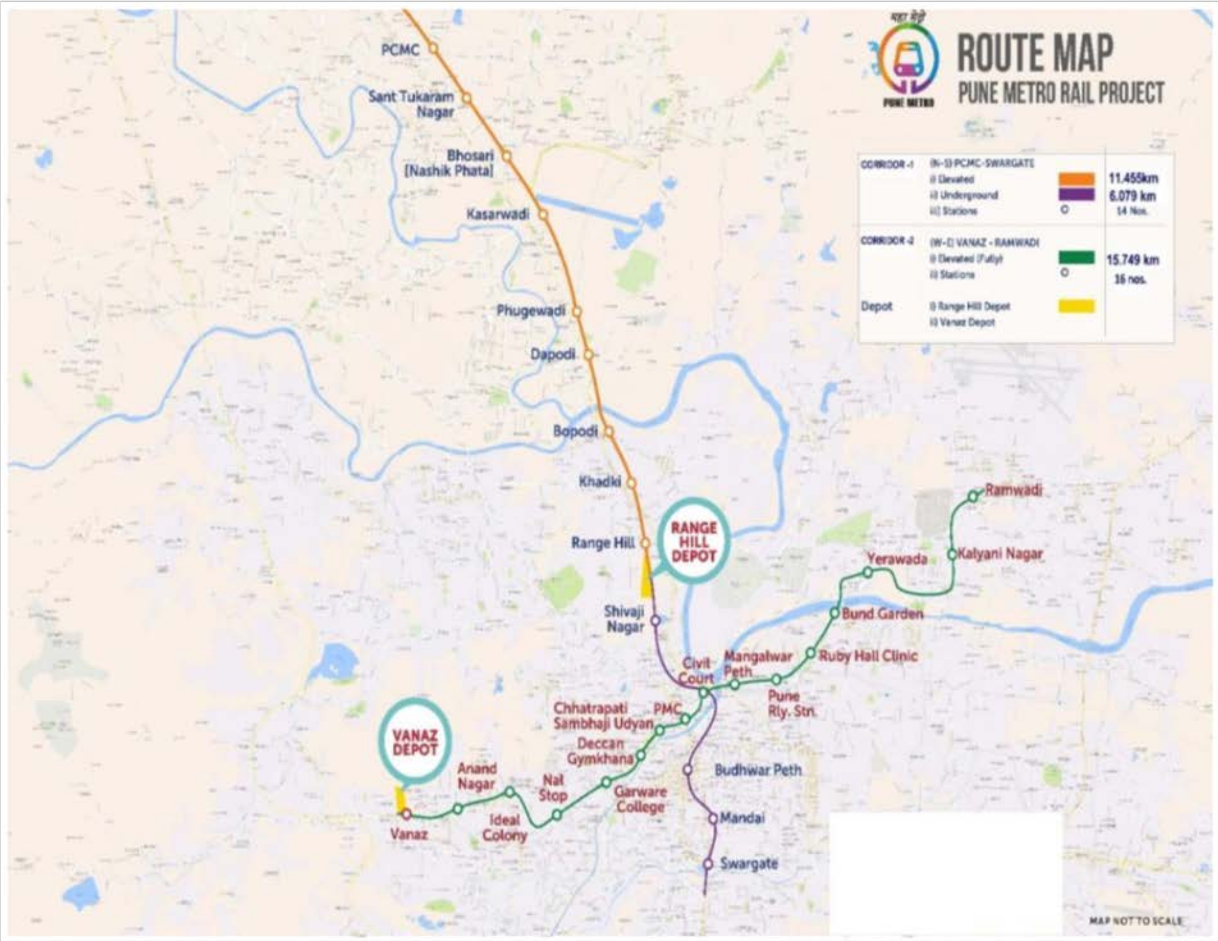
Environmental and Social Impact Assessment (ESIA) and Environmental and Social Management Plan (ESMP) for both the corridors (North-South and East-West) of Pune Metro Rail Project



(May -2022)

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List of document update & submission:

SNo.	Document	Submitted to AFD /EIB	Comments Received AFD /EIB	Remarks
1.	1st Revision	16th January,18	January,18	Updated
2.	2nd Revision	11th Feb,2018	-	Updated
3.	3rd Revision	5th April,2018	-	Updated
4.	4th Revision	17th May,2018	-	Updated
5.	5th Revision	20th March,2019	-	Updated
6.	6th Revision	2nd July,2019	16th July,2019	Updated & Reoganized the entire Report
7.	7th Revision	28th Sept,2019	7th October,2019	Comments incorporated
8.	8th Revision	24th May,2022	24th May,2022	Submitted

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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

Executive Summary

1. INTRODUCTION

Maharashtra Metro Rail Corporation Ltd intends to develop the proposed Pune Metro Rail Project having North-South and East-West Corridors.

1.1 OBJECTIVE AND SCOPE OF THE EIA STUDY

The objective of the present 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.

The scope of work for the EIA study was issued vide letter Maha-Metro/ PMRP/P1Consul-02/2017/LOA/351/3463 dated June 03, 2017. The EIA and Hydraulic Studies of 1.45 km alignment passing parallel to Mutha River have been incorporated in this EIA report.

The scope of Environmental Impact Assessment (EIA) is to include environmental baseline, assess impacts resulting from pre-construction, construction and operation phases and propose safeguard measures for protection of the environment.

2. POLICY, LEGAL AND INSTITUTIONAL REQUIREMENTS

The Indian Acts, Rules and Notifications applicable to the proposed project are considered while preparing the EIA report. In addition to these, requirement as per the EIB Environmental and Social Handbook, December 2013 and AFDs Environmental and Social Risk Management Policy, July 2017 are also considered. As per the MOEFCC, GOI Notifications, a metro rail project does not require environmental clearance.

3. PROJECT DESCRIPTION

The Pune Metro Rail Project is consisting of two corridors (north-south and east-west) having total length of 33.283 km, 30 stations and 2 depots. The details of the corridors like stations, underground, elevated alignment etc. are presented in below table.

S. NO.	ROUTE		LENGTH IN KM		STATIONS
1.	North – South Corridor (PCMC to Swargate)	Elevated	11.455	17.534	9
		Underground	6.079		5
2.	East–West Corridor (Vanaz to Ramwadi)	Elevated		15.749	16
			TOTAL	33.283	29*

**Civil Court Metro Station - Interchange Station*

The 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 on N-S corridor of which 9 stations are elevated and 5 stations are UG. Summary of stations is given in below **Table**

Table :List of N-S Corridor Stations

S. No	Station Name	Elevated/ Underground
1	PCMC	Elevated
2	Sant Tukaram Nagar	Elevated
3	Bhosari	Elevated
4	Kasarwadi	Elevated
5	Phugewadi	Elevated
6	Dapodi	Elevated
7	Bopodi	Elevated
8	Khadki	Elevated
9	Range Hill	Elevated
10	Shivaji Nagar	Underground
11	Civil Court - Interchange Station	Underground
12	Budhwarpeth	Underground
13	Mandai	Underground
14	Swargate	Underground

The E-W 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 on E-W corridor. Summary of stations are given in below **Table**

Table:List of E-W corridor Stations

S. No	Station Name	Elevated/Underground
1	Vanaz	Elevated
2	Anand Nagar	Elevated
3	Ideal Colony	Elevated
4	Nal Stop	Elevated
5	Garware College	Elevated
6	Deccan Gymkhana	Elevated
7	Sambhaji Park	Elevated
8	PMC	Elevated
9	Civil Court	Elevated
10	Mangalwar Peth	Elevated
11	Pune Rly. Stn	Elevated
12	Ruby Hall Clinic	Elevated
13	Bund Garden	Elevated

14	Yerawada	Elevated
15	Kalyani Nagar	Elevated
16	Ramwadi	Elevated

Two depots are planned, 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 overall capital cost, at November 2015price level, works out to Rs.5333 crores for PCMC - Swargate Corridor and Rs. 2794 crores for Vanaz - Ramwadi Corridor, excluding taxes and duties, but including general charges & design charges @ 5% on all items except land.

