadam	*Neolamarckia cadamba*	40	8	T
131.		Subabul	*Leucaena leucocephala*	80	8	C
132.		Kadam	*Neolamarckia cadamba*	40	7	T
133.		Subabul	*Leucaena leucocephala*	60	8	C
134.		Kadam	*Neolamarckia cadamba*	40	8	T
135.		Subabul	*Leucaena leucocephala*	60	8	C
136.		Subabul	*Leucaena leucocephala*	60	8	C
137.		Kadam	*Neolamarckia cadamba*	40	8	T
138.		Subabul	*Leucaena leucocephala*	60	8	C
139.		Kadam	*Neolamarckia cadamba*	40	8	T
140.		Subabul	*Leucaena leucocephala*	60	8	C
141.		Kadam	*Neolamarckia cadamba*	50	8	T
142.		Kadam	*Neolamarckia cadamba*	50	8	T
143.		Subabul	*Leucaena leucocephala*	50	8	C
144.	Bhosari Station	Kadam	*Neolamarckia cadamba*	30	8	T
145.		Subabul	*Leucaena leucocephala*	50	8	C
146.		Kadam	*Neolamarckia cadamba*	40	8	T
147.		Subabul	*Leucaena leucocephala*	40	8	C
148.		Kadam	*Neolamarckia cadamba*	40	8	T
149.		Subabul	*Leucaena leucocephala*	60	8	C

S. No	Location	Common Name	Botanical Name	App. Girth(cm)	App. Height (m)	Cut (C)/ Transplant (T)
150.		Kadam	*Neolamarckia cadamba*	40	7	T
151.		Subabul	*Leucaena leucocephala*	60	8	C
152.		Kadam	*Neolamarckia cadamba*	10	6	T
153.		Rain tree	*Samania saman*	90	10	T
154.		Subabul	*Leucaena leucocephala*	40	8	C
155.		Kadam	*Neolamarckia cadamba*	15	8	T
156.		Rain tree	*Samania saman*	220	12	C
157.		Kadam	*Neolamarckia cadamba*	40	8	T
158.		Subabul	*Leucaena leucocephala*	50	8	C
159.		Kadam	*Neolamarckia cadamba*	30	6	T
160.		Subabul	*Leucaena leucocephala*	60	8	C
161.		Kadam	*Neolamarckia cadamba*	20	8	T
162.		Rain tree	*Samania saman*	90	10	T
163.		Subabul	*Leucaena leucocephala*	60	8	C
164.		Kadam	*Neolamarckia cadamba*	40	8	T
165.		Subabul	*Leucaena leucocephala*	60	8	C
166.		Subabul	*Leucaena leucocephala*	40	8	C
167.		Rain tree	*Samania saman*	220	12	T
168.		Subabul	*Leucaena leucocephala*	40	8	C
169.		Kadam	*Neolamarckia cadamba*	40	6	T
170.		Subabul	*Leucaena leucocephala*	40	6	C
171.		Kadam	*Neolamarckia cadamba*	40	8	T
172.		Rain tree	*Samania saman*	110	12	T
173.	Bhosari Station - Kasarwadi Station	Kadam	*Neolamarckia cadamba*	40	8	T
174.		Subabul	*Leucaena leucocephala*	60	8	C
175.		Subabul	*Leucaena leucocephala*	60	8	C
176.		Rain tree	*Samania saman*	90	8	T
177.	Kasarwadi Station	Nil	Nil	Nil	Nil	T
178.	Kasarwadi Station - Fugewadi Station	Devils tree	*Alstonia scolaris*	20	2	T
179.		Shisham	*Dalbergia sissoo*	20	2	T
180.		Shisham	*Dalbergia sissoo*	20	2	T
181.	Fugewadi Station	Nil	Nil	Nil	Nil	T
182.	Fugewadi Station - Dapodi Station	Subabul	*Leucaena leucocephala*	80	10	C
183.		Subabul	*Leucaena leucocephala*	90	10	C
184.		Devils Tree	*Alstonia scholaris*	60	10	T
185.	Dapodi Station	Gulmohar	*Delonix regia*	80	10	T
186.		Subabul	*Leucaena leucocephala*	60	10	C
187.		Gulmohar	*Delonix regia*	90	10	T
188.		Gular	*Ficus glomerata*	50	4	T
189.		Devils Tree	*Alstonia scholaris*	40	3	T
190.		Subabul	*Leucaena leucocephala*	60	10	C
191.		Gulmohar	*Delonix regia*	120	10	T
192.		Subabul	*Leucaena leucocephala*	60	10	C
193.		Gulmohar	*Delonix regia*	40	10	T
194.	Dapodi Station - Bopadi Station	Gulmohar	*Delonix regia*	90	10	T
195.		Devils Tree	*Alstonia scholaris*	80	10	T
196.		Subabul	*Leucaena leucocephala*	110	10	C
197.		Siris	*Albizia lebbeck*	80	10	T
198.		Devils Tree	*Alstonia scholaris*	40	3	T
199.		Devils Tree	*Alstonia scholaris*	40	4	T
200.		Devils Tree	*Alstonia scholaris*	80	10	T
201.		Rain tree	*Samania saman*	40	8	T

S. No	Location	Common Name	Botanical Name	App. Girth(cm)	App. Height (m)	Cut (C)/ Transplant (T)
202.		Siris	*Albizia lebbeck*	80	10	T
203.		Rain tree	*Samania saman*	80	10	T
204.		Rain tree	*Samania saman*	80	10	T
205.		Siris	*Albizia lebbeck*	90	10	T
206.		Neem	*Azadirachta indica*	60	10	T
207.		Siris	*Albizia lebbeck*	40	10	T
208.		Siris	*Albizia lebbeck*	60	10	T
209.		Siris	*Albizia lebbeck*	60	10	T
210.		Siris	*Albizia lebbeck*	70	10	T
211.		Siris	*Albizia lebbeck*	60	10	T
212.		Rain tree	*Samania saman*	60	10	T
213.		Kante sawar	*Bombax ceiba*	70	12	T
214.		Kante sawar	*Bombax ceiba*	80	12	T
215.		Kante sawar	*Bombax ceiba*	110	12	T
216.		Bahawa	*Cassia fistula*	40	8	T
217.		Bahawa	*Cassia fistula*	40	8	T
218.		Neem	*Azadirachta indica*	60	8	T
219.		Nirgudi	*Vitex nigundo*	40	8	T
220.		Chinch	*Tamarindus indica*	450	12	C
221.	Bopadi Station	Umbar	*Ficus glomerata*	120	12	T
222.		Asoka	*Polyalthia longifolia*	50	12	T
223.		Kathahal	*Arthocarpusheterophyllus*	60	12	T
224.	Bopadi Station to Khadki Station	Rain tree	*Samania saman*	110	12	T
225.		Pipal	*Ficus religiosa*	450	12	C
226.		Coconut	*Cocos nucifera*	40	12	C
227.		Mango	*Mangifera indica*	40	10	T
228.		Nivdung	*Cactus sp*	40	8	C
229.		Neem	*Azadirachta indica*	60	10	T
230.		Coconut	*Cocos nucifera*	40	12	C
231.		Neem	*Azadirachta indica*	40	8	T
232.		Siris	*Albizia lebbeck*	80	10	T
233.		Rain tree	*Samania saman*	40	8	T
234.		Siris	*Albizia lebbeck*	60	8	T
235.		Karanj	*Pongamia pinnata*	60	4	T
236.		Karanj	*Pongamia pinnata*	40	3	T
237.		Karanj	*Pongamia pinnata*	40	3	T
238.		Rain tree	*Samania saman*	220	12	C
239.		Karanj	*Pongamia pinnata*	40	10	T
240.		Devils tree	*Alstonia schloris*	30	04	T
241.		Devils tree	*Alstonia schloris*	30	04	T
242.		Devils tree	*Alstonia schloris*	30	04	T
243.		Subabul	*Leucaena leucocephala*	50	8	C
244.		Subabul	*Leucaena leucocephala*	60	10	C
245.		Subabul	*Leucaena leucocephala*	60	12	C
246.		Jungle jalebi	*Pithocellobium dulce*	40	6	T
247.		Jungle jalebi	*Pithocellobium dulce*	40	8	T
248.		Jungle jalebi	*Pithocellobium dulce*	40	8	T
249.		Jungle jalebi	*Pithocellobium dulce*	80	10	T
250.		Asoka	*Polyalthia longifolia*	40	10	T
251.		Subabul	*Leucaena leucocephala*	40	8	C
252.		Jungle jalebi	*Pithocellobium dulce*	60	8	T

S. No	Location	Common Name	Botanical Name	App. Girth(cm)	App. Height (m)	Cut (C)/ Transplant (T)
253.		Jungle jalebi	*Pithocellobium dulce*	60	10	T
254.		Jungle jalebi	*Pithocellobium dulce*	60	8	T
255.		Jungle jalebi	*Pithocellobium dulce*	60	10	T
256.		Subabul	*Leucaena leucocephala*	40	6	C
257.		Coconut	*Cocos nucifera*	40	10	C
258.		Jungle jalebi	*Pithocellobium dulce*	60	6	T
259.		Jungle jalebi	*Pithocellobium dulce*	60	4	T
260.		Jungle jalebi	*Pithocellobium dulce*	40	4	T
261.		Subabul	*Leucaena leucocephala*	50	10	C
262.		Rain tree	*Samania saman*	80	10	T
263.		Ber	*Zizyphus mauritiana*	60	8	C
264.		Shisham	*Dalbergia sissoo*	40	8	T
265.		Shisham	*Dalbergia sissoo*	40	8	T
266.		Pipal	*Ficus religiosa*	60	8	T
267.		Khajur	*Phoenix sylvestris*	60	12	C
268.	Khadki Station	Umbar	*Ficus glomerata*	60	8	T
269.		Karanj	*Pongamia pinnata*	60	12	T
270.		Pipal	*Polyalthia longifolia*	90	12	T
271.		Subabul	*Leucaena leucocephala*	90	12	C
272.		Umbar	*Ficus glomerata*	25	4	T
273.		Shisham	*Dalbergia sissoo*	60	10	T
274.		Shisham	*Dalbergia sissoo*	60	10	T
275.		Badam	*Terminalia catapa*	40	10	T
276.		Bakaneem	*Melia azedarach*	80	10	T
277.		Gular	*Ficus glomerata*	40	10	T
278.		Bakaneem	*Melia azedarach*	80	10	T
279.		Asoka	*Polyalthia longifolia*	60	8	T
280.		Asoka	*Polyalthia longifolia*	60	8	T
281.		Neem	*Azadirachta indica*	50	8	T
282.		Neem	*Azadirachta indica*	50	8	T
283.		Asoka	*Polyalthia longifolia*	60	8	T
284.		Asoka	*Polyalthia longifolia*	60	8	T
285.	Khadki Station - Range Hill Station	Neem	*Azadirachta indica*	50	10	T
286.		Neem	*Azadirachta indica*	40	12	T
287.		Asoka	*Polyalthia longifolia*	40	12	T
288.		Asoka	*Polyalthia longifolia*	40	12	T
289.		Pipal	*Polyalthia longifolia*	52	14	T
290.		Karanj	*Pongamia pinnata*	50	10	T
291.		Subabul	*Leucaena leucocephala*	40	4	C
292.		Asoka	*Polyalthia longifolia*	40	6	T
293.		Subabul	*Leucaena leucocephala*	60	10	C
294.		Amrud	*Psidium guajava*	25	4	T
295.		Neem	*Azadirachta indica*	40	8	T
296.		Mango	*Mangifra indica*	20	4	T
297.		Khejari	*Prosopis julifera*	60	8	C
298.		Khejari	*Prosopis julifera*	60	8	C
299.		Khejari	*Prosopis julifera*	60	6	C
300.		Khejari	*Prosopis julifera*	60	8	C
301.		Neem	*Azadiracta indica*	80	10	T
302.		Khejari	*Prosopis julifera*	60	8	C
303.		Khejari	*Prosopis julifera*	60	8	C
304.		Bakain	*Melia Azadiracta*	60	08	T

S. No	Location	Common Name	Botanical Name	App. Girth(cm)	App. Height (m)	Cut (C)/ Transplant (T)
305.		Kala kuda	*Wrightia tinctoria*	10	04	T
306.		Kala kuda	*Wrightia tinctoria*	10	08	T
307.		Kala kuda	*Wrightia tinctoria*	10	03	T
308.		Neem	*Azadirachta indica*	40	04	T
309.		Neem	*Azadirachta indica*	10	02	T
310.		Neem	*Azadirachta indica*	10	02	T
311.		Neem	*Azadirachta indica*	10	02	T
312.		Neem	*Azadirachta indica*	10	02	T
313.		Rain tree	*Samania saman*	50	3	T
314.		Karanj	*Pongamia pinnata*	30	03	T
315.		Karanj	*Pongamia pinnata*	30	03	T
316.		Pipal	*Ficus religiosa*	80	10	T
317.		**8 Karanj**	*Pongamia pinnata*	30	2.5	T
318.		Bakain	*Melia azedarach*	80	10	T
319.		Neem	*Azadirachta indica*	40	6	T
320.		Subabul	*Leucaena leucocephala*	60	10	C
321.	Range Hill Station	Rain tree	*Samania saman*	120	12	T
322.		Rain tree	*Samania saman*	80	10	T
323.		Rain tree	*Samania saman*	80	10	T
324.		Subabul	*Leucaena leucocephala*	70	10	T
325.		Umbar	*Ficus glomerata*	40	6	C
326.		Nirgudi	*Vitex nigundo*	60	8	T
327.		Subabul	*Leucaena leucocephala*	40	8	C
328.	Range Hill Station to end of Elevated Section	Rain tree	*Samania saman*	60	10	T
329.		Badam	*Terminalia catapa*	40	6	T
330.		Khejari	*Prosopis julifera*	40	3	C
331.		Rain tree	*Samania saman*	450	12	C
332.		Bargad	*Ficus benghalensis*	60	8	T
333.		Bargad	*Ficus benghalensis*	40	8	T
334.		Khejari	*Prosopis julifera*	40	8	C
335.		Khejari	*Prosopis julifera*	60	8	C
336.		Khejari	*Prosopis julifera*	60	8	C
337.		Khejari	*Prosopis julifera*	60	8	C
338.		Rain tree	*Samania saman*	60	8	T
339.		Rain tree	*Samania saman*	80	10	T
340.		Rain tree	*Samania saman*	90	8	T
341.		Rain tree	*Samania saman*	60	10	T
342.		Rain tree	*Samania saman*	70	10	T
343.		Khejari	*Prosopis julifera*	60	8	C
344.		Kamala tree	*Mallotus philippensis*	60	8	T
345.		Rain tree	*Samania saman*	80	10	T
346.		Rain tree	*Samania saman*	70	10	T
347.		Rain tree	*Samania saman*	80	08	T
348.		Kamala tree	*Mallotus philippensis*	60	10	T
349.		Kamala tree	*Mallotus philippensis*	70	10	T
350.		Kamala tree	*Mallotus philippensis*	80	10	T
351.		Khejari	*Prosopis julifera*	60	10	C
352.		Khejari	*Prosopis julifera*	50	10	C
353.		Talwar babool	*Acacia auruculoformis*	80	10	T
354.		Pomegranate	*Punica granatum*	60	08	T
355.		Rain tree	*Samania saman*	60	10	T
356.		Rain tree	*Samania saman*	80	10	T

S. No	Location	Common Name	Botanical Name	App. Girth(cm)	App. Height (m)	Cut (C)/ Transplant (T)
357.		Khejari	*Prosopis julifera*	50	10	C
358.		Rain tree	*Samania saman*	60	10	T
359.		Babul	*Acacia Arabica*	60	08	C
360.		Rain tree	Samania saman	80	10	T
361.		Babul	*Acacia Arabica*	60	08	C
362.		Rain tree	*Samania saman*	90	10	T
363.		Rain tree	*Samania saman*	60	10	T
364.		Rain tree	*Samania saman*	120	12	T
365.		Rain tree	*Samania saman*	70	10	T
366.		Rain tree	*Samania saman*	60	10	T
367.		Rain tree	*Samania saman*	50	10	T
368.		Babul	*Acacia Arabica*	60	10	T
369.		Babul	*Acacia Arabica*	50	10	C
370.		Babul	*Acacia Arabica*	50	10	C
371.		Copper pod	*Peltoforam pterocarpum*	60	10	T
372.		Copper pod	*Peltoforam pterocarpum*	50	08	T
373.		Copper pod	*Peltoforam pterocarpum*	60	08	T
374.		Copper pod	*Peltoforam pterocarpum*	40	10	T
375.		Copper pod	*Peltoforam pterocarpum*	60	10	T
376.		Neem	*Azaridachta indica*	40	6	T
377.		Khejari	*Prosopis julifera*	60	10	T
378.		Khejari	*Prosopis julifera*	60	10	T
379.		Rain tree	*Samania saman*	40	8	T
380.		Khejari	*Prosopis julifera*	40	8	T
381.		Khejari	*Prosopis julifera*	50	8	T
382.		Neem	*Azaridachta indica*	40	8	T
383.		Subabul	*Leucaena leucocephala*	30	8	C
384.		Khejari	*Prosopis julifera*	60	10	C
385.		Khejari	*Prosopis julifera*	30	6	C
386.		Khejari	*Prosopis julifera*	60	10	C
387.		Khejari	*Prosopis julifera*	60	10	C
388.		Rain tree	*Samania saman*	80	8	T
389.		Rain tree	*Samania saman*	60	4	T

VANAZ - RAMAVADI

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
1.	Start to Vanaz station	Nil	Nil	Nil	Nil	T
2.	Vanaz station	Saptaparni (champa)	*Plumeraia rubra*	40	03	T
3.	Vanaz station to Ananad nagar station	Nil	Nil	Nil	Nil	T
4.	Anand nagar station	Umbar	*Ficus glomerata*	60	10	T
5.		Peepal	*Ficus religiosa*	50	10	T
6.		Rain tree	*Samania saman*	50	10	T
7.		Rain tree	*Samania saman*	60	10	T
8.	Ananad nagar station - Ideal colony station	Rain tree	*Samania saman*	40	08	T
9.		Rain tree	*Samania saman*	50	08	T
10.		Rain tree	*Samania saman*	40	08	T
11.	Ideal colony station	Nil	Nil	Nil	Nil	Nil

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
12.	Ideal colony station - Nal stop station	Neem	*Azadirachta indica*	50	08	T
13.		Peepal	*Ficus religiosa*	80	08	T
14.		Subabool	*Leucaena leucocephala*	50	10	C
15.		Umbar	*Ficus glomerata*	50	10	T
16.		Subabool	*Leucaena leucocephala*	60	10	C
17.		Subabool	*Leucaena leucocephala*	40	10	C
18.		Subabool	*Leucaena leucocephala*	40	10	C
19.		Bad	*Ficus glomerata*	60	10	T
20.	Nal stop station	Nil	Nil	Nil	Nil	Nil
21.	Nal stop to Garvare college	Nil	Nil	Nil	Nil	Nil
22.	Garvare college station	Nil	Nil	Nil	Nil	T
23.	Garvare college station – Deccan station	Peepal	*Ficus religiosa*	120	12	T
24.		Rain tree	*Samania saman*	40	08	T
25.		Peepal	*Ficus religiosa*	120	12	T
26.		Peepal	*Ficus religiosa*	120	12	T
27.		Rain tree	*Samania saman*	120	12	T
28.		Rain tree	*Samania saman*	40	12	T
29.		Chinchbhilai	*Pithecellobium dulce*	50	10	T
30.		Rain tree	*Samania saman*	40	12	T
31.		Rain tree	*Samania saman*	42	14	T
32.		Chinchbhilai	*Pithecellobium dulce*	40	08	T
33.		Chinchbhilai	*Pithecellobium dulce*	40	06	T
34.		Rain tree	*Samania saman*	55	14	T
35.		Umbar	*Ficus glomerata*	50	10	T
36.		Chinchbhilai	*Pithecellobium dulce*	40	06	T
37.		Rain tree	*Samania saman*	50	14	T
38.		Rain tree	*Samania saman*	50	14	T
39.		Chinchbhilai	*Pithecellobium dulce*	40	06	T
40.		Rain tree	*Samania saman*	40	08	T
41.		Rain tree	*Samania saman*	80	10	T
42.		Rain tree	*Samania saman*	80	10	T
43.		Umbar	*Ficus glomerata*	50	08	T
44.		Peepal	*Ficus religiosa*	40	02	T
45.	Deccan Station	Nil	Nil	Nil	Nil	Nil
46.	Deccan Station - Sambhaji Park Station	Nil	Nil	Nil	Nil	Nil
47.	Sambhaji Park Station	Nil	Nil	Nil	Nil	Nil
48.	Sambhaji Park Station - PMC Station	Babul	*Acacia nilotica*	80	10	C
49.		Rain tree	*Samania saman*	80	10	T
50.		Rain tree	*Samania saman*	80	10	T
51.		Rain tree	*Samania saman*	80	10	T
52.		Peepal	*Ficus religiosa*	60	10	T
53.		Bad	*Ficus bengalensis*	80	10	T
54.		Umbar	*Ficus glomerata*	40	10	T
55.		Umbar	*Ficus glomerata*	40	02	T
56.		Babul	*Acacia nilotica*	40	03	T
57.		Tad palm	*Baorassus flaberiformis*	40	12	T
58.		Tad palm	*Baorassus flaberiformis*	50	12	T
59.		Subabool	*Leucaena leucocephala*	80	08	T

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
60.		Shahatut	*Morus alba*	60	08	T
61.		Subabool	*Leucaena leucocephala*	80	08	T
62.	PMC Station	Nil	Nil	Nil	Nil	Nil
63.	PMC Station - Civil Court Station	Umbar	*Ficus glomerata*	80	10	T
64.		Rain tree	*Samania saman*	50	08	T
65.		Rain tree	*Samania saman*	60	10	T
66.	Civil Court Station	Shisam	*Dalbergia sisoo*	60	03	T
67.		Nilgiri	*Eucalyptus sp*	60	14	T
68.		Reetha	*Sapindus mukorossi*	60	08	T
69.		Rain tree	*Samania saman*	70	10	T
70.		Neem	*Azadirachta indica*	80	10	T
71.	Civil Court Station - Mangalwar Peth Station	Rain tree	*Samania saman*	40	08	T
72.		Rain tree	*Samania saman*	50	10	T
73.		Nilgiri	*Eucalyptus sp*	60	14	T
74.		Rain tree	*Samania saman*	50	08	T
75.		Rain tree	*Samania saman*	60	10	T
76.		Rain tree	*Samania saman*	50	10	T
77.	Mangalwar Peth Station	Nil	Nil	Nil	Nil	Nil
78.	Mangalwar Peth Station - Pune Railway Station	Peepal	*Ficus religiosa*	300	14	C
79.		Peepal	*Ficus religiosa*	500	14	C
80.		Chinch	*Tamarindus indica*	45	14	T
81.	Pune Railway Station	Rain tree	*Samania saman*	55	14	T
82.		Peepal	*Ficus religiosa*	90	14	T
83.		Chinch	*Tamarindus indica*	08	04	T
84.		Peepal	*Ficus religiosa*	55	14	T
85.	Pune Railway Station - Ruby hall Clinic	Bad	*Ficus bengalensis*	32	10	T
86.		Gulmohar	*Delonix regia*	60	08	T
87.		Arjuna	*Terminalia arjuna*	50	08	T
88.		Peepal	*Ficus religiosa*	55	14	T
89.		Mango	*Mangifera indica*	50	08	T
90.		Chinch	*Tamarindus indica*	60	10	T
91.		Rain tree	*Samania saman*	60	08	T
92.		Rain tree	*Samania saman*	60	08	T
93.	Ruby hall Clinic	Nil	Nil	Nil	Nil	Nil
94.	Ruby hall Clinic - Bund Garden	Nil	Nil	Nil	Nil	Nil
95.	Bund Garden Station	Nil	Nil	Nil	Nil	Nil
96.	Bund Garden - Yerwada	Badam	*Terminalia catapa*	40	08	T
97.		Peepal	*Ficus religiosa*	60	10	T
98.		Devils tree	*Alstonia scholaris*	60	10	T
99.		Dhavada	*Anogeissus latifolia*	80	14	T
100.		Kadam	*Neolamarckia cadamba*	40	10	T
101.		Dhavada	*Anogeissus latifolia*	30	06	T
102.		Dhavada	*Anogeissus latifolia*	20	06	T
103.		Kadam	*Neolamarckia cadamba*	40	10	T
104.		Kadam	*Neolamarckia cadamba*	40	10	T
105.		Asoka	*Polyalthia longifolia*	50	12	T
106.		kesari	*Mallotus sp*	80	10	T
107.		Babaul	*Acacia nilotica*	60	10	T

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
108.		Bakul	*Mimusops elengi*	40	10	T
109.		Bakul	*Mimusops elengi*	40	10	T
110.		Bakul	*Mimusops elengi*	50	10	T
111.		Dhavada	*Anogeissus latifolia*	90	10	T
112.		Rain tree	*Samania saman*	40	12	T
113.		Rain tree	*Samania saman*	50	12	T
114.		Rain tree	*Samania saman*	40	10	T
115.		Neem	*Azadirachta indica*	60	12	T
116.		Coconut	*Cocos nucifera*	80	10	C
117.		Subabool	*Leucaena leucocephala*	80	10	C
118.	Yerwada station	Shisam	*Dalbergia sisoo*	80	10	T
119.		Shisam	*Dalbergia sisoo*	40	06	T
120.		Subabool	*Leucaena leucocephala*	60	08	C
121.		Subabool	*Leucaena leucocephala*	70	08	C
122.	Yerwada - Kalyani Nagar	Rain tree	*Samania saman*	70	10	T
123.		Shisam	*Dalbergia sisoo*	40	08	T
124.		Subabool	*Leucaena leucocephala*	60	08	C
125.		Subabool	*Leucaena leucocephala*	50	08	C
126.		85 sindi palm tree	*Phoenix sylvestris*	50	08	T
127.	Kalyani Nagar Station	10 sindi palm tree	*Phoenix sylvestris*	50	08	T
128.		01 palmera palm	*Borassus flabellifer,*	80	06	T
129.	Kalyani Nagar - Ramavadi	Nil	Nil	Nil	Nil	Nil
130.	Ramavadi -End of the alignment	Nil	Nil	Nil	Nil	Nil