ANALYSIS OF ALTERNATIVES

The objective of the metro was to meet traffic demand on arterial corridors while reducing congestion and ensuring minimal adverse impact. 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. The project also provides benefits in terms of savings in road infrastructure.

Garvare College to PMC section (1.45 km) of Vanaz - Ramwadi corridor has been modified by passing along the left bank of Mutha River between Garware College and Civil Court. The initial length of the metro alignment along the Mutha river bank was 1.7 Km and efforts were made to reduce the length to 1.45 km by considering the sensitivity of construction along the river bed and to reduce the environmental impact. This was achieved by reducing the 250 metre stretch from Shivaji Bridge to Dengale Bridge.

The revised alignment with 1.45 Km length enters the river bed 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 13. 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%.

In addition to above, Changes in the alignment for both the corridors have been carried out to overcome the land related issues. UG alignment was proposed where road right of way constrains elevated Metro. On balance sections the alignment is elevated which requires less energy, water and cost.

4. Environmental Baseline Data

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

4.1 Land Environment

Physiography: The city is situated at the confluence of the rivers Mula and Mutha; and falls in Haveli Sub Division of Pune District with an average altitude of 560 meters above msl.

Geology and Minerals: The district forms part of Western Ghat and Deccan Plateau. The basalt is a predominant rock formation of the district under Deccan Traps. No minerals are available in and around the project area.

Soils: In the Pune City black soils are predominant. Soil samples were collected from 12 locations and it is found that the soils are slightly alkaline; electrical conductivity shows the project area as non saline nature. Over all soil quality data reveal that soil is deficient in Nitrogen, Phosphorous and sulphur. Growing of local (native) plant species is required for greenbelt development to improve the soil quality.

Land Use Pattern: The land use of 5 km on either side of the project corridors has been identified, which states that the built-up area is 64.70%, forest area 4.6%, water body 2.1%, agricultural and plantation land 8.4% for PCMC – Swargate corridor; and built-up area is 58.5%, forest area 8.7%, water body 1.8%, agricultural and plantation land 9.1% for Vanaz – Ramwadi corridor.

Seismicity: The proposed project corridors in Pune City fall in Zone III as per revised seismic zoning map of India.

4.2 Water Environment

Water Resources of the District: The water of the Mutha River from the Khadakwasla reservoir is used by PMC for water supply in Pune City. Water is supplied to different parts of the city through a network of pumping stations and pipelines. Existing water treatment plants are sufficient till year 2031. Ground water in Pune City is categorized as safe as per CGWB data.

Drainage: Mula Mutha River system is the major source of drainage system along the corridors.

Water Quality: Testing of water samples collected from 11 locations including surface and ground water samples. 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. Most of the parameters are within the tolerance limits in all the samples.

4.3 Ambient Environment

Climate: Summer months are from March to May and 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. 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.

Air Quality: Air quality monitoring was carried out at 33 locations which include stations, depot and casting yard, the air quality monitoring results indicate that PM10 & PM2.5 exceeding the permissible limits for residential, Industrial and Sensitive areas at all locations and CO is exceeding the permissible limits at some locations. Parameters SO2 and NO2 were noted within the permissible limits. Road suspended dust and vehicle emissions are the major sources of pollution.

Noise Environment: Noise level survey was carried out at all air quality monitoring locations as discussed above. From the results, it is observed 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.

Vibration: Vibration monitoring was carried out at 15 locations (8 locations on PCMC - Swargate alignment and 7 locations on Vanaj - Ramwadi alignment) for 24 hr at each location. Vibration levels varies from 0.53 to 0.9 mm/s at 14 locations and levels were higher ie 3.5 mm/sec at harris bridge. The vibration levels are predominantly due to the road traffic.

4.4 Ecological Environment

The vegetation pattern of the city is conducive almost for all types of tropical species. 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. 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. No National Parks, Wildlife Sanctuary and Biosphere reserve etc are found within 5 km on either side of the metro corridors.

4.5 Sensitive Receptors

The sensitive receptors were reported corridor wise. 23 sensitive receptors are identified, out of which 9 receptors are on elevated section and remaining are on UG section.

Archaeological Monuments: The proposed corridors are passing near three archaeological monuments. The distance of these monuments vary from 116 m to 178 m from the alignment and the metro corridors near the monuments fall in regulated area. Prior approval is required for construction activities in regulated area of these monuments from Archaeological Survey of India.

Heritage Buildings, Heritage Precincts and Natural Features: District and Sessions Court and City Post of Grade I List of Heritage assets 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.

4.6 Socio-Economic Profile & Rehablitation of Kamgar Putla & Rajiv Gandhi Nagar slums

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. 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%.

Total land requirement for both the corridors is 43.93 hectares. Out of this, 42.98 ha is Government land and balance 0.95 ha are private land. Ownership wise details of the land is given in below tables.

S.N	Ownership of the land	Area of Land (in ha)
1.	GoM	20.27
2.	PMC	16.71
3.	PCMC	2.21
4.	PMPL	0.01
5.	Railway	0.18
6.	Defence	3.47
7.	All India Radio	0.13
8.	Pvt land (Cor1 +Cor2)	0.95
Total		**43.93**

As per original plan total 688 families was affected permanently due to the N-S and W-E corridor. Out of the total 688 families, 628 are Non-Title Holders (NTH) and the 60 are Title Holders (TH). The details of the original PAF is presented in below table.

S.No.	Name of Location	Category of PAF		
		Title Holder	Non-Title Holder	Total
1.	Deccan Corner	0	28	28
2.	Ideal Colony	0	30	30
3.	Kaamgar Putla	0	132	132
4.	Nashik Phata	0	4	4
5.	Khadki	0	6	6
6.	Nal Stop	0	5	5

7.	Phugewadi	0	4	4
8.	Rajiv Nagar/Juna Topkhana	10	92	102
9.	Budhwarpeth	22	89	111
10.	Mandai	28	86	114
11.	Agriculture collage	0	33	33
12.	Shivaji Nagar Bus Stop	0	32	32
13.	Swargate	0	87	87
	Total	**60**	**628**	**688**

The Civil court area, to be developed as a multimodal integration hub wherein 2 lines of Maha Metro are interconnecting with the overhead and underground stations. The third line of PMRDA starting from Hinjewadi also culminates at Civil Court area. PMC will widen the roads for additional traffic load and the interconnectivity of the stations. The development of this area is being undertaken by these independent agencies as per their priority and timelines.