RANGE HILL DEPOT

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
1.	Agriculture college depot	Indian rain tree	Samania saman	20	14	T
2.		Indian rain tree	Samania saman	80	14	T
3.		Papdi	Holoptelea integrifolia	50	14	T
4.		Indian rain tree	Samania saman	60	10	T
5.		Babul	Acacia nilotica	60	08	C
6.		Neem	Azadirachta indica	80	10	T
7.		Shahatut	Morus alba	50	08	T
8.		Peepal	Ficus religiosa	600	14	C
9.		Indian rain tree	Samania saman	60	10	T
10.		Babul	Acacia nilotica	60	10	C
11.		Babul	Azadirachta indica	80	12	C
12.		16 mango	Mangifera indica	60	03	T
13.		90 guava	Psidium guajava	30	02	T
14.		Coconut	Cocos nucifera	60	02	C
15.		Coconut	Cocos nucifera	60	02	C
16.		Jambhul	Syzygium cumini	60	03	T
17.		18 jambhul	Syzygium cumini	60	03	T
18.		90 Pomegranate	Punica granatum	30	02	T
19.		Subabul	Leucaena leucocephala	40	03	C
20.		Shisam	Dalbergia sisoo	40	04	T
21.		108 Aola	Phyllanthus emblica	60	10	T
22.		Neem	Azadirachta indica	60	08	T

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
23.		Neem	Azadirachta indica	60	08	T
24.		10 Sitafal	Annona reticulate	20	02	T
25.		Neem	Azadirachta indica	60	07	T
26.		Babaul	Azadirachta indica	40	05	C
27.		Subabool	Leucaena leucocephala	50	10	C
28.		Karanj	Pongamia pinnata	55	10	T
29.		Karanj	Pongamia pinnata	50	08	T
30.		Neem	Azadirachta indica	40	08	T
31.		Talvar baool	Acacia auriculoformis	45	10	T
32.		Neem	Azadirachta indica	50	08	T
33.		Shevaga	Moringa tinctorea	45	08	C
34.		Karanj	Pongamia pinnata	50	07	T
35.		Rain tree	Samania saman	90	10	T
36.		Subabool	Leucaena leucocephala	50	10	C
37.		Guava	Psidium guajava	30	05	T
38.		Babool	Acacia nilotica	45	08	C
39.		Rain tree	Samania saman	60	10	T
40.		Neem	Azadirachta indica	60	10	T
41.		Rain tree	Samania saman	85	10	T
42.		Rain tree	Samania saman	102	12	T
43.		Subaool	Leucaena leucocephala	50	10	C
44.		Jambhul	Syzygium cumini	70	10	T
45.		Babool	Acacia nilotica	45	10	T
46.		Shiisam	Dalbergia sisoo	45	08	T
47.		Neem	Azadirachta indica	50	07	T
48.		Karanj	Pongamia pinnata	50	07	T
49.		Babool	Acacia nilotica	60	08	T
50.		Rain tree	Samania saman	75	10	T
51.		Neem	Azadirachta indica	50	08	T
52.		Shevaga	Moringa sp	40	10	C
53.		Shahatut	Morus alba	70	10	T
54.		Peepal	Ficus religiosa	40	08	T
55.		Neem	Azadirachta indica	40	08	T
56.		Bad	Ficus bengalensis	75	10	T
57.		Jambhul	Syzygium cumini	50	10	T
58.		Rain tree	Samania saman	80	10	T
59.		Coconut	Cocos nucifera	40	12	C
60.		Shevaga	Moringa sp	45	08	C
61.		Babul	Acacia nilotica	45	08	C
62.		Rain tree	Samania saman	95	12	T
63.		Kante sawar	Bombax ceiba	80	10	T
64.		Umbar	Ficus glomerata	50	10	T
65.		Babul	Acacia nilotica	42	10	c
66.		Rain tree	Samania saman	70	12	T
67.		Kante sawar	Bombax ceiba	60	10	T
68.		Shisam	Dalbergia sisoo	40	08	T
69.		Coconut	Cocos nucifera	45	12	C
70.		Mango	Mangifera indica	60	08	T
71.		Bad	Ficus religiosa	75	10	T
72.		Kante sawar	Bombax ceiba	60	12	T
73.		Bel	Aegle marmelos	50	10	T
74.		Kusum	Schleichera oleosa	50	10	T

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
75.		Arjun	Terminalia arjuna	40	10	T
76.		Chopadi sawar	Bombax malabarica	65	10	T
77.		Shisam	Dalbergia sisoo	40	10	T
78.		Rain tree	Samania saman	65	10	T
79.		Amaltash	Cassia fistula	60	10	T
80.		Gulmohar	Delonix regia	50	10	T
81.		Peepal	Ficus religiosa	50	10	T
82.		Babool	Acacia nilotica	40	10	C
83.		Subabul	Leucaena leucocephala	45	10	C
84.		Rain tree	Samania saman	50	10	T
85.		Talwar babul	Acacia auriculoformis	50	10	T
86.		Subabul	Leucaena leucocephala	70	10	C
87.		Arjuna	Terminalia arjuna	45	10	T
88.		Babul	Acacia nilotica	40	08	C
89.		Neem	Azadirachta indica	50	08	T
90.		Babul	Acacia nilotica	45	10	C
91.		Rain tree	Samania saman	70	12	T
92.		Neem	Azadirachta indica	50	07	T

VANAZ DEPOT

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
1.	Kachara Depot Vanaz	Rain tree	Samania saman	30	10	T
2.		Shisam	Dalbergia sisoo	60	10	T
3.		Rain tree	Samania saman	60	08	T
4.		Shisam	Dalbergia sisoo	60	10	T
5.		Peepal	Ficus religiosa	40	06	T
6.		Peepal	Ficus religiosa	40	04	T
7.		Bad	Ficus bengalensia	60	08	T
8.		Shisam	Dalbergia sisoo	60	10	T
9.		Peepal	Ficus religiosa	60	10	T
10.		Peepal	Ficus religiosa	60	10	T
11.		Peepal	Ficus religiosa	60	10	T
12.		Bad	Ficus bengalensia	60	08	T
13.		Rain tree	Samania saman	60	08	T
14.		Arjuna	Terminalia arjuna	40	08	T
15.		Shisam	Dalbergia sisoo	60	10	T
16.		Shisam	Dalbergia sisoo	60	10	T
17.		Babul	Acacia nilotica	80	10	C
18.		Neem	Azadirachta indica	60	05	T
19.		Rain tree	Samania saman	60	10	T
20.		Peepal	Ficus religiosa	50	10	T
21.		Keekar	Prosopis jilifera	40	08	C
22.		Neem	Azadirachta indica	60	10	T
23.		Umbar	Ficus glomerata	60	10	T
24.		Subabool	Leucaena leucocephala	60	10	C
25.		3 chinchbhilai	Pithecellobium dulce	60	10	T
26.		Saptaparni (champa)	Plumeria rubra	60	10	T
27.		Umbar	Ficus glomerata	60	10	T
28.		Rain tree	Samania saman	40	08	T
29.		Bad	Ficus bengalensia	70	08	T

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
30.		Subabool	Leucaena leucocephala	60	10	C
31.		Subabool	Leucaena leucocephala	70	10	C
32.		Saptaparni (champa)	Plumeria rubra	40	02	T
33.		Gulmohar	Delonix regia	50	08	T
34.		Saptaparni (champa)	Plumeria rubra	40	02	T
35.		Sagwan	Tectona grandis	40	08	T
36.		Chinch	Tamarindus indica	40	08	T
37.		Arjuna	Terminalia arjuna	60	10	T
38.		4 Subabool	Leucaena leucocephala	60	10	C
39.		Talwar babool	Acacia auriculoformis	50	10	T
40.		Subabool	Leucaena leucocephala	320	14	C
41.		Peepal	Ficus religiosa	240	14	C
42.		Rain tree	Samania saman	40	08	T
43.		2 Bad	Ficus bengalensia	60	08	T
44.		Rain tree	Samania saman	40	08	T
45.		Umbar	Ficus glomerata	120	14	T
46.		Peepal	Ficus religiosa	220	14	C
47.		Bad	Ficus bengalensia	60	08	T
48.		Nilgiri	Eucalyptus sp	80	14	T
49.		Saptaparni(champa)	Plumeria rubra	25	02	T
50.		Nilgiri	Eucalyptus sp	80	14	T
51.		Rain tree	Samania saman	210	14	C
52.		Shevaga	Moringa tinctorea	45	08	C
53.		Gulmohar	Delonix regia	40	08	T
54.		Rain tree	Samania saman	210	10	T
55.		Rain tree	Samania saman	210	14	T
56.		Badam	Terminalia catapa	40	08	T
57.		Umbar	Ficus glomerata	120	14	T
58.		Apata	Bauhinia sp	80	10	T
59.		Umbar	Ficus glomerata	60	08	T
60.		Umbar	Ficus glomerata	80	12	T
61.		Umbar	Ficus glomerata	120	12	T
62.		chinchbhilai	Pithecellobium dulce	40	08	T
63.		Subabool	Leucaena leucocephala	40	06	C
64.		Subabool	Leucaena leucocephala	60	10	C
65.		Subabool	Leucaena leucocephala	40	10	C
66.		3 Subabool	Leucaena leucocephala	60	10	C
67.		Talwar babool	Acacia auriculoformis	40	10	T
68.		Talwar babool	Acacia auriculoformis	40	08	T
69.		2 Subabool	Leucaena leucocephala	40	10	C
70.		Umbar	Ficus glomerata	60	10	T
71.		Umbar	Ficus glomerata	80	10	T
72.		Rain tree	Samania saman	85	10	T
73.		Rain tree	Samania saman	110	10	T
74.		Rain tree	Samania saman	80	10	T
75.		Babul	Acacia nilotica	50	10	C
76.		Rain tree	Samania saman	60	10	T
77.		Ber	Zizyphu jujuba	40	10	T
78.		Khejari	Prosopis julifera	50	07	C
79.		Khejari	Prosopis julifera	60	07	C

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
80.		Ber	Zizyphu jujuba	40	08	C
81.		Ber	Zizyphu jujuba	50	08	C
82.		Ber	Zizyphu jujuba	40	10	C
83.		Peepal	Ficus religiosa	60	10	T
84.		Arjuna	Terminalia arjuna	50	10	T
85.		Subabool	Leucaena leucocephala	50	10	C
86.		Subabool	Leucaena leucocephala	60	10	C
87.		Subabool	Leucaena leucocephala	50	10	C
88.		Subabool	Leucaena leucocephala	60	10	C
89.		Rain tree	Samania saman	60	10	T
90.		Rain tree	Samania saman	50	10	T
91.		Neem	Azadirachta indica	60	10	T
92.		Rain tree	Samania saman	75	10	T
93.		Rain tree	Samania saman	50	10	T
94.		Neem	Azadirachta indica	60	10	T
95.		Rain tree	Samania saman	50	10	T
96.		Rain tree	Samania saman	60	10	T
97.		Neem	Azadirachta indica	60	10	T
98.		Umbar	Ficus glomerata	50	10	T
99.		Khejari	Prosopis julifera	60	07	T
100.		Bad	Ficus bengalensis	85	10	T
101.		Khejari	Prosopis julifera	40	07	C
102.		Rain tree	Samania saman	90	10	T
103.		Neem	Azadirachta indica	60	10	T
104.		Subabool	Leucaena leucocephala	80	10	C
105.		Rain tree	Samania saman	120	12	T
106.		Subabool	Leucaena leucocephala	70	10	C
107.		Subabool	Leucaena leucocephala	50	10	C
108.		Rain tree	Samania saman	90	10	T
109.		Shevaga	Morus alba	50	10	C
110.		Khejari	Prosopis julifera	40	07	C

ANNEXURE 7.1

HIGHEST FLOOD DISCHARGE THROUGH KHADAKWASLA DAM IN TO MUTHA RIVER

Date	Year	Discharge from Khadakwasla dam	
		(in cumecs)	(in cusecs)
21.08.1940	1940	1171.13	41358
01.07.1941	1941	1738.55	61397
15.07.1942	1942	1779.72	62851
10.07.1943	1943	2287.04	80767
12.07.1944	1944	1266.56	44729
07.07.1945	1945	1317.39	46524
28.07.1946	1946	1351.37	47724
17.07.1947	1947	1222.33	43167
14.08.1948	1948	1223.55	43210
01.08.1949	1949	1028.22	36312
20.07.1950	1950	1728.5	61042
26.07.1951	1951	933.78	32976
24.07.1952	1952	1762.62	62247
29.06.1953	1953	1158.36	40907
15.07.1954	1954	2977.22	105141
01.06.1955	1955	1497.2	52874
02.08.1956	1956	1954.21	69013
08.08.1957	1957	1454.5	51366
19.07.1958	1958	3210.89	113393
05.09.1959	1959	1211.29	42777
07.07.1960	1960	833.85	29447
1961	1961	NA	NA
1962	1962	NA	NA
1963	1963	NA	NA
1964	1964	NA	NA
1965	1965	NA	NA
27.09.1966	1966	1024.37	36176
28.07.1967	1967	2125.76	75071
07.08.1968	1968	717.13	25325
01.08.1969	1969	1223.55	43210
21.08.1970	1970	500.19	17664
31.08.1971	1971	955.76	33753
12.09.1972	1972	871.8	30788
08.06.1973	1973	841.86	29730
07.08.1974	1974	560.34	19788
19.08.1975	1975	1128.21	36843
01.08.1976	1976	2050.15	72401
23.07.1977	1977	474.53	16758
29.08.1978	1978	437.64	15455
11.08.1979	1979	669.69	23650
03.08.1980	1980	1376.47	48610

Date	Year	Discharge from Khadakwasla dam	
		(in cumecs)	(in cusecs)
06.08.1981	1981	851.2	30060
22.06.1982	1982	730.57	25800
15.08.1983	1983	2449.11	86490
12.09.1984	1984	1009.58	35653
30.07.1985	1985	434.85	15357
13.08.1986	1986	311.8	11011
26.08.1987	1987	36.16	1277
21.08.1988	1988	982.99	34714
24.07.1989	1989	964.72	34069
16.08.1990	1990	970.84	34285
26.08.1991	1991	329.3	11629
17.08.1992	1992	790.98	27933
19.06.1993	1993	442.98	15644
14.07.1994	1994	1371.54	48436
22.07.1995	1995	196.51	6940
04.10.1996	1996	1328.18	46905
23.08.1997	1997	2565.18	90589
15.09.1998	1998	658.36	23250
21.07.1999	1999	539.84	19064
15.07.2000	2000	79.21	2797
2001	2001	NA	NA
2002	2002	NA	NA
2003	2003	NA	NA
12.08.2004	2004	1003.41	35435
02.08.2005	2005	1467.69	51831
22.07.2006	2006	1603.77	56637
08.08.2007	2007	730.49	25797

Yearly record of water discharge in many sub-canals (Khadakwasla)

Date and Year	Maximum Discharge(cusecs)	Hours	Annual Rainfall(mm)
12/07/1961	-	-	-
12/08/1964	40,300	-	-
20/07/1965	38,222	-	-
27/07/1966	27,930	-	-
27/07/1967	69,550	-	-
07/08/1968	24,800	-	-
1/08/1969	42,610	-	-
2/08/1970	17,664	-	-
31/08/1971	33,752	-	-
06/07/1972	27,020	-	-
08/07/1973	29,730	-	-
07/08/1974	19,788	-	-
09/08/1975	39,842	4	-
09/08/1976	72,400	1.30	-

Date and Year	Maximum Discharge(cusecs)	Hours	Annual Rainfall(mm)
26/08/1977	34,469	2	-
12/08/1978	27,918	2	-
08/08/1979	24.160	4	-
03/08/1980	42,690	2	-
01/7/1981	34,760	3	841
25/08/1982	26,037	2	610.40
15/08/1983	86,480	1.15	943.90
12/09/1984	34,649	3	757.50
02/08/1985	23,650	3	626.00
13/08/1986	11,790	7	695.00
26/08/1987	1277	1	802.00
21/08/1988	34,710	2	993
24/08/1989	34,065	1	734.20
16/08/1990	34,289	1	853.80
26/08/1991	11,628	3	899.00
17/08/1992	27,930	1	737.30
14/07/1994	48,430	2	1161.20
22/07/1995	6939	1	856.90
04/10/1996	46,899	2	1115.00
15/09/1997	90,470	3	1358.00
15/09/1998	23,247	1.30	810.80
29/07/1999	19,062	1	674.00
15/07/2000	2797	5	632.00
17/08/2009	1000	-	691.00
10/08/2002	1400	-	505.00
14/08/2003	1000	-	505.00
12/08/2004	34,439	-	9024.00
02/08/2004	51,824	2	1578.00
22/07/2006	56,630	2	1256.00
02/07/2007	27,180	3	-
11/08/2008	23,023	4	783
22/07/2009	11,396	2	927
20/07/2010	2442	15	900
06/09/2011	19,230	6	917
08/08/2012	3034	1	639
02/08/2013	27,203	2	864
31/07/2014	27,303	5	871
31/07/2015	Nil	Nil	524

Annexure 7.2

PIERWISEAFFLUXCOMPUTATION AND SUBMERGENCE

PierNumber		Adjacent Pierspan	Easting	Northing	Project Chainages	Pier dimensions (tran x long)			River Width at red line, m (W1)	Increased width due to afflux, m (W2)	Increase in width due to afflux, m (a=W2-W1)	RL at Red Line m	Increased RL at Red Line in m	Increase in water Level in m (afflux)	Increase in water Level in mm (afflux)
P	152	31-31	377738.62	2047402	4301.409	2.2	x	2.2	214.885	214.895	0.009687333	550.594	550.599	0.004843666	4.843666
P	153	31-25	377767.42	2047413.5	4332.409	2.2	x	2.2	211.25	211.256	0.006496623	550.532	550.535	0.003248311	3.248311
P	154	25-31	377790.44	2047423.2	4357.409	2.2	x	2.2	203.997	204.004	0.006931838	550.482	550.485	0.003465919	3.465919
P	155	31-46	377817.64	2047438	4388.409	2.5	x	3.5	200.375	200.383	0.007514623	550.42	550.424	0.003757312	3.757312
P	156	46-28	377852.94	2047467.4		2.5	x	3.5	211.786	211.794	0.007573061	550.322	550.326	0.003786531	3.786531
P	157	28-28	377870.72	2047489	4434.409	2.2	x	2.2	231.94	231.944	0.004129853	550.258	550.26	0.002064927	2.064927
P	158	28-28	377885.93	2047512.5	4462.409	2.2	x	2.2	251.29	251.294	0.003601736	550.194	550.196	0.001800868	1.800868
P	159	28-22	377900.23	2047536.5	4490.409	2.2	x	2.2	253.128	253.132	0.003951228	550.13	550.132	0.001975614	1.975614
PP	160	22-31	377911.76	2047555.3	4518.409	2.2	x	2.2	253.822	253.826	0.003691328	550.08	550.082	0.001845664	1.845664
P	161	31-28	377929.02	2047581	4571.409	2.2	x	2.2	255.11	255.113	0.003243293	550.009	550.011	0.001621647	1.621647
P	162	28-28	377945.22	2047603.9	4599.409	2.2	x	2.2	254.833	254.836	0.003381081	549.945	549.947	0.001690541	1.690541
PP	163	28-27.164	377961.46	2047626.7	4627.409	2.2	x	2.2	248.586	248.59	0.004483203	549.881	549.883	0.002241602	2.241602
START STATION			377976.49	2047647.8											
DE	1	27.164-13	377977.21	2047648.8	4654.573	3	x	2.5	240.941	240.951	0.009502955	549.819	549.824	0.004751477	4.751477
DE	2	13-13	377984.75	2047659.4	4667.573	3	x	2.5	238.572	238.582	0.00985882	549.789	549.794	0.00492941	4.92941
DE	3	13-17.9	377992.29	2047670	4680.573	3	x	2.5	236.206	236.215	0.009195192	549.758	549.763	0.004597596	4.597596
DE	4	17.9-17.9	378002.67	2047684.6	4698.473	3	x	2.5	232.247	232.253	0.00569918	549.715	549.718	0.00284959	2.84959
DE	5	17.9-13.9	378013.05	2047699.2	4716.373	3	x	2.5	229.688	229.695	0.007484494	549.673	549.677	0.003742247	3.742247
CL			378017.08	2047704.8	4723.409										
DE	6	13.9-17.9	378021.11	2047710.5	4730.359	3	x	2.5	228.721	228.729	0.007627958	549.639	549.643	0.003813979	3.813979
DE	7	17.9-17.9	378031.48	2047725.1	4748.173	3	x	2.5	228.666	228.675	0.008852373	549.597	549.601	0.004426187	4.426187
DE	8	17.9-13.0	378041.86	2047739.6	4766.073	3	x	2.5	228.61	228.619	0.008948529	549.554	549.558	0.004474264	4.474264
DE	9	13-13	378049.4	2047750.2	4779.073	3	x	2.5	228.57	228.579	0.009053346	549.523	549.528	0.004526673	4.526673
DE	10	13-22	378056.94	2047760.8	4792.073	3	x	2.5	228.53	228.538	0.007792808	549.492	549.496	0.003896404	3.896404

PierNumber		Adjacent Pierspan	Easting	Northing	Project Chainages	Pier dimensions (tran x long)			River Width at red line, m (W1)	Increased width due to afflux, m (W2)	Increase in width due to afflux, m (a=W2-W1)	RL at Red Line m	Increased RL at Red Line in m	Increase in water Level in m (afflux)	Increase in water Level in mm (afflux)
END			378057.67	2047761.9											
P	164	22-31	378069.7	2047778.8	4814.073	2.2	x	1.7	227.801	227.807	0.00633736	549.44	549.443	0.00316868	3.16868
P	165	31-28	378087.67	2047804	4845.073	2.2	x	1.7	227.163	227.169	0.006037355	549.366	549.369	0.003018677	3.018677
P	166	28-31	378103.91	2047826.8	4873.073	2.2	x	1.7	227.302	227.308	0.005953843	549.31	549.313	0.002976921	2.976921
P	167	31-28	378121.88	2047852.1	4904.073	2.2	x	1.7	227.456	227.462	0.005680975	549.249	549.252	0.002840487	2.840487
P	168	28-28	378138.24	2047874.8	4932.073	2.2	x	1.7	228.919	228.925	0.005998738	549.193	549.196	0.002999369	2.999369
P	169	28-28	378155.06	2047897.2	4960.073	2.2	x	1.7	230.899	230.904	0.004541511	549.138	549.14	0.002270755	2.270755
P	170	28-28	378172.34	2047919.2	4988.073	2.2	x	1.7	230.775	230.78	0.005012599	549.082	549.085	0.0025063	2.5063
P	171	28-28	378189.73	2047941.2	5016.073	2.2	x	1.7	222.65	222.655	0.005417689	549.026	549.029	0.002708845	2.708845
P	172	28-28	378206.93	2047963.3	5044.073	2.2	x	1.7	216.587	216.595	0.007542468	548.971	548.975	0.003771234	3.771234
P	173	28-28	378223.87	2047985.6	5072.073	2.2	x	1.7	223.544	223.551	0.007156062	548.915	548.919	0.003578031	3.578031
PP	174	28-31	378240.67	2048008	5100.073	2.2	x	1.7	225.718	225.724	0.006248875	548.86	548.863	0.003124437	3.124437
PP	175	31-28	378259.34	2048032.7	5131.073	2.2	x	1.7	221.46	221.467	0.00680826	548.86	548.863	0.00340413	3.40413
PP	176	28-31.298	378277.44	2048054.1	5159.073	2.2	x	1.7	217.317	217.323	0.006331162	548.739	548.742	0.003165581	3.165581
START			378298.59	2048075.4											
SP	1	31.298-13	378299.48	2048076.3	5190.371	3	x	2.5	211.698	211.708	0.009542955	548.68	548.685	0.004771478	4.771478
SP	2	13-13	378308.77	2048085.4	5203.371	3	x	2.5	208.284	208.3	0.01554777	548.655	548.663	0.007773885	7.773885
SP	3	13-17.9	378318.06	2048094.5	5216.371	3	x	2.5	205.281	205.293	0.012412324	548.629	548.635	0.006206162	6.206162
SP	4	17.9-17.9	378330.85	2048107	5234.271	3	x	2.5	201.251	201.262	0.010717878	548.593	548.598	0.005358939	5.358939
SP	5	17.9-13.9	378343.64	2048119.5	5252.171	3	x	2.5	193.116	193.136	0.019729501	548.558	548.568	0.00986475	9.86475
CL			378348.6	2048124.4	5259.121										0
SP	6	13.9-17.9	378353.57	2048129.2	5266.071	3	x	2.5	185.111	185.129	0.017947007	548.53	548.539	0.008973503	8.973503
SP	7	17.9-17.9	378366.36	2048141.8	5283.971	3	x	2.5	174.802	174.823	0.020827177	548.495	548.505	0.010413588	10.413588
SP	8	17.9-13.0	378379.15	2048154.3	5301.871	3	x	2.5	176.398	176.418	0.020473619	548.459	548.469	0.01023681	10.23681
SP	9	13-13	378388.43	2048163.4	5314.871	3	x	2.5	173.511	173.533	0.021633727	548.433	548.444	0.010816864	10.816864
SP	10	13-20.669	378397.72	2048172.5	5327.871	3	x	2.5	169.499	169.522	0.023328694	548.407	548.419	0.011664347	11.664347