The original RAP report submitted in 2019 indicated that the Metro footprint on Kamgar Putla and Rajiv Gandhi Nagar slums was likely to affect about 234 families which is now 274 Subsequently, it was decided by the Govt. of Maharashtra that entire area of Kamgar Putla and Rajiv Gandhi Nagar is required for infrastructural development by multiple stakeholder's i.e., Pune Municipal Corporation (PMC), Pune Metropolitan Region Development Authority (PMRDA), Slum Rehabilitation Authority and Maha Metro. Due to involvement of Multiple Stake Holders at Kamgar Putla & Rajiv Gandhi Nagar a unified Rehabilitation policy was adopted by Divisional Commissioner, Pune who is the administrative head of Pune and thus the approved resettlement policy framework (RPF) and RAP of Maha-Metro could not be implemented to the letter.

Due to development of entire area of Kamgar Putla and Rajiv Gandhi Nagar by different stakeholders, the Slum Rehabilitation Authority was assigned the task for conducting the survey to determine the number of families residing in Rajiv Gandhi Nagar and Kamgarputla slums.

Upon completion of survey, it was concluded that that 1264 families are residing in this area. These 1264 families to be rehabilitated by the three agencies and share of rehabilitation had been duly allocated i.e. Maha Metro -274, PMRDA -114, PMC -322 while another 554 families (distributed among all stake holders) directly not being affected but would be impacted by the other development facilities for the commuters and need to be rehabilitated. Maha-Metro footprint is only impacting 274 families at Kamgar Putla and Rajiv Gandhi Nagar slums hence the no. of PAF get revised.

The details of the revised PAFs are presented in below table.

S.No.	**Location**	**PAFs**	**PAPs**	**Remarks**

1.	Deccan	15	60	Out of 28 only 15 PAFs are getting impacted
2.	Shivaji Nagar	32	157	-
3.	Swargate	87	257	-
4.	Agri. College	33	130	-
5.	Mandai-Residential and Commercial	50 113	220	-
6.	Kaamgar Putla & Rajiv Gandhi Nagar	274	1370	
7.	Khadki	0	0	No impact due to reduction in land requirement.
8.	Budhwarpeth	2	10	Due to relocation of the Budhwarpeth station into defunct Dado ji Kondev school building, the no. of PAF has drastically reduced from earlier 111 to 2
9.	Ideal Colony	0	0	No impact due to change in design
10	Nashik Phata	0	0	No impact due to change in design
10.	Nal Stop	0	0	No impact due to change in design
11.	Phugewadi	0	0	No impact due to change in design
Total		**606**	**2769**	

After Revision in PAFs numbers, Shri Nitin Udhaas, Dy. Commissioner, PMC (Zone 2) was appointed vide letter 05.07.2019 and 1.10.2020 as the Competent Authority for SRA to undertake this assignment and to determine the eligibility of the families.

The Competent Authority initiated the process of survey in January 2020 and the residents were asked to submit their documents to the SRA office for verification, but the families has not came forward till October 2020. Then Rajiv Gandhi Nagar slum dwellers came forward with their papers to initiate the eligibility process.

Subsequently, a series of meetings were held among the various stake holders PMC, PMRDA and Maha Metro and the residents of Kamgar Putla and Rajiv Gandhi Nagar were informed that the entire area under survey No 806, 806A, 807, 808, 809 and 810 is required by the State Govt. for development work of Khardi to Shiveni – D.P. (Development Plan) Road, Red line and blue line of Irrigation Department, Maha Metro and PMRDA lines. This was communicated to all the individual slum dwellers residing in the said slum areas vide letter no. 4213 dated 01.01.2021 and signed by Maha-Metro, PMRDA, PMC, SRA and Divisional Commissioner.

In the same letter it was clarified by the Competent Authority that there is no possibility for in situ rehabilitation. The families residing on the said premises, on meeting the eligibility criteria would be entitled to ready to move in residential units at Viman Nagar or Hadapsar. Location of other houses available with SRA /PMC schemes was also shared but those were rejected by the families in favour of Viman Nagar and Hadapsar. Initially, the SRA cut-off date was 1.1.2000 but this was extended up to 23.12.2016 (Metro cut-off date) on humanitarian grounds to accommodate more residents under the benefit which is in line with the definition of “Cut-off date” defined in World Bank Guidelines on Environment and Social Impact.

Fixing Eligibility of Affected Families:

To fix the eligibility criteria, proof of residence like Aadhaar card, gas bills, ration cards, water bills, and electricity bills etc. prior to Metro cut-off date was required. As per SRA Minimum three documents were necessary to establish proof of residence. In some cases, marriage cards and vaccination certificates were also accepted as proof of same.

Out of 1264 families, 1063 (84%) families had met the eligibility criteria and were entitled to housing facilities. As per directive of the Divisional Commissioner, Pune, all eligible families were to be given the same benefits since any discrimination in benefits would evidently lead to chaos, unrest and even create a law-and-order situation.

After fixing the eligibility, the Competent Authority on 24.03.2021 published a public notice in newspapers Lokmat Daily Pudari, intimating the slum dwellers to raise objections if any to this process.

Maha-Metro footprint is only impacting 274 families (earlier it was 234). Of these 12 are commercial units and balance 262 are residential families of the 12 commercial units, 10 have collected compensation while 2 have been rejected. The rejection for commercial units was on inadequate papers in one case and Family had claimed a housing unit in another scheme. Out of these 262 families, 26 families have been rejected due to the reasons mentioned in the below.

- 4 Families claimed in other scheme and not eligible under current R&R Scheme.
- 14 Families already received one unit in current R&R Scheme,
- 4 Families - No claim was submitted,
- 2 Families are unable to provide proof of residence prior to cut off date.
- 1 Family has to establish their legal heir,
- 1 Family submitted fake claim

Grievance Redressal Mechanism:

A grievance redressal mechanism is in place for the aggrieved families with reference to disagreement regarding their eligibility. These affected families had the option of meeting the Competent Authority of SRA (Slum Rehabilitation Authority) for confirming their eligibility. In case of dispute, they could prefer a first appeal to SRA; then a second appeal to the Divisional Commissioners Office; then the district court at Pune and subsequently the Bombay High Court. Some of the residents approached the Bombay High court and District court pertaining to this rehabilitation process and honorable court has observed that joint action of rehabilitation taken up by SRA, PMRDA, PMC and Maha-Metro has been strictly according to due process of law.

Allotment Process:

On 24.03.2021, the Competent Authority published a notice in the newspapers Lokmat Daily Pundari, intimating the slum dwellers to raise objections if any by 26.03.2021. Since the families meeting the eligibility criteria were entitled to drawing lottery for the allocation of apartments. This process of lottery was initiated on 31.03.2021. It was also intimated that the final list of allottees would be published on 01.04.2021.

Special camps were arranged in the vicinity of Civil Court for registration of Sale Agreements between SRA and joint ownership of husband and wife of the rehabilitated family. Those families who completed the registration formalities were handed out the keys of the new flats at Viman Nagar / Hadapsar. The families were provided the actual transportation cost from Civil Court to Viman Nagar /Hadapsar.