PierNumber		Adjacent Pierspan	Easting	Northing	Project Chainages	Pier dimensions (tran x long)			River Width at red line, m (W1)	Increased width due to afflux, m (W2)	Increase in width due to afflux, m (a=W2-W1)	RL at Red Line m	Increased RL at Red Line in m	Increase in water Level in m (afflux)	Increase in water Level in mm (afflux)
END			378398.62	2048173.3											
P	177	20.669-28	378413.48	2048187.7	5349.766	2.2	x	1.7	170.261	170.278	0.01651233	548.364	548.372	0.008256165	8.256165
P	178	28-28	378435.22	2048205.3	5377.766	2.2	x	1.7	175.459	175.472	0.013400559	548.308	548.315	0.006700279	6.700279
P	179	28-28	378459.21	2048219.7	5405.766	2.2	x	1.7	184.375	184.385	0.010483076	548.286	548.291	0.005241538	5.241538
P	180	28-28	378484.13	2048232.4	5433.766	2.2	x	1.7	189.216	189.225	0.009453393	548.275	548.28	0.004726697	4.726697
P	181	28-28	378509.14	2048245	5461.766	2.2	x	1.7	179.729	179.742	0.012831372	548.263	548.269	0.006415686	6.415686
P	182	28-31	378535.09	2048255.5	5489.766	2.2	x	1.7	178.565	178.585	0.019948128	548.252	548.262	0.009974064	9.974064
P	183	31-28	378565.07	2048263.3	5520.766	2.2	x	1.7	187.955	187.967	0.011963375	548.24	548.246	0.005981688	5.981688
PP	184	28-28	378592.37	2048269.5	5548.766	2.2	x	1.7	183.058	183.071	0.012800121	548.229	548.235	0.006400061	6.400061
P	185	28-22	378619.68	2048275.7	5576.766	2.2	x	1.7	181.275	181.292	0.017399729	548.217	548.226	0.008699864	8.699864
P	186	22-47	378641.13	2048280.6	5598.766	2.5	x	3.5	182.907	182.927	0.019888513	548.209	548.219	0.009944257	9.944257
P	187	47-31	378686.92	2048291.2	5645.766	2.5	x	3.5	185.927	185.937	0.010315583	548.176	548.181	0.005157791	5.157791
P	188	31-21	378716.8	2048299.5	5676.766	2.2	x	1.7	183.292	183.302	0.009868669	548.142	548.147	0.004934334	4.934334
P	189	21-28	378736.72	2048306.1	5697.766	2.2	x	1.7	181.346	181.356	0.010301412	548.118	548.123	0.005150706	5.150706
P	190	28-28	378762.84	2048316.2	5725.766	2.2	x	1.7	179.018	179.029	0.01076714	548.086	548.091	0.00538357	5.38357
P	191	28-31	378788.56	2048327.2	5753.766	2.2	x	1.7	177.554	177.564	0.009752302	548.66	548.665	0.004876151	4.876151

ANNEXURE 7.3

LIST OF FLORAL DIVERSITY RECORDED IN THE STUDY AREA

S.No.	Scientific Name	Family	Common Name	Number ofTrees
1.	Acacia auriculiformis Benth.	Leguminosae	Australian Acacia	4
2.	Acacia catechu (L.f.) Willd.	Leguminosae	Khair	2
3.	Acacia farnesiana (L.) Willd.	Leguminosae	Dev babul	3
4.	Acacia horrida (L.) Willd.	Leguminosae	Gukikar	1
5.	Acacia leucophloea (Roxb.) Willd.	Leguminosae	Hivar	4
6.	Acacia nilotica (L) Delile.	Leguminosae	Babool	95
7.	Manilkara zapota (L.) P.Royen	Sapotaceae	Chiku	111
8.	Aegle marmelos (L.) Corr.	Rutaceae	Bael Tree	80
9.	Agathis robusta F.M.Bailey	Araucariaceae	Kauri Pine	11
10.	Ailanthus excelsa Roxb.	Simaroubaceae	Maharukh	7
11.	Albizia julibrissin Durazz	Leguminosae	Silk Tree	1
12.	Albizia lebbeck (L.) Bth.	Leguminosae	Shirish	8
13.	Alstonia scholaris (L.) R.Br.	Apocynaceae	Saptaparni	60
14.	Annona reticulata L.	Annonaceae	Ramphal	176
15.	Annona squamosa L.	Annonaceae	Sitaphal	143
16.	Anogeissus latifolia (Roxb. Ex DC)	Combretaceae	Dhavda	1
17.	Neolamarckia cadamba (Roxb.) Bosser	Rubiaceae	Kadamb	15
18.	Aphanamixis polystachya (Wall.) R.N. Parker	Meliaceae	Rohitak	42
19.	Araucaria columnaris J.R.Forst. Hook.	Araucariaceae	X-Mas Tree	68
20.	Archontophoenix alexandrae (F.Muell.)H. Wendl.& Drude	Arecaceae	Alexandar Palm	1
21.	Areca catechu Linn.	Arecaceae	Supari	56
22.	Artocarpus heterophyllus Lam.	Moraceae	Phanas	204
23.	Artocarpus incisa Linn.f.	Moraceae	Nirphanas	5
24.	Averrhoa bilimbi L.	Oxalidaceae	Bilimbi	1
25.	Azadirachta indica A.Juss	Meliaceae	Neem	361
26.	Barringtonia acutangula (L.) Gaertn.	Lecythidaceae	Samudraphul	1
27.	Bauhinia vahlii Wight & Arn	Leguminosae	Apta	3
28.	Bauhinia variegata L.	Leguminosae	Kanchan	60
29.	Bombax ceiba Linn.	Malvaceae	Savar	30
30.	Borassus flabellifer L.	Arecaceae	Todi Palm	1
31.	Schefflera actinophylla (Endl.) Harms	Araliaceae	Umbrella Tree	35
32.	Broussonetia papyrifera (L.) L Hér. ex Vent.	Moraceae	Jangali Toot	37
33.	Buchanania cochinchinensis (Lour.) M.R. Almeida	Anacardiaceae	Charoli	1
34.	Butea monosperma (Lam.) Taub..	Leguminosae	Palash	4
35.	Caesalpinia coriaria (Jacq.)Willd.	Leguminosae	Divi Divi Tree	1
36.	Caesalpinia pulcherrima (L.) Sw.	Leguminosae	Shankasur	5

S.No.	Scientific Name	Family	Common Name	Number ofTrees
37.	Callistemon citrinus (Curtis) Skeels	Myrtaceae	Bottle Brush	37
38.	Capparis grandis L.f.	Capparaceae	Pachunda	1
39.	Caryota rumphiana Mart.	Arecaceae	Australian Fishtail Palm	1
40.	Caryota urens L.	Arecaceae	Bherali mad	297
41.	Cascabela thevetia (L.) Lippold	Apocynaceae	Pivla Kanher	49
42.	Senna pallida (Vahl) H.S.Irwin& Barneby	Leguminosae	Twin Flowered Cassia	1
43.	Cassia fistula L.	Leguminosae	Bahava	25
44.	Cassia grandis L.f.	Leguminosae	Pink shower	18
45.	Cassia javanica L.	Leguminosae	Java Cassia	1
46.	Cassia renigera Benth.	Leguminosae	The Burmese Pink Cassia	4
47.	Senna siamea (Lam.) H.S.Irwin& Barneby	Leguminosae	Kashid	144
48.	Castanospermum australe A.Cunn. &C.Fraser	Leguminosae	Australian chestnut tree	1
49.	Casuarina equisetifolia L.	Casurinaceae	Suru	45
50.	Dypsis lutescens (H.Wendl.) Beentje &J.Dransf.	Arecaceae	Ornamental Palm	148
51.	Cinnamomum tamala (Buch.-Ham.) T.Nees& C.H.Eberm.	Lauraceae	Tamal Patra	5
52.	Cinnamomum verum J.S. Presl.	Lauraceae	Dalchini	1
53.	Citrus aurantifolia (Christn. (Panz.) Swingle	Rutaceae	Limbu	94
54.	Citrus maxima (Burm.) Merr.	Rutaceae	Papanas	1
55.	Citrus medica L.	Rutaceae	Mosambi	8
56.	Citrus limon (L.) Osbeck	Rutaceae	Idlimbu	7
57.	Clusia major L.	Clusiaceae	Balsam Tree	1
58.	Cocos nucifera L.	Arecaceae	Naral	860
59.	Colvillea racemosa Bojer	Leguminosae	Manimor	2
60.	Cordia dichotoma G. Forst.	Boraginaceae	Bhokar	10
61.	Cordia sebestena L	Boraginaceae	Scarlet Cordia	6
62.	Cordia sinensis Lam.	Boraginaceae	Grey Leaved Saucer berry	1
63.	Couroupita guianensis Aubl.	Lecythidaceae	Kailashpati	28
64.	Crateva tapia L.	Capparaceae	Vaivarna (O)	1
65.	Crescentia cujete L.	Bignoniaceae	Calabash Tree	1
66.	Cupressus macrocarpa Hartw.	Cupressaceae	Monterey Cypress	1
67.	Cycas circinalis L.	Cycadaceae	Cycas (C)	16
68.	Cycas revoluta Thunb.	Cycadaceae	Sago Cycad	2
69.	Cycas rumphii Miq.	Cycadaceae	Sago palm	2
70.	Dalbergia latifolia Roxb.	Leguminosae	Sisvi	1
71.	Dalbergia melanoxylon Guill. & Perr.	Leguminosae	Patangi	2
72.	Dalbergia sissoo DC.	Leguminosae	Sisoo	6
73.	Delonix regia (Hook.) Raf.	Leguminosae	Gulmohar	315

S.No.	Scientific Name	Family	Common Name	Number ofTrees
74.	Desmodium oojeinense (Roxb.) H.Ohashi	Leguminosae	Kala Palash	1
75.	Dichrostachys cinerea (L.) Wight & Arn.	Leguminosae	Durangi Babool	1
76.	Dillenia pentagyna Roxb.	Dilleniaceae	Karmal	11
77.	Diospyros malabarica (Desr.) Kostel.	Ebenaceae	Gaub	1
78.	Dolichandrone falcata (Wall. ex DC.) Seem.	Bignoniaceae	Medshing	2
79.	Putranjiva roxburghii Wall.	Putranjivaceae	Putranjiva	109
80.	Ehretia laevis Roxb.	Boraginaceae	Chamror	13
81.	Elaeis guineensis Jacq.	Arecaceae	Oil Palm	11
82.	Elaeocarpus tuberculatus Roxb.	Elaeocarpaceae	Rudraksha	2
83.	Phyllanthus emblica L.	Phyllanthaceae	Amla	19
84.	Erythrina variegata L.	Leguminosae	Pangara	2
85.	Eucalyptus globulus Labill.	Myrtaceae	Nilgiri	55
86.	Ficus benghalensis L.	Moraceae	Vad	177
87.	Ficus benjamina L.	Moraceae	F.Benjamina	58
88.	Ficus carica L.	Moraceae	Anjir	1
89.	Ficus elastica Roxb. ex Hornem.	Moraceae	Indian Rubber Tree	42
90.	Ficus hispida L.f.	Moraceae	Kala Umber	11
91.	Ficus longifolia Schott	Moraceae	Narrow Leaf Fig	1
92.	Ficus lyrata Warb.	Moraceae	Fiddle-leaf Fig	1
93.	Ficus microcarpa L.f.	Moraceae	Nandruk	550
94.	Ficus racemosa L.	Moraceae	Umber	830
95.	Ficus religiosa L.	Moraceae	Pimpal	543
96.	Ficus virens Aiton.	Moraceae	Piparni	2
97.	Ficus amplissima Sm.	Moraceae	Payar	3
98.	Filicium decipiens (Wight & Arn.) Thwaites.	Sapindaceae	Fern Tree	7
99.	Garcinia indica (Thou.) Choisy.	Clusiaceae	Kokam	3
100.	Gardenia resinifera Roth.	Rubiaceae	Anant	50
101.	Gliricidia sepium (Jacq.) Walp.	Leguminosae	Giripushpa	20
102.	Gmelina arborea Roxb.	Lamiaceae	Shivan	3
103.	Grevillea robusta A.Cunn. ex R.Br.	Proteaceae	Silver Oak	167
104.	Grewia asiatica L.	Malvaceae	Sherbet Berry	1
105.	Guazuma ulmifolia Lam	Malvaceae	Bhadraksha	2
106.	Heterophragma quadriloculare (Roxb.) K. Schum	Bignoniaceae	Varas	1
107.	Hibiscus tiliaceus L.	Malvaceae	Sea hibiscus	1
108.	Holoptelea integrifolia (Roxb)	Ulmaceae	Vavla	165
109.	Ixora brachiata Roxb.	Rubiaceae	Lokhanidi	1
110.	Ixora pavetta Andr.	Rubiaceae	Ixora Parviflora	1
111.	Jacaranda acutifolia Bonpl.	Bignoniaceae	Nilmohar	22
112.	Jatropha gossypiifolia L.	Euphorbiaceae	Mogali Erand	3
113.	Khaya grandifoliola C.DC.	Meliaceae	Khaya	101