Clearing the Kamgar Putla and Rajiv Gandhi Nagar Land Parcel:

After availing all legal recourse by the affected families, the process for vacating the area was initiated. Accordingly, intimation was sent to individuals and notices were published in the newspapers. It was posted at all prominent places in the area, informing the residents that the area will be cleared out. Announcements were made over microphone so residents who had failed to read these notices are aware that on the given date and time demolition activity will be undertaken and they are requested to take their belongings and move away from the area. The eligible slum dwellers already had tenements allotted to them with proper registration of sale deeds. This process has been underway since March 2021 and affected families had been given sufficient time to vacate the land.

PMC officers with support of man and machinery provided by Maha Metro undertook the evacuation process. In order to avoid any law-and-order problem district administration had provided adequate police protection which included female police personnel. The slum dwellers were treated with utmost dignity and there was no instance of man handling. The belongings of the non-eligible residents were packed and a Panchama (i.e., a list) is written covering the details of the items packed. This is signed by the resident and the PMC officer before being moved to a warehouse from where it can be collected on showing of valid document.

Kamgar Putla & Rajiv Gandhi Nagar land parcel and its Utilization by Stakeholders:

Kamgar Putla land is 7135.927 sq. meters and belongs to Govt. of Maharashtra (Pune District Soldier, Sailor and Airmen Board). There are 651 families living on these premises. Metro footprint on this area is 1114 sq.m i.e. 15.61% of the total area and impacts 59 families living in this area. The total Area for Rajiv Gandhi Nagar is 13433.513 sq.m. and belongs to Pune Municipal Corporation (PMC). Besides the PMC land this land parcel comprises three private land holdings measuring a total of 3731.05 Sq.m. In this case Metro impact is about 49% of the land which is inclusive of the private land holdings and affecting 215 families. The land details and their distribution among stakeholders are presented in below Table .

Table : Area Requirement by different stakeholders

S. No.	Description	Area in S.Q.M	Remarks
Kamgar Putla			
1.	Maha-Metro Corridor-2	917.011	Govt land
2.	PMRDA Line-3	1462.484	Govt land
3.	Maha-Metro and PMRDA Combined	393.966	Govt land
4.	MMI and Public Conveniences	3838.103	Govt land
5.	Area for PMC DP Road	524.363	Govt land
Total		7135.927	Govt land
Rajiv Gandhi Nagar			
6.	Maha-Metro Corridor-2	2096.212	Govt land
7.	FP807B/1&2 Maha-Metro	1171.29	*Private Land
8.	FP808 Maha-Metro	2225.76	**Private Land
9.	CTS 20 Maha-Metro	334	***Private Land
10.	Maha-Metro + PMC DP Road Combined	774.623	Govt land
11.	Area for PMC DP Road	6831.628	Govt land
Total		13433.513	Govt +Private land

*Private land 807 B1&2 is owned by several owners; family has dispute on ownership and the matter is under discussion for procurement.
**Private land owned by Mr. Pathan has been negotiated privately and acquired By Maha Metro.
***Private land -CTS 20 is owned by Mr. Bairagi. Discussions are underway for procurement of property.

4.7 Public Consultations

Project level consultations with local people were held at various places along the proposed metro corridors. Major findings of public consultations are adequate compensations, widening of roads, and reduction in pollution levels etc.

Further, the rehabilitation of Kamgar Putla & Rajiv Gandhi Nagar slums involves multi stakeholder i.e., Maha-Metro, PMRDA, PMC and SRA therefore it became a complex issue. To deal with this issue, the Competent Authority and his team had several interactions with the project affected families at their residence/office and at the relocation sites of Hadapsar and Viman Nagar. Photographs of such consultation are given in below Figure.

Figure : SRA consultation with Community Members at his office and impacted site


5. ENVIRONMENTAL IMPACTS

5.1 Impacts due to Project Location

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 no forest land is required for the proposed project corridors.

Impact on Ecological Environment:

As per initial assessment it was estimated that 1125 trees likely to be impacted in N-S and E-W corridors and Depots. During execution and detail investigation, verification at ground it was established that total 2452 trees impacted (includes 188 felled trees). The impacted tree numbers has gone up due to change in alignment (to avoid the Agan Khan Palace) increase in alignment length various other R&R and design factors. Further impact on trees are not envisaged.

Majority no. of impacted trees to be transplanted at various locations of the City whereas some of the trees felled due to non feasibility of transplantation viz. age, safety concerns. Location wise details of transplanted and felled trees are presented in below table :

Sr. No.	Project site including Stations	Trees Felled	Trees Transplanted	Transplantation Site
1.	Reach -1 (PCMC- Range Hill)	0	443	Kasarwadi STP
2.	Reach -2 (Vanaz-Civil Court) i.e.	7	158	Forest Area ARAI
3.	Reach- 3 (Civil court-Ramwadi) i.e.	17	427	Dr.Salim Ali Bird Sanctuary, Bund Garden. Nagar Road
4.	(Reach-4) – Swargate,Civil Court,Shivajinagar,Mandai	164	569	Arey Dairy Bus Stand, Range Hill & Taljai Forest Area, Alandi MSRTC Bus

Sr. No.	Project site including Stations	Trees Felled	Trees Transplanted	Transplantation Site
	,Budhwar Peth and Are Dairy			Depot, Survey No.01Taljai & Survey No. 69, Dhanori & Range Hill/Command Hospital
5.	Range Hill Depot	0	506	Agriculture College, Range Hill-KCB
6.	Vanaz Depot	0	161	Vanaz Kachara Depot, ARAI
Grand Total		**188 +**	**2264**	**= 2452**

Further, Location wise details of felled trees are as below.

S.No.	Locations	Trees to be felled
1.	Budhwar Peth	10
2.	Mandai	7
3.	Shivaji Nagar	10
4.	Civil Court	13
5.	Are Dairy	123
6.	Swargate	1
7.	Garware College	7
8.	Mangalwar Peth	9
9.	Ruby Hall	7
10.	Kalyani Nagar	1
Total		**188**

Utility/Drainage Problems: The alignment will cross drains, large number of sub-surface, surface and utility services. These utilities/ services are essential and have to be maintained in working order during different stages of construction. Plans and cost of such diversions are covered in the section on Civil Engineering.

Impact on Archaeological Monuments/ Heritage Sites: No Archaeological Monuments / Heritage structures are affected due to the proposed metro rail project.

5.2 Impacts due to Project Design

Right of Way: The space at ground level and above can continue to be used for roads and light structures and visual intrusion will be minimized for UG section. Visually less-intrusive viaduct and stations can be constructed subject to construction cost.

Alignment, Stations, Track design and Architecture: An alignment with less number of curves and radius, optimal station spacing, track with elastic fittings result in decrease in energy consumption, wear & tear and noise & vibration.

Inter Modal Integration: Physical and operational integration of metro with other modes is found to increase ridership and decrease congestion inside and outside the stations.

Use of Energy at stations and depots: Consumption of energy is significantly reduced by proper design of open spaces at stations and multimodal integration facilities outside stations.

5.3 Impacts due to Project Construction

Air pollution: Particulate pollution occurs due to excavation, loading/unloading of construction materials, vehicular, construction equipment and DG sets etc. It also occurs in sites of muck disposal, debris disposal and pre-casting yards. Resulting pollution is for short term.

Noise Pollution: Noise from construction equipment (Lmax) measured at 50 feet distance ranged from 70 dB (A) to 101 dB (A), which decreases with increase in distance. The noise levels due to different activities during construction phase will be reduced to ambient noise levels at a distance of 125 m. These estimated noise levels are typical and will vary with specifications of the equipment, usage pattern etc.