S.No.	Scientific Name	Family	Common Name	Number ofTrees
114.	Kigelia africana (Lam.) Benth.	Bignoniaceae	Sausage Tree	7
115.	Lagerstroemia indica (L.)	Lythraceae	Chinai Mehandi	8
116.	Lagerstroemia speciosa (L.) Pers.	Lythraceae	Tamhan	4
117.	Leucaena leucocephala (Lam.) de Wit	Leguminosae	Subabul	596
118.	Licuala sps.	Arecaceae	Licula palm	5
119.	Limonia acidissima Groff	Rutaceae	Kavath	8
120.	Livistona chinensis (Jacq.) R.Br. ex Mart..	Arecaceae	Chinese Palm	4
121.	Macaranga peltata (Roxb.) Muell.-Arg.	Euphorbiaceae	Chanda	1
122.	Madhuca longifolia (J.Koenig ex L.) J.F.Macbr.	Sapotaceae	Moha (L)	27
123.	Magnolia liliifera (L.) Baill.	Magnoliaceae	Kauthi Chapha	4
124.	Mammea suriga (Buch.-Ham. ex Roxb.) Koesterm	Clusiaceae	Surangi	1
125.	Mangifera indica L.	Anacardiaceae	Amba	868
126.	Manilkara hexandra (Roxb.) Dub.	Sapotaceae	Khirani	5
127.	Markhamia lutea (Benth.) K.Schum.	Bignoniaceae	Markhamia	3
128.	Melaleuca bracteata F.Muell.	Myrtaceae	Golden Bottle Brush	6
129.	Melia azedarach L.	Meliaceae	Akashneem	313
130.	Melia composita L.	Meliaceae	Malabar Neem	12
131.	Magnolia champaca (L.) Baill. ex Pierre	Magnoliaceae	Sonchapha	311
132.	Mimusops elengi L.	Sapotaceae	Bakul	85
133.	Morinda coreia Buch.-Ham.	Rubiaceae	Bartondi (P)	5
134.	Moringa oleifera Lam	Moringeae	Shevga	78
135.	Morus alba L.	Moraceae	Tuti	35
136.	Muntingia calabura L.	Muntingiaceae	Singapor cherry	57
137.	Murraya koenigii (L.) Spreng.	Rutaceae	Curry Patta	68
138.	Murraya paniculata (L.) Jack.	Rutaceae	Kamini	8
139.	Myristica fragrans Houtt..	Myristicaceae	Jaiphal	2
140.	Litchi chinensis Sonn.	Sapindaceae	Litchi	2
141.	Nyctanthes arbor-tristis L.	Oleaceae	Parijatak	202
142.	Parkia biglandulosa Wight.& Arn.	Leguminosae	Chenduphal	21
143.	Peltophorum pterocarpum (DC.) K.Heyne	Leguminosae	Sonmohar	271
144.	Persea americana Mill.	Lauraceae	Avacado	2
145.	Phoenix dactylifera Linn	Arecaceae	Khajur	5
146.	Phoenix sylvestris (L.) Roxb	Arecaceae	Wild Date Palm	2
147.	Phyllanthus acidus (L.) Skeels	Phyllanthaceae	Rai Awla	48
148.	Pisonia umbellifera (J.R. Forst. & G. Forst.) Seem.	Nyctaginaceae	The Lettuce Tree	2
149.	Pithecellobium dulce (Roxb.) Benth.	Leguminosae	Vilayati Chinch	264
150.	Plumeria alba L.	Apocynaceae	Chapha (a)	171

S.No.	Scientific Name	Family	Common Name	Number ofTrees
151.	Plumeria obtusa Linn.	Apocynaceae	Chapha(O)	39
152.	Plumeria rubra L.	Apocynaceae	Chapha (Red)	36
153.	Podocarpus elongatus Aiton L'Herit. ex Pers.	Podocarpaceae	Podocarpus	2
154.	Polyalthia longifolia (Sonn.) Thw.	Annonaceae	Asupalav (D)	1983
155.	Pongamia pinnata (L.) Pierre	Leguminosae	Karanj	131
156.	Populus alba L.	Salicaceae	Poplar	4
157.	Prosopis juliflora (SW.) DC.	Leguminosae	Vilayati babul	9
158.	Psidium guajava L.	Myrtaceae	Peru	192
159.	Ptelea trifoliata L	Rutaceae	Common Hoptree	1
160.	Pterospermum acerifolium (L.) Willd.	Malvaceae	Muchkund	16
161.	Punica granatum L.	Lythraceae	Dalimb	30
162.	Roystonea regia (Kunth) O.F.Cook	Arecaceae	Royal Palm	186
163.	Salix tetrasperma Roxb.	Salicaceae	Salix	1
164.	Albizia saman (Jacq.) Merr.	Leguminosae	Rain Tree	511
165.	Santalum album L.	Santalaceae	Chandan	108
166.	Sapindus laurifolius Vahl.	Sapindaceae	Ritha	19
167.	Saraca asoca (Roxb.) Willd.	Leguminosae	Sita Ashok	8
168.	Saribus rotundifolius (Lam.) Blume	Arecaceae	Chinese Fan Palm	57
169.	Schinus terebinthifolia Raddi	Anacardiaceae	Pink Paper Tree	3
170.	Schleichera oleosa (Lour.) Merr.	Sapindaceae	Kusum	3
171.	Spathodea campanulata P.Beauv.	Bignoniaceae	Pichkari	183
172.	Sterculia foetida L.	Malvaceae	Jangali Badam	64
173.	Swietenia macrophylla King.	Meliaceae	Mothi Mahogani	65
174.	Swietenia mahagoni (L.) Jacq.	Meliaceae	Mahogani	41
175.	Syagrus romanzoffiana (Cham.) Glassman	Arecaceae	Queen palm	1
176.	Syzygium cumini (L.) Skeels	Myrtaceae	Jamun	474
177.	Syzygium jambos (L.) Alston.	Myrtaceae	Jam	3
178.	Syzygium samarangense (Blume) Merr. & L.M.Perry	Myrtaceae	Safed Jam	3
179.	Tabebuia aurea (Silva Manso) Benth. & Hook.f. ex S.Moore	Bignoniaceae	T.argentia	6
180.	Tabebuia heterophylla (DC.) Britton	Bignoniaceae	T.Pentaphylla	14
181.	Tabebuia rosea (Bertol.) Bertero ex A.DC.	Bignoniaceae	T.Rosea	4
182.	Tamarindus indica L.	Leguminosae	Chinch	93
183.	Tecoma stans (L.) Juss. ex Kunth	Bignoniaceae	Tecoma	89
184.	Tectona grandis L.f.	Lamiaceae	Sag	1
185.	Terminalia arjuna (Roxb. DC.) Wight. & Arn.	Combretaceae	Arjun	40
186.	Terminalia bellirica (Gaertn.) Roxb.	Combretaceae	Behada	1
187.	Terminalia catappa L.	Combretaceae	Deshi Badam	269
188.	Theobroma cacao L.	Malvaceae	Cocoa	1

S.No.	Scientific Name	Family	Common Name	Number ofTrees
189.	Thespesia populnea (L.) Sol. ex Corrêa	Malvaceae	Bhendi	9
190.	Thuja biota (Linn.) Blume	Cuppressecaceae	Mayurpankhi	16
191.	Trema orientalis (L.) Blume	Cannabaceae	Charcoal Tree	22
192.	Vitex negundo L.	Lamiaceae	Nirguni	8
193.	Washingtonia filifera (Linden ex André) H.Wendl. ex de Bary	Arecaceae	Washingtonia palm	3
194.	Wodyetia bifurcataA.K.Irvine	Arecaceae	Fox Tail Palm	15
195.	Ziziphus jujuba L.	Rhamnaceae	Bor	70
196.	Ceiba pentandra (L.) Gaertn	Malvaceae	Shalmali/ Sawar	08

ANNEXURE 7.4

CHECKLIST OF HERBS AND SHRUBS

S. No.	Scientific Name	Family	Common Name
Herbs			
1.	Abutilon indicum (L.) Sweet	Malvaceae	Kanski
2.	Acalypha ciliata Forssk.	Euphorbiaceae	-
3.	Achyranthes aspera L.	Amaranthaceae	Aghara
4.	Alocasia macrorrhizos (L.) G.Don	Araceae	Alu
5.	Alternanthera pungens Kunth	Amaranthaceae	-
6.	Alternanthera philoxeroides (Mart.) Griseb.	Amaranthaceae	Alligator weed
7.	Alternanthera sessilis (L.) R.Br. ex DC.	Amaranthaceae	-
8.	Altternanthera triandra Lam.	Amaranthaceae	-
9.	Amaranthus cruentus L.	Amaranthaceae	Spiny pigweed
10.	Amaranthus spinosus L.	Amaranthaceae	
11.	Amaranthus polygamus L.	Amaranthaceae	Green amaranth
12.	Asclepias curassavica L.	Asclepiadaceae	Scarlet milkweed
13.	Hygrophila auriculata (Schumach.) Heine	Acanthaceae	-
14.	Bacopa monnieri (L.) Wettst.	Plantaginaceae	Brahmi
15.	Blumea lacera (Burm.f.) DC.	Compositae	Kakronda
16.	Boerhavia diffusa L.	Nyctaginaceae	Punarnava
17.	Brassica juncea (L.) Czern.	Brassicaceae	Indian mustard
18.	Canna indica L.	Cannaceae	Kardal
19.	Cardiospermum helicacabum L.	Sapindaceae	Balloon vine
20.	Senna alata (L.) Roxb.	Leguminosae	-
21.	Senna occidentalis (L.) Link	Leguminosae	Velvet leaf
22.	Senna tora (L.) Roxb.	Leguminosae	Takala
23.	Senna uniflora (Mill.) H.S.Irwin& Barneby	Leguminosae	-
24.	Chrozophora plicata (Vahl) A.Juss. ex Spreng.	Euphorbiaceae	-
25.	Cleome gynandra L. Sp. Pl. ed.	Brassicaceae	-
26.	Cleome rutidosperma DC	Capparaceae	-
27.	Cleome viscosa L. Sp. Pl.	Cleomaceae	-
28.	Commelina forsskalaei Vahl.	Commelinaceae	-
29.	Crinum viviparum (Lam.) R.Ansari& V.J.Nair	Amaryllidaceae	Grand crinum lily
30.	Croton bonplandianus Baill	Euphorbiaceae	Ban tulsi
31.	Croton gibsonianus Nimmo	Euphorbiaceae	-
32.	Cucurbita maxima Duchesne	Cucurbitaceae	Pumpkin
33.	Cynodon dactylon (L.) Pers.	Poaceae	Durva
34.	Cyperus compressus L.	Cyperaceae	-
35.	Cyperus rotundus L.	Cyperaceae	Nut Grass
36.	Datura metal L.	Solanaceae	Kala Dhotra
37.	Echinochloa colona (L.) Link	Poaceae	-
38.	Echinops Echinatus Roxb	Asteraceae	Utanti
39.	Eclipta prostrata (L.) L.	Asteraceae	Maka
40.	Eichhornia crassipes (Mart.) Solms	Pontederiaceae	Water hyacinth