Vibration Impacts and Risk to Existing Buildings: Threshold criteria for various structures are given in the report. Vibration source levels for typical construction equipment are also listed in the report.

Impact Pile Driver - PPV has been estimated conservatively (no mitigation measure along the wave propagation) at the monitored locations. At Ruby Hall, Rajeev Gandhi Hospital, Galaxy Care Hospital, Sangam Bridge and Harris Bridge predicted levels are likely to exceed permissible limits without considering any mitigation measures.

It is understood that the predicted PPV from the Impact pile driver is very higher than other type of pile drivers. Auger Displacement Piling (ADP) system offers a quick, quiet and virtually vibration free alternative to driven type piles. Hence, Impact Piles should be used in case of hard rock only and for other areas Auger displacement piling system should be used.

Tunnel Boring Machine - consists of a large rotating cutting wheel in front of large metal cylinder(s). Predicted PPV attenuates from the source location to permissible levels at all monitored locations without considering any mitigation measures. However, prior building condition survey should be taken up before commencing the TBM operation.

Controlled Blasting - These operations may have to be carried out to excavate for certain underground stations close to important buildings, old and sensitive structures. Modeling result at all locations infers that vibration level significantly within the permissible limits of Director General of Mine Safety (DGMS). Further, all the buildings/structures in the vicinity to excavation site should be surveyed carefully, as precautionary measure to assess the type and condition of structures. 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.

Impact due to Muck Disposal: Construction activities will result in excavation of about 7.50 lakh cum and fill of about 1.35 lakh cum with net quantity to be disposed of about 6.15 lakh cum. Muck disposal if not properly done can result in air and water pollution, noise, diversion of green parks and temporary displacement.

Impact due to Hazardous Waste: Hazardous waste would mainly arise from the maintenance of equipment. Unsafe disposal can result in water and soil pollution.

Increased Water Demand: The water demand is estimated to be 498 kilolitres per day (kld) for construction activities.

Impact on Water Quality: Ground water contamination can take place if sewage at labour camps or chemical 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.

Soil Erosion and land subsidence: Run off from unprotected excavated areas can result in excessive soil erosion.

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

Impact on Associated Facilities: Currently about 300,000 vehicles are added annually to Pune City which have a negative impact on the health of the Pune residents due to noise and air pollution besides the traffic congestion. Pune Municipal Corporation intends to substantially reduce this number of private vehicles by providing a reliable and efficient transport support. Pune Municipal Corporation is supporting the use of Metro by providing

- 200 feeder buses for metro stations.
- Reducing Public parking space by 10% and introducing telescopic parking charges.
- 3 bus depots will be provided by PMC for feeder buses.

Impacts due to Labour Camps: Improper disposal of municipal solid waste generated by labour camps can pollute surface water bodies and groundwater. The water requirement at labour camp is the responsibility of the contractor. Construction workers are more prone to infectious diseases due to unsafe sexual activity and lack of sanitation facilities and insect vectors. Problems could arise due to cultural differences between workers from outside and local residents.

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

5.4 Impacts due to Project Operation

Noise Pollution: Effect of predicted day-time noise level has low impact with respect to the existing ambient noise environment. The predicted noise levels at a distance of 15 m due to metro operation are within the permissible limits for commercial zone.

Vibration: Passing of trains on elevated section as well as underground section causes vibrations. The dominant component of vibration due to passing on elevated section is horizontal while in tunnel vertical component is dominant. The resultant magnitude of PPV at all receptors locations are predicted to be within vibration damage threshold criteria under non-conservative conditions.

Water Supply, Waste Water and municipal solid waste disposal at Stations: The water demand at all stations will be 551 KLD, Waste water generation will be 496 KLD and Solid Waste generation will be 100 gram/passenger/day. The water demand during operation phase will be supplied by Pune Municipal Corporation.

5.5 Impacts due to Depot

Impacts identified due to depot are loss of trees, impact on surface drainage, noise pollution, oil pollution, sewage and effluent. Management plans are proposed for these impacts.

6 POSITIVE ENVIRONMENTAL IMPACTS

Employment Opportunities: In operation phase, about 1100 people will be employed for operation and maintenance of the system. Thus, the project would provide substantial direct employment and consequent indirect employment.

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

Direct Benefits to Passengers: The project will result in direct benefits to users of Metro like 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.

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

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.

Reduced Air Pollution: The operation of metro will reduce generation of CO, PM, HC & NOx and CO2; which will reduce the health impacts along with reduction in cost of carbon capture.

Carbon Credits: These are estimated based on the reduction in the road traffic and corresponding reduction in the CO2 emissions after accounting for the CO2 emission due to grid power with due consideration to regenerative breaking system.

7.Additional EIA and Hydraulics Studies of Mula Mutha River

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. In response to National Green Tribunal (NGT), Maha Metro Pune carried out the EIA studies and hydraulic studies for the 1.45 km stretch.

The flow in Mutha River has two sources, the first and major source is water released from the Khadakwasla Dam (20 km u/s of study area) during high rainfall days. Additional flow joins the river through small tributaries on the downstream side of Khadakwasla dam; these contribute less than 10% to the flow. Blue line and Red line of Mutha River are decided by the irrigation Department on discharge of 60000 cusecs and 100,000 cusecs respectively.

Hydrology of Mutha River has been studied by using historical data of 75 years and observed that the river has mainly two flows. Flow during entire non-monsoon season is very low, almost close to the environmental flow and through waste water generated from residential area. The second is Higher River flows are released through the Khadakwasla dam on very few occasions of heavy rainfall in the catchments of dam. Such flow may last for only one to four days at one occasion and they are also spread widely apart.

There will be no significant adverse flow -structure interaction. That means the metro piers will have no adverse action on the flow and vice versa. At any cross section of the river, the area blocked by the width of a single pier is negligible compared to the cross -sectional area of river. Major obstruction is generated when bridges with multiple large-size bridge piers for multiple spans 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 - Bridge) and Baba Bhide Bridge. However, proposed metro rail alignment is parallel to river and along blue and red line only on the left bank of the river envisages non-significant impacts. The bridge pears as well as the foundation 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 by filling up the hole by large stones.

Due to orientation locations and shape of piers minimum impacts are predicted even for discharge higher than 60,000 cusecs. Discharge data obtained from Irrigation department depicts that, in seventy years time span, only on 12 occasion discharge of water recorded more than 60,000 cusecs.

With reference to Geology, the Vertical Electrical Sounding (VES) shows that the strata below soil are not favorable to form aquifer. However unconfined aquifer reported from project area has poor potential. It is envisaged that construction of Piers on the bank are not likely to cause significant impact on any aquifers. Natural springs are not observed in the area during the study period. Hence no adverse impacts during construction phase are envisaged on existing hydro geological condition.

With reference to water quality the findings show that the river is eutrophicated with high number of algae blooms and depleted oxygen levels which is attributed to several locations along the river length where municipal sewage is released into river through existing drainage network. It is observed that the water quality of Mutha River is polluted. Samples collected from River show the higher organic load. High BOD and COD concentration was observed.

Most of the physico-chemical parameters are found well within prescribed limits of IS 10500:2012. However, presence of Total Coliforms and E coli indicates that ground water in the study area is not suitable for drinking purpose.

It is concluded that soils in the study area are moderately fertile. Soils in the river basin are found to be fertile and with predominantly clay-loam texture. These soils are favorable to nurture herbaceous flora in the project area.

The site being influenced by winds would result in quick dispersal of the pollutants and thereby the impacts due to NOX, SO2 emissions during the construction will not be significant. The magnitude will not be high because the soil remains wet due to constant presence of water in the river, which makes it difficult to get air-born due to wind. It is estimated that during construction phase there is a likelihood of adding 39.39 µg/m3 of particulate matter to base line concentrations. Adopting mitigation measures would help in reduction of the same.

Proposed metro route is part of riverine ecosystem. This is habitat for butterfly, dragonfly /damselflies etc. Herbaceous vegetation will be disturbed due to excavation and allied activities however there are no irreversible damages to biodiversity as no rare, endangered and threatened species of flora & fauna were observed during study period. Total 15128 individual trees were recorded in the study area of 500 m around project site. The Area shows overall 309 species (Trees 196, Herbs 80 and Shrubs 33). Total 13 trees likely to be affected which will be transplanted at project site at suitable locations. Scientific methodology for transplantation shall be adopted to minimize mortality. Nine trees will be cut and compensatory afforestation shall be done at designated plantation area at Pachgaon Parvati.

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.

7A. CWPRS Mathematical Model Studies of Mutha River :

In addition to Hydraulics Studies of Mula Mutha River conducted by M/s MITCON (presented in Chapter-7) and in order to comply the NGT Expert committee recommendation a mathematical model study was also conducted by Central Water and Power Research Station, Khadakwasala, Pune and the Technical Report no. 5886 (January-2021) was submitted to Maha-Metro vide letter no. HAPT/Maha-Metro/2021-46/23 dated 22 January,2021. This study was intended to estimate the afflux for two river discharges of 60,000 ft3/s and 1,00,000 ft3/s and inundation of riverbanks caused by afflux in Mutha river due to the construction of metro pier and allied structures.

The Mathematical model of river Mutha covers a reach of about 15.0 km from Khadakwasla dam to Sangam near confluence of Mutha river with Mula river was developed using HEC-RAS 5.0.7. Simulations were carried out for the discharges of 60,000 ft3/s and 1,00,000 ft3/s to compute the water surface profiles under existing conditions (without Metro Piers) and also by incorporating the Metro piers to estimate the afflux and inundation. The summary of the CWPRS report are as below:

1. *"The maximum afflux (rise in water level) for the 100,000 ft3/s and 60,000 ft3/s due to introduction of Metro piers have been estimated as 216 mm at Metro pier no. P152 and 241 mm at pier no. DE 1 respectively.*
2. *This increase in water level results in incremental increase in inundation. Inundation is the spread of the water along both banks (i.e. left bank + right Bank).*
3. *For the discharge of 100, 000 ft3/s the incremental increase in inundation would be insignificant (0.02 m) in the reach between Shivaji Bridge and Shinde Bridge. In the reach between Shinde Bridge and Metro pier DE 8 incremental increase inundation varies between 0.02 to 10 m. Further from DE 8 to Baba Bhide bridge the incremental inundation varies from 2.6 to 10.94 m. (i.e. about 5m on either bank.)*
4. *At three locations i.e. P159, P160 and Z Bridge the inundation is 22.2 m 20.6 and 29. 8 m respectively. The incremental inundation extent 55.76 m at pier no P167 due to specific topography at this location. There is a low level cross road connecting the river front road and Kelkar road at this location. Water is spreading along this road and hence the higher inundation extent at this particular location was observed.*
5. *The incremental increase in inundation extent for 60,000 ft3/s in the reach between Shivaji Bridge and Shinde Bridge is insignificant (0 to 0.01 m). In the reach between Shinde Bridge and Metro pier DE 8 varies between 0 to 2.27 m. From DE 8 to upstream of Baba Bhide bridge is 2.27 to 11.44 m. At two locations i.e. P162 and P 163 is 10 to 11.4 m. (i.e. 5 to 5.6 m on either bank.)*
6. *The Irrigation Department has demarcated the redline for a discharge of 100,000 ft3/s and blue line for discharge of 60,000 ft3/s in year 2011.The expert committee is of the opinion that the Red line and Blue line to be redefined by the competent authority taking into account the recent developments along the river reach.*
7. *The CWPRS has also highlighted that the contribution of discharge from the local catchment downstream of the Khadakwasla dam to Sangam Bridge will only yield about 8,500 cusecs corresponding to the discharge of 90,000 cusecs. Therefore, in the worst-case scenario the total discharge will not breach 100,000 cusecs. Also, the spillway design capacity of Khadakwasla dam is 97,000 cusecs only.*

8. *The CWPRS scientist has also pointed out that in the last 56 years the discharge of 60,000 cusecs has only been breached four times and the 100,000 cusecs has not been breached even once, so scenario for breaching the 100,000 cusec discharge would be a rare.*

9. *It was referred that the Irrigation Department and the Smart City project both have robust flood alarm and evacuation system to avoid loss of life and property. The Smart City Project has already identified the flood prone locations and areas to where people will be moved in case of floods. This has been tested during the floods of 2019."*

The above mentioned report was presented to NGT Expert committee meeting held on 8th March, 2021 under the ageis of Divisional Commissoner, Pune. The copy of Minutes of the meeting and complete CWPRS Mathematical Model studies of River Mutha and add on reports has been enclosed as **Annexure-1**

8.Additional EIA Study of Revised Alignment of Reach -3 Passing Adjacent to Dr. Salim Ali Bird Sanctuary

The original DPR alignment of the Pune Metro East West Corridor was aligned along the Pune Ahmednagar Highway from Parna Kuti Yerwada Chowk. Alignment was provided in consort with the centre line of BRTS median and passing by the Aga Khan Palace (Ch:12575 to Ch:12675). The distance available from the elevated viaduct to the central core of the monument was 118.5m. Clear distance from the boundary wall of the monument to the edge of elevated viaduct was 19.80m.

According to the 2016 order issued by the Bombay High Court in response to a petition filed by the city-based NGO Parisar that construction of the Metro project should not proceed without getting permissions from the NMA. As Aga Khan Palace was declared as a Nationally Protected Monument in 2003, application for seeking NOC/permission for construction of viaduct was submitted to RD & CA on 13 April 2018 and the proposal was forwarded to National Monuments Authority (NMA) on 31 August 2018. The National Monument Authority (NMA) has rejected the permission sought by Maharashtra Metro Rail Corporation Limited (Maha-Metro) to undertake Pune Metro alignment from Civic Court to Ramwadi near Aga Khan Palace as it falls within the prohibited area of the monument. The NMA took the decision of diverted alignment in a meeting, as this section lies within the prohibited area of the Aga Khan palace. General Consultants of Maha Metro conducted feasibility studies and identified the following alignment. Starts at Ch:11015 (Gunjan Chowk), turns RHS near Garbage collection center, runs along DP road and re-joins the main alignment at Ch:13454. A small segment of this alignment runs on the median of DP road adjacent to Dr Salim Ali Bird Sanctuary. This has resulted in an increase of 920 m to the original alignment and relocation of Kalyani Nagar station

The current alternative at Gunjan Chowk diverts towards reserved land for Metro Depot and extends through median of existing DP road which is adjacent to the Dr. Salim Ali bird sanctuary.