41.	Eleusine coracana (L.) Gaertn.	Poaceae	Indian millet
42.	Euphorbia hirta L.	Euphorbiaceae	-
43.	Fimbristylis quinquangularis (Vahl) Kunth	Cyperaceae	-
44.	Gomphrena celosioide	Amaranthaceae	-
45.	Grangea maderaspatana	Asteraceae	Madras Carpet
46.	Hydrocotyle rotundifolia Roxb.	Apiaceae	Mandukparni
47.	Hygrophila auriculata (Schumach.) Heine	Acanthaceae	Talimkhana
48.	Ipomoea aquatica Forssk.	Convolvulaceae	-
49.	Ludwigia octovalvis (Jacq.) P.H.Raven	Onagraceae	-
50.	Kyllinga tenuifolia Steud.	Cyperaceae	-
51.	Lemna minor L.	Araceae	Common duckweed
52.	Ludwigia octovalvis (Jacq.) P.H.Raven	Onagraceae	Pan lavang
53.	Ludwigia perennis L.	Onagraceae	-
54.	Marsilea minuta L.	Marsileaceae	Water Clover
55.	Ocimum tenuiflorum L.	Lamiaceae	Tulas
56.	Parthenium hysterophorus L.	Asteraceae	Gajar Gavat
57.	Passiflora foetida L.	Passifloraceae	Krashna kamal
58.	Persicaria glabra (Willd.)M.Gomez.	Polygonaceae	-
59.	Phyla nudiflora (L.) Greene	Verbenaceae	-
60.	Phyllanthus amarus Schum & Thonn.	Euphorbiaceae	-
61.	Cullen corylifolium (L.) Medik.	Leguminosae	-
62.	Plectranthus forskalaei Vahl	Lamiaceae	-
63.	Portulaca oleracea L.	Portulacaceae	-
64.	Ricinus communis L.	Euphorbiaceae	Castor Bean
65.	Senna occidentalis (L.) Link	Fabaceae	Coffee Senna
66.	Sesuvium portulacastrum (L.) L.	Aizoaceae	Sea Purslane
67.	Setaria glauca Kunth	Ceraniaceae	Wire weed
68.	Setaria intermedia Roem. & Schult.	Gramineae	-
69.	Sida acuta Burm.f.	Malvaceae	Horn bean leaved
70.	Sida rhombifolia L.	Malvaceae	-
71.	Solanum surattense Burm. f.	Solanaceae	Kanteli
72.	Synedrella nodiflora (L.) Gaertn.	Compositae	Cinderella Weed
73.	Tinospora sinensis (Lour.) Merr.	Menispermaceae	Guduchi
74.	Tridax procumbens (L.) L.	Compositae	Dagdi Pala
75.	Typha angustifolia L.	Typhaceae	Pankanis
76.	Verbascum chinens (L.) Santapau	Scrophulariaceae	Chinese mullein
77.	Cyanthillium cinereum (L.) H.Rob.	Compositae	-
78.	Withania somnifera (L.) Dunal	Solanaceae	Winter cherry
79.	Wolffia globosa (Roxb.) Hartog & Plas	Araceae	Khai nam
80.	Xanthium strumarium L.	Asteraceae	-
Shrubs			
1.	Abutilon indicum (L.) Sweet	Malvaceae	-
2.	Acalypha indica L.	Euphorbiaceae	-
3.	Agave sisalana Perrine	Agavaceae	Ghaypat
4.	Allamanda cathartica L.	Apocyanaceae	Golden Trumpet

5.	Asclepias curassavica L.	Asclepiadaceae	Haldi Kunku
6.	Bambusa bambos (L.) Voss	Poaceae	Kalak
7.	Bougainvillea spectabilis Willd.	Nyctaginaceae	Boganvel
8.	Breynia retusa (Dennst.) Alston	Phyllanthaceae	Dolfodi, Kangli
9.	Callistemon citrinus (Curtis) Skeels	Myrtaceae	Bottle Brush
10.	Calotropis procera (Aiton) Dryand.	Apocynaceae	Rui
11.	Capparis zeylanica L.	Capparaceae	Waghati
12.	Chromolaena odorata (L.) R.M.King& H.Rob.	Compositae	-
13.	Chrozophora rottleri (Geiseler) A.Juss. ex Spreng.	Euphorbiaceae	-
14.	Cocculus hirsutus (L.) W. Theob	Menispermaceae	Jaljamni
15.	Combretum albidum G. Don.	Combretaceae	Shendari
16.	Colocasia esculenta (L.) Schott	Araceae	-
17.	Cyperus difformis L.	Cyperaceae	-
18.	Duranta erecta L.	Verbenaceae	Da-myanti
19.	Datura stramonium L.	Solanaceae	-
20.	Hamelia patens Jacq	Rubiceae	Fire Bush
21.	Hibiscus rosa – sinensis L.	Malvaceae	Jasvand
22.	Ipomoea carnea Jacq.	Convolvulaceae	Besharam
23.	Ixora coccinea L.	Rubiaceae	Bakora
24.	Lantana camara L.	Verbenaceae	Ghaneri
25.	Ixora pavetta Andr.	Rubiaceae	Raikuda
26.	Jatropha gossypifolia L	Euphorbiaceae	Mogli Erand
27.	Lantana camara L.	Verbenaceae	Ghaneri
28.	Maytenus rothiana (Walp.) L.	Celastraceae	Yenkali
29.	Nerium oleander L.	Apocynaceae	Kanher
30.	Phyllanthus reticulatus Poir.	Phyllanthaceae	Black-Honey
31.	Ricinus communis L.	Euphorbiaceae	Castor bean
32.	Solanum torvum Sw.	Solanaceae	Berry
33.	Vitex negundo L.	Lamiaceae	Nirgudi

ANNEXURE 8.1

CHECKLIST OF INFORMATION TO BE SUBMITTED ALONG WITH CONSENT APPLICATION

CONSENT UNDER WATER & AIR ACT

For Consent to Establish

- Site plan/index
- Topographical Map
- Detailed layout plant of different processes and point sources of effluent discharge/ emissions and position of stack and documents including D.G. set capacity in KVA
- Process flow sheet
- Details of Water Pollution Control/Air Pollution Control devices proposed to be provided
- Ambient Air Quality Report (if available)
- SSI Certificate/NOC from Directorate of Industries Government of Maharashtra
- D.G.T.D. Registration. (if applicable)
- Details of chemical reactions with mass balance
- Consent fees in the form of D.D. drawn on favour of MPCB
- Local body NOC
- Under taking on Rs. 20 stamp paper or Chartered Accountant certificate about proposed Capital Investment (Land, building, and machineries)

For Consent to Operate/Renewal

- Detailed layout plant of different processes and point sources of effluent discharge/emissions and position of stack and documents including D.G. set capacity in KVA.
- Process flow sheet
- Latest analysis report of effluent, fuel gases, solid waste & hazardous wastes
- Details of Water Pollution Control/Air Pollution Control devices provided
- Ambient Air Quality Report (if available)
- SSI Certificate/NOC from Directorate of Industries Government of Maharashtra
- D.G.T.D. Registration. (if applicable)
- Details of chemical reactions with mass balance
- Consent fees in the form of D.D. drawn on favour of MPCB
- Xerox copy of previous consent (for renewal only)
- Xerox copy of Environmental Clearance of Government of Maharashtra or Government of India in case of 1st consent to operate in case of industries/process requiring environmental clearance.

ANNEXURE 8.2

PERMISSION FOR CUTTING AND TRANSPLANTING TREES

FORM-"C"

Application under Section 8(2):

Date:

To,

Tree Authority,

____

Sub: Permission for cutting/ transplanting the trees.
coming in the work of proposed_______________.

I, the undersigned apply for cutting of the trees. The details are given below.

1) Name of the applicant:
2) City Survey No./Survey No.

Ward No.	Sr.No	Existing Number of Trees	Proposed Number of trees to be cut down/ Transplanted	Balance number of trees to be retained	Reasons for cutting of the trees
(1)	(2)	(3)	(4)	(5)	(6)

I enclose herewith plan showing the position of trees. I undertake to plant/ transplant and maintain_________ trees as per authority's direction and also within stipulated time. I am ready to pay the required security deposit for the same to the Tree Authority.

Yours faithfully,

(Owner/ Occupier)

- Documents to be submitted along with this application.

1) Property ownership of the land.
2) Approved building plan for construction, if any.
3) Photographs of the trees, to be cut, if possible.
4) Undertaking required under Section 11(2).

FORM-"D"

Undertaking under Section 11(2)

(to be submitted along with the application)

Date:

The Tree Officer,

I hereby undertake to abide by the orders issued under Sections 8/9/10 of the Act. I further undertake to plant the trees properly and preserve all existing as well as newly planted trees in proper manner. I also undertake to furnish 6-monthly report for the first 3 years from the date of plantation/ transplantation. I also undertake to pay security deposit according to the orders and I am aware that necessary security deposit shall get forfeited in case of non-compliance of the order under Section 8/9.

I am also aware that failure to comply will also attract the legal action as per the provisions of the Act.

Owner/ Occupier.

ANNEXURE 8.3

APPLICATION FOR CONSTRUCTION NEAR PROTECTED AREA

FORM I

Application for permission for construction/mining
Operation within a protected area.
(See rule 10)

1. Name and address of applicant[1]
2. Name of the protected area within which construction/mining operation is proposed.

Locality **District** **State**

3. Nature and details of the proposed construction/mining operation in respect of which permission is sought.

(In the case of construction, a site-plan in triplicate showing in red outline the location of the building in relation to the protected area and the plan and elevation of the building should be attached; and the colour, external appearance and method of the screening of the building and the depth down to which the soil will be excavated for the appurtenances of the building should be specified.

In the case of mining operation, a site-plan in triplicate showing in red outline the extent of the operation in relation to the protected area should be attached; and details, regarding the depth down to which the operation is to be carried out, the mode of the operation, the method of the muffling of sound, the kind and charge of blasting material and the depth and number of blast-holes to be fired at a time should be specified.)

4. Purpose of the proposed construction/mining operation.
5. Approximate duration and date of commencement of the proposed construction/mining operation.

I declare that the above information is correct. I also undertake to observe the provisions of the Ancient Monuments and Archaeological Sites and Remains Act, 1958, and rules made thereunder.

Station

Seal of the organization

Date

Signature of the applicant[2]

[1] If the application is on behalf of an organisation, the name thereof should be given.

[2] If the application is on behalf of an organization, the signature should be that of the head of the department.

FORM II

Application For Licence To Excavate In A Protected Area
(Vide rule 12)

1. Name and address of applicant[1]

2. Name of the site

Locality District State

3. Extent of the proposed excavation (a plan of the site in triplicate showing in red outline the extent of the proposed excavation should be attached).

4. Approximate duration and date of commencement of the proposed excavation.

5. Approximate expenditure on the proposed excavation.

6. Name and status of the Director of the proposed excavation.

7. Details of photographic, surveying and other equipments available for the proposed excavation.

I declare that the above information is correct. I also undertake to observe the provisions of the Ancient Monuments and Archaeological Sites and Remains Act, 1958, and the rules made there under.

Station

Seal of the institution

Date

Signature of the applicant[2]

[1] If the application is on behalf of an institution, the name thereof should be given.

[2] If the application is on behalf of an institution, the signature should be that of the head of the institution, which term includes the Registrar of a University.

ANNEXURE 8.4

DETAILS OF BATCHING PLANT
(To be filled by the Contractor)

Name of Location ____________________
Report for Batching Plant
Reporting Month……………………..
Date of Submission…………………..

1. Environment Features of the surrounding area

1.1	Name and location of Batching Plant	
1.2	Wind direction	
1.3	Name (s), distance population and type of settlements in a 1.5 km radius of site.	

2. Details of Batching Plant and Mitigation Measures taken

2.1	Installed Capacity	
2.2	Average Utilization	
2.5	Last maintenance date	

3. Explain Air Pollution Control Measures taken at the Batching Plant site

4. Explain Noise Pollution Control Measures taken at the Batching Plant site

Remark

Submitted	Checked	Approved
Signature ……………	Signature …………..	Signature …………..
Name …………………	Name ……………..	Name …………………
Designation …………		
Contractor	Environmental Engineer of Construction Supervision Consultant	In-charge Officer (PIU)

ANNEXURE 8.5

DETAILS OF MUCK DUMPING OPERATIONS

(To be filled by the Contractor)

Dumping site location ____________________
Reporting Month…………………….
Date of Submission …………………

1. Environment Features of the surrounding area

1.1	Location of Dumping site	
1.2	Capacity of Dumping site	
1.3	Safety measure taken at Dumping site (s)	
1. 2. 3. 4. 5.		

Remark

Submitted	**Checked**	**Approved**
Signature …………….	Signature …………..	Signature …………..
Name …………………	Name ……………..	Name …………………
Designation …………		
Contractor	Environmental Engineer of Construction Supervision Consultant	In-charge Officer (PIU)

ANNEXURE 8.6

DETAILS OF MACHINERY DURING CONSTRUCTION

(To be filled Monthly by the Contractor)

Location Name ____________________
Reporting Month…………………….
Date of Submission ………………….