Considering the environmental sensitivity/presence of valued environmental components around the new route alignment, EIA study has been carried out for ascertaining the direct & indirect impact on surrounding fauna & flora, including within the Bird sanctuary area, and accordingly the mitigation measures have been delineated.

8.1 Existing Environment

Proposed metro route is adjacent to riverine ecosystem. This is habitat for bird, butterfly, dragonfly/damselflies etc. The studies were conducted from December 2018 to February 2019. Primary data have been collected along proposed metro rail alignment and 500 m periphery.

Surface water quality of Mula Mutha River at four locations from Bund Garden Bridge to Kalyannagar Bridge has been estimated. Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) levels do not comply with prescribed limits specified by CPCB and Bureau of Indian Standards for different users, except all other physicochemical parameters.

The electrical conductivity was highest at Kalyaninagar Bridge (683 µS/cm) and minimum at along the Dr. Salim Ali Bird Sanctuary (514.1µS/cm). The BOD ranged from 16- 27 mg/l while the COD ranged from 58 -90 mg/.

All the sampling locations of Mula Mutha River showed low DO values varying from 1.1 to 2.1 mg/lit that indicates heavy organic pollution.

Total Alkalinity ranged from 161.6 to 185.84 mg/l. Maximum calcium level (46.49 mg/l) was found at Kalyani nagar and minimum (39.27 mg/l) at Bund garden. Total hardness ranged from 148.11 to 164.13 mg/l.

Chloride was highest at 57.79 mg/l and minimum at 42.73 mg/l. Ammonical nitrogen ranged from 0.38 to 1.96 mg/l.

Presence of Total Coliforms and E coli indicates that Mula Mutha River water is not suitable for domestic purpose. It is observed that due to direct discharge of treated and untreated sewage Mula Mutha River is organically polluted. Nutrient level present in the water favors growth of various phytoplankton, zooplankton and macrophytes.

Ambient Air Quality was monitored at four different locations including Dr. Salim Ali Bird Sanctuary area. It is concluded that concentrations of PM_{10} and $PM_{2.5}$ were at higher sides as per NAAQ standards due to vehicular pollution. However, the levels of SO_2 and NO_2 were substantially less as compared to above referred standards. Air quality inside the Dr. Salim Ali Bird Sanctuary is comparatively good.

Ambient Noise levels were monitored at five different locations including Dr. Salim Ali Bird Sanctuary. Noise levels recorded at various stations were higher than the permissible level. In the Bird Sanctuary Nosie level was almost equivalent to Ambient Air Quality standard with respect to noise.

Soil quality was monitored at 3 locations. It is concluded that soils in the study area are moderately fertile. Soils in the Dr. Salim Ali Bird Sanctuary were found to be fertile. These soils are favorable to nurture herbaceous as well arboreal flora in the project area.

The area shows diversity of vegetation, comprising species of trees 236, herbs 44, shrubs 20, and climber 12 during study period. No rare, endangered and threatened flora was recorded during the study period.

Total 105 species of bird were recorded from sanctuary and adjacent area along the Mula Mutha River. During the survey 87 species of birds were observed. Comparatively less diversity of fish eater species were recorded as turbidity of river water is higher. Good bird diversity was recorded along the river bed, islands and rocky outskirts of the river. Vegetation in this area is highly disturbed due to various anthropogenic activities and dumping of the garbage. Arboreal vegetation in the sanctuary area comprises mostly of exotic tree species. This vegetation is being used for perching and nesting site by various birds, however, some migratory bird species have also been recorded throughout the riverine habitat near Dr. Salim Ali Sanctuary area. Besides, 21 species of butterfly, 5 species of dragonfly and damselfly species were also recoded.

8.2 Impact Identification

Impact Identification and prediction on the environment due to proposed metro rail project alignment passing adjacent to Dr. Salim Ali Bird Sanctuary through Mutha River bed have been considered by assessment of baseline environmental status. Impact during the construction phase is regarded as temporary or short term, while impacts during the operational phase are considered long-term impacts.

Direct impacts on air quality and noise levels envisaged due to construction activity. The main source for impact of air quality during construction period is the fugitive dust from the activities like excavation, dumping and vehicle movement/ transportation of materials etc. The noise, to be generated during excavation, loading, unloading and transportation of material, would be in the range of 90 to 100 dB (A) and this will occur only when all the equipment's operate together and simultaneously. The workers, in general, are likely to be exposed to an equivalent noise level of 75-80 dB (A) in an 8 hour shift.

No significant impacts are envisaged on surface and ground water quality due to proposed metro rail alignment. Mobile toilet facility, sewage treatment and disposal facility are proposed during construction phase. No labor camps and casting yards are proposed in the study area including Dr. Salim Ali Bird Sanctuary.

Total 160 trees comprising of species like *Azadirachta indica* L, *Pongamia pinnata* (L.) Pierre, Tam*arindus indica* L., *Santalum album* L, *Prosopis juliflora (*Sw.) DC.,*Acacia nilotica* (L.) Delile, *Leucaena leucocephala* (Lam.) de Wit, *Ziziphus jujuba* Lam., *Carissa carandas* G.Lodd. and *Pithecellobium dulce* (Roxb.) Benth envisaged to be affected but only 106 trees has actually bee impacted which were transplanted at site vicinity.

No significant direct impacts are envisaged on bird habitat and diversity as proposed Metro rail alignment is not passing directly through the sanctuary area. It is recorded that most of the bird species uses flight route along the river. Hence due to proposed Metro rail alignment no direct impacts are envisaged on flight or route of the avifauna or any other migratory bird species. During construction phase temporary impact due to fugitive dust and generation of noise is envisaged within the project area.

8.3 **Environment Management plan**

Excavated *murum* and hard rock shall be used for backfilling and remaining quantity will be used and disposed at identified designated site. Stockpiling of excessive excavated material will be avoided. Existing road will be used for transportation. There would be minimum usage of *Kaccha* road / un-metaled road at the site 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 will be used for landscaping or plantation. Non degradable waste will be handed over to authorized agency for further treatment and disposal. Fertile top soil shall be used for plantation.