1. Details of Machinery Operation

1.1	Total machinery in operation (Nos.)	
1.2	Number of pavers	
1.3	Number of rollers	
1.4	Number of excavators	
1.5	Number of graders	
1.6	Number of dumpers	
1.7	Number of Cranes	
1.8	No. of workshops with repairs facility (furnish location and type of facility provided)	Workshop on Facility Location Provided
1.9	Number of vehicles in repair at each location	
1.10	Details of waste disposal	
1.11	Others	

Remark

Submitted	**Checked**	**Approved**
Signature …………….	Signature ……………	Signature ……………
Name ………………..	Name ……………..	Name ………………..
Designation ………….		
Contractor	Environmental Engineer of Construction Supervision Consultant	In-charge Officer (PIU)

ANNEXURE 8.7

SAFETY CHECK LIST
(To be filled by the Contractor)

1	Contract No.	
2	Name of Contractor	
3	Representation	
4	Name of Safety Officer	
5	Date of Inspection	

Location 1 ………… Location 2 ………….... Location 3 ……………

Adequate at time of Inspection **Needs Improvement** **Needs Immediate Attention**	**Location 1**			**Location 2**			**Location 3**			**Remark**
	A	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	
General										
House keeping										
Stacking of Material										
Passageway										
Lighting										
Ventilation										
Others										
Electrical										
Switches										
Wirings										
Fixed Installation										
Portable Lighting										
Portable Tool										
Welding Machine										
Others										
Fire Prevention										
Fire Fighting Appliance										
Dangerous Goods Store										
Gas Welding Cylinders										
Others										
Others										
Dust Control										
Noise Control										
First Aid Equipment										
Washing Facility										
Latrine										
Canteen										
Provision of Personal Protective										
Helmet										
Eye Protector										
Ear Protector										
Respirator										
Safety Shoes										
Safety Belts										
Others										

Remark

Submitted	Checked	Approved
Signature …………….	Signature ……………	Signature ……………
Name …………………	Name ……………..	Name …………………
Designation …………		
Contractor	Environmental Engineer of Construction Supervision Consultant	In-charge Officer (PIU)

ANNEXURE 8.8

ACCIDENT REPORT
(To be completed on Occurrence of Injury by the Safety Officer)

Type of Accident

	Fall of person from a height		Explosion
	Slip, trip or fall on same level		Fire
	Struck against fixed objects		Contact with hot or corrosive substances
	Struck by flying or falling objects		Contact with poisonous gas or toxic substances
	Struck by moving objects		Contact with electric current
	Struck / caught by cable		Hand tool accident
	Stepping on hail etc.		Vehicle / Mobile plant accident
	Handling without machinery		Machinery operation accident
	Crushing / burying		Other (please specify)
	Drowning or asphyxiation		

Agent Involved in Accident

	Machinery		Excavation / underground working
	Portable power appliance		Floor, ground, stairs or any working, surface
	Vehicle or associated equipment / machinery		Ladder
	Material being handled, used or stored		Scaffolding/gondola
	Gas, vpour, dust, fume or oxygen		Construction formwork, shuttering and falsework
	Hand tools		Electricity supply cable, wiring switchboard and associated equipment
	Floor edge		Nail, sllnter or chipping
	Floor opening		Other (Please specify)
	Left shaft		
	Stair edge		

Unsafe Action Relevant to the Accident

	Operating without authority		Failure to use proper footwear
	Failure to secure objects		Failure to use eye protector
	Making safety devices inoperative		Failure to use respirator
	Working on moving or dangerous equipment		Failure to use proper clothing
	Using un-safety equipment		Failure to use warn others or given proper signals
	Adopting unsafe position or posture		Horseplay
	Operating or working at unsafe speed		No unsafe action
	Unsafe loading, Placing, mixing		Others (please specify)

	etc.		
	Failure to use helmet		

	No Protective gear		Unsafe layout of job, traffic etc.
	Defective protective gear		Unsafe process of job methods
	Improper dress / footwear		Poor housekeeping
	Improper guarding		Lack of warming system
	Improper ventilation		Defective tool, machinery or materials
	Improper illumination		No unsafe condition
	Improper procedure		Others (please specify)

Personal Factor Relevant to the Accident

	Incorrect attitude / motive		Unsafe act by another person
	Lack of knowledge or skill		No unsafe personal factor
	Physical defects		Other (please specify)

Remark

Submitted	**Checked**	**Approved**
Signature ………………	Signature …………………..	Signature ………………..
Name …………………	Name ……………………..	Name ……………………..
Designation ………….	Designation ……………….	Designation ……………..
Contractor	Environmental engineer. Construction Supervision Consultant	In-charge Officer (PIU)

ANNEXURE 8.9

POLLUTION MONITORING

Construction site location ____
Construction Stage: Report – Date: __________Month _______Year________
Mitigation measures suggested in last report complied or Not……………………………………………….
If not reasons thereof……………………………………………………………………………………….
(Location at which monitoring to be conducted as per EMP)

Sl. No.	Chainage (km)	Details of locations	Duration of monitoring	Instruments used	Completion	Monitoring Parameters	Standards	Results	Reasons for exceeding standards	Mitigation Measures suggested	Type of area (Residential / Industrial / Commercial)	Remark
1. Air Monitoring (As per National Ambient Air Quality Standards, CPCB (2009)												
		As per decision of Engineer in Charge	As per Section 8.1			$PM_{2.5}$	60 µg/m3					
						PM_{10}	100 µg/m3					
						SO_2	80 µg/m3					
						CO	02 mg/m3					
						NOx	80 µg/m3					
2. Water Monitoring (As per Drinking Water Quality Standards, IS 10500, 2012)												
		As per decision of Engineer in Charge	As per Section 8.1			pH	6.5-8.5					
						BOD	Nil					
						COD	Nil					
						TDS	500 mg/l					
						Chlorides	250 mg/l					
						Nitrates	45 mg/l					
						Sulphates	200 mg/l					
						Iron	0.3 mg/l					
						Calcium	75 mg/l					
						Lead	0.01 mg/l					
3. Soil Monitoring												
		As per decision of Engineer in Charge	As per Section 8.1			pH	<7.0 Acid 6.5–7.5 Neutral >7.5 Alkaline					
						Organic Matter	0.5 -0.75 %					
						Sodium	0-1 %					

Sl. No.	Chainage (km)	Details of locations	Duration of monitoring	Instruments used	Completion	Monitoring Parameters	Standards	Results	Reasons for exceeding standards	Mitigation Measures suggested	Type of area (Residential / Industrial / Commercial)	Remark
						Potassium	2-6 %					
						Chloride	0-1 %					
						Available Nitrogen	280-560 kg/hac					
						Phosphorous	11.5 – 24.5 kg/hac					
						Arsenic	< 20 mg/kg					
						Cadmium	< 1 mg/kg					
						Mercury	< 1 mg/kg					
						Lead	< 35 mg/kg					
						Electric Conductivity	0.0-2.0 Non Saline 4.1-8.0 Saline 16.0 Strongly Saline					
4. Noise Monitoring (As per National Ambient Noise Standards, CPCB												
		As per decision of Engineer in Charge	As per Section 8.1			L_{day}	Residential-55 dB(A) Commercial-65 dB(A)					
						L_{night}	Residential-45 dB(A) Commercial-55 dB(A)					
Remark												

Submitted
Signature ………………
Name …………………
Designation ………….
Contractor

Checked
Signature …………………..
Name ………………………
Environmental Engineer of
Construction Supervision Consultant

Approved
Signature …………………
Name …………………….
In-charge Officer (PIU)

ANNEXURE 8.10

Format for Vibration monitoring

Construction site location ____
Construction Stage: Report – Date: __________Month _______Year________
Mitigation measures suggested in last report complied or Not…………………………………………………
If not reasons thereof…………………………………………………………………………………………
(Location at which monitoring to be conducted as per EMP)

	Format for Vibration monitoring								
Sampling code	**Location**	**Date**	**Start Time**	**Stop Time**	**Vibration level (PPV in mm/s)**	**Latitude**	**Standard**	**Longitude**	**Remarks**
1							DGMS (Directorate General of Mines and Safety)		
2									
3									

Submitted
Signature ………………
Name …………………
Designation ………….
Contractor

Checked
Signature …………………..
Name ……………………..
Environmental Engineer of
Construction Supervision Consultant

Approved
Signature ………………..
Name ……………………..
In-charge Officer (PIU)

ANNEXURE 8.11

RESTORATION OF CONSTRUCTION SITES
(To be filled by the Contractor)

Construction site location ____
(Reporting by Contractor to PIU)
Construction stage: Monthly Report – Date ………Month ………Year.

Sl. No.	Contract Package	Labor Camp		Construction Camp		Plant Site		Disposal Locations		Top Soil	
		O	R	O	R	O	R	O	R	Preserved	Restored

Remark

Submitted	Checked	Approved
Signature ………………	Signature …………………..	Signature …………………
Name ………………….	Name ……………………..	Name ……………………..
Designation ………….	Designation ……………….	Designation ……………..
Contractor	Environmental engineer of Construction Supervision Consultant	In-charge Officer (PIU)

ANNEXURE 8.12

FORMAT FOR KEEPING RECORDS OF CONSENT OBTAINED BY CONTRACTOR

Construction site location ______________________
Construction Stage: Report – Date: __________Month_______ Year________

Sl. No.	Contractor's Name	Clearance	Applicable Acts	Agencies	Obtained on	Valid up to	Remarks
	Construction site location						

Remark

Submitted	Checked	Approved
Signature ………………	Signature …………………..	Signature …………………
Name …………………	Name ……………………..	Name ……………………..
Designation ………….	Designation ……………….	Designation ……………..
Contractor	Environmental engineer of Construction Supervision Consultant	In-charge Officer (PIU)

ANNEXURE 8.13

CHECKLIST FOR ENVIRONMENT INSPECTION
(Points / Issues to be covered)

Construction site location ____________________

Date of Inspection_________________

S. No.	ESMP Measures
1	Provision of a personnel accountable for implementation of ESMP / Safety Measures with Contractor
2	Consent of PCB to Establish Batching Plant
3	Consent of PCB to operate Batching Plant
4	Compliance of PCB Conditions for Batching Plant installation and operation
5	Whether compliance reported through monthly Progress report to In-Charge (PIU)
6	PUC taken for all Construction vehicles
7	Concrete platform with trap under bitumen boiler, Fuel Tank for Batching Plant and generator set provided or not
8	Precautions to prevent contamination of soil by emulsion, oil and lubricant taken while storing
9	Providing cover to fine construction material & bituminous mix during transportation
10	Muck /debris disposal:
	a) Present status of land
	b) Closure and completion plan
11	Site specific traffic Safety management Plan:
	a) Contractor installed the warning / regulatory Traffic signs at the construction site
	b) The arrangement adequate
12	Safety equipment i.e helmet, gloves, gumboot, mask, earplugs etc. provided to workers
13	Health Facility at camp and work site i.e. First Aid kit & suitable vehicle for conveyance in case of emergency / accident
14	Permit for Procuring River sand
15	Licence from Department of mines for quarrying
16	Consent to establish / operation of crusher
17	Provision of labour camp with sanitation & potable water
18	Fire precautions at Plant and site Office
19	Air and noise monitoring done in camp site
20	Whether any cultural property is being impacted
21	Status of drainage provision in camp area
22	General House Keeping

Remarks:……………………………………………………………..

Submitted	**Checked**	**Approved**
Signature ………………	Signature …………………..	Signature …………
Name ………………….	Name ……………………..	Name …………………
Designation …………..	Designation ………………..	Designation …………
Contractor	Environmental engineer of Construction Supervision Consultant	In-charge Officer (PIU)

ANNEXURE 8.14

SUMMARY SHEET
(To be filled monthly by supervisory staff and Submitted to HO, Maha-Metro, Pune)

Construction site location ___________________________
Month__________________________________Date__________________________________

S No.	Description	Remarks
1	***No Objection Certificate***	
A	Cement Batching Plant	
	Location 1	
	Location 2	
	Location 3	
2	***Pollution Under Certificate***	
	Vehicles	
	Machineries	
3	**No Objection Certificate for Diesel Gen set**	
	Location 1	
	Location 2	
4	**Labour Camps**	
	No. of sites Identified	
	Approved	
	Opened	
	Conforms to conditions imposed at the time of opening of sites	
	Closed	
5	***Workers***	
	No of workers employed	
	No of male workers	
	No of female workers	
	No of day workers	
6	**Borrow Area**	
	No. of sites identified	
	Approved	
	Opened	
	Quantity of available material	
	Quantity of material Utilized	
	Quantity of Topsoil preserved	
	Quantity of top soil used	
	No of sites closed	
	No. of sites Rehabilitated	
7	**Quarry**	
	No. of sites identified	
	Approved	
	Opened	
	Material available	
	Material obtained	
	No. of sites Rehabilitated	

S No.	Description	Remarks
8	**Disposal Locations**	
	No. of sites identified	
	Approved	
	Opened	
	Amount of Waste disposed	
	Type of waste disposed	
	No. of sites Rehabilitated	
9	**Road Safety**	
	Road Safety norms and approved Traffic plan	
10	**Cleaning of Culvert/ drains**	
	No. of culverts/ drains	
	Nos Cleaned	
11	**Trees**	
	No of trees marked for cutting in field	
	No of trees cut	
	No of trees to be Planted	
	Trees Planted	
12	**Haul Roads**	
	Adequacy of maintenance of Haul Road Network	

Remarks:………………………………………………….

Submitted	**Checked**	**Approved**
Signature ……………	Signature …………………..	Signature …………………
Name ……………..	Name ……………………..	Name ……………………..
Designation …………	Designation ……………….	Designation ………………
Contractor	Environmental engineer of Construction Supervision Consultant	In-charge Officer (PIU)