For habitat suitability of the birds, plantation of bird attracting floral species are proposed. Illegal poaching, tree cutting, trace passing, anthropogenic pressure of any kind, solid waste disposal, cattle grazing etc. will be controlled. Interdepartmental cooperation in regard with developmental activities will be sought. Compensatory plantation will be carried out in the project area and in the designated greenbelt area. The tentative compensatory plantation area is circled in yellow colour in below presented photographs:

Biodiversity awareness program will be conducted for all workers prior to construction. No labor camp shall be provided in the project area. Light control barriers are highly recommended near Sanctuary area. The noise control measures during the construction phase include provision of acoustics hoods wherever possible on the construction equipment and regular maintenance of the equipment

Budgetary provision of Rs. 179.00 Lakhs as a capital cost & Rs. 65.00 Lakhs as annual operation and maintenance cost has been made for Environment Management Plan

9.ENVIRONMENTAL MANAGEMENT PLAN

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

9.1 EMP during Location and Design

Compensatory Afforestation:

In order to conserve/Preserve trees, Maha-Metro has taken a conscious decision not to cut trees as much as possible and affected trees are being transplanted. In this regard out of 2452 impacted trees 2264 transplanted at other available location of the city while other 188 no. trees felled due to its age and safety concern. Location wise details of transplanted and new planted saplings are presented in below tables :

Sr. No.	Project site including Stations	Trees Felled	Trees Transplanted	Transplantation Site
1.	Reach -1 (PCMC- Range Hill)	0	443	Kasarwadi STP
2.	Reach -2 (Vanaz-Civil Court) i.e.	7	158	Forest Area ARAI
3.	Reach- 3 (Civil court-Ramwadi) i.e.	17	427	Dr.Salim Ali Bird Sanctuary, Bund Garden. Nagar Road
4.	(Reach-4) – Swargate,Civil Court,Shivajinagar,Mandai ,Budhwar Peth and Are Dairy	164	569	Arey Dairy Bus Stand, Range Hill & Taljai Forest Area, Alandi MSRTC Bus Depot, Survey No.01Taljai & Survey No. 69, Dhanori & Range Hill/Command Hospital
5.	Range Hill Depot	0	506	Agriculture College, Range Hill-KCB
6.	Vanaz Depot	0	161	Vanaz Kachara Depot, ARAI
Grand Total		**188 +**	**2264**	**= 2452**

Further, Location wise details of felled trees are as below.

S.No.	Locations	Trees Felled
1.	Budhwar Peth	10
2.	Mandai	7
3.	Shivaji Nagar	10
4.	Civil Court	13
5.	Are Dairy	123
6.	Swargate	1
7.	Garware College	7
8.	Mangalwar Peth	9
9.	Ruby Hall	7
10.	Kalyani Nagar	1
Total		**188**

The survival rate of transplanted trees are about 67%,.In order to maximize the survival rate of transplanted trees a well defined method statement is in place, despite that some trees have failed their survival due to other climatic factors, Hence to compensate the loss, a compensatory plantation is being done by the contractor with same species at the ratio of 1:5 and maintenance like watering, manuring, watch and ward is being done for another one year at his own cost.

In order to compensate the loss of trees,total **17,986 new saplings have been planted at various locations of the city against 2452 no. of impacted trees which is almost 8 times more and well beyond the requirement of 3 times of new plantation for each transplant/cutting mandated under local law** i.e. Maharashtra (Urban Areas) Protection & Preservation of Trees Act 1975 and Maharashtra (Urban Areas) Protection & Preservation of Trees Rules 2009. New Sapling plantations across the Pune City and major planted species are presented in below subsequent tables:

New Sapling Plantations across the Pune City

Year	Sr.	Place	PMC	PCMC
2017 (A)	1	Vanvihar Taljai	3000	-
	2	Akurdi Metro Eco Park	-	100
	3	Sahyog Kendra	-	40
		Total (A)	**3000**	**140**
2018 (B)	1	I.T.I Aundh	1200	-
	2	Vanvihar Taljai	1000	-
	3	Range Hill Campus	1700	-
	4	Gref Centre, Dighi	2000	-
	5	Akurdi Railway Line	-	-
	6	Akurdi Metro Eco-Park	-	500
	7	Ordnance Factory Khadki	200	
		Total (B)	**6100**	**500**
2019 (C)	1	Kharadi Forest Survvey No. 74	100	-
	2	Army Campus Pimple Nilakh		4700
	3	Deccan College Campus	270	
		Total (C)	**370**	**4700**
		Total A+B+C	**9470**	**5340**
2020 (D)	1	Deccan College Campus	25	-
	2	Agriculture College Campus	115	-
	3	National Institute of Naturopathy	200	-
	4	Tarkeshwar Tekdi, Yerwada	270	-
	5	Dhanori Forest Survey No. 69	275	-
	6	Wagholi Forest Area Gat No. 864	714	-
		Total D	**1599**	

Year	Sr.	Place	PMC	PCMC
2021 (E)	1	Casting Yard-Nashik Phata	-	17
	2	Pimple Nilakh	-	10
	3	Casting Yard – Kiwale	-	5
	4	College of Agriculture	55	-
	5	River Bed Deccan	15	-
	6	Yerwada J.Kumar Office	15	-
	7	Casting Yard –Wagholi	25	-
	8	Khadki Cantonment Area	1416	-
	9	HVPC Depot Kothrud	9	-
	10	Range Hill Office Campus	10	-
		Total E	**1545**	**32**
		Total A+B+C+D+E	**12614**	**5372**
		Total PMC & PCMC	**12614+5372= 17986**	

The survival rate of new saplings are about 89%. Again to compensate the dead plant, a compensatory plantation is being done by the contractor with same species @ ratio of 1:5 and maintenance like watering, manuring, watch and ward is being done for another one year at his own cost. Plantation of the new saplings is still balance and will be planted in coming months. Major planted species across the Pune city are as presented below table:

Major Species of new plantations across the Pune City

S. No.	Local Name	Botanical Name
1.	Bakul	Mimusops Elengi
2.	Jambhul	Syzygium Cumini L
3.	Mahogany	Swietenia
4.	Naral	Cocos Nucifera
5.	Pipal	Ficus Religiosa
6.	Vad	Ficus Benghalensis
7.	Karanj	Pongame oiltree
8.	Sheesham	Indian rosewood
9.	Jamun	Java Plum
10.	Kanchan	Bauhinia variegata
11.	Audumber	Cluster fig
12.	Chinch	Tamarindus Indica
13.	Bhendi	Portia tree

S. No.	Local Name	Botanical Name
14.	Kadam	Neolamarckia cadamba
15.	Amba	Mangifera indica
16.	Fanas (Jack fruit)	Arthocarpus heterophyllus
17.	Peru	Myroxylon balsamum
18.	Ramphal	Annona reticulata
19.	Malbery	Morus alba
20.	Tabobia	Lagerstroemia speciosa
21.	Badam	T. catappa
22.	Tamhan	Lagerstromia reginea/ Speciosa
23.	Sitaphal	Annona reticulata
24.	Chinch	Tamarindus indica
25.	Awala	Phyllanthus emblica/ Emblica officinali
26.	Chiku	Manilkara zapota
27.	Bel	Aegle marmelos
28.	Kavath	Limonia aciddissima
29.	Khaya	Psidium
30.	Arjun	Khaya senegalensis
31.	Shnkasur	Swietenia
32.	Gulmohar	Caesalpinia pulcherrima
33.	Kanteshawar	Delonix regia
34.	imali	Neolamarckia cadamba
35.	Neem	Azadirachta indica
36.	Sirs	Albizia lebbec
37.	Kathal	Albizia lebbeck

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

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

Green Buildings: 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.

Solar Power: Solar energy generation per year is estimated along with the installation cost. 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.

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 day light and design of passenger flow inside stations and on streets outside stations. Rain water harvesting and installations for solar power shall be implemented at stations and Depot.

Utility Plan: 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.

9.2 EMP during Construction

Measures to mitigate impacts observed during construction shall be implemented by Contractor and duly monitored by Owner in accordance with approved method statements.

The procurement source of the construction materials will be decided by the Contractor, but it will be from the licensed supplier. Sites for casting of structural concrete elements and material stockpiling will be decided before start of construction.

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

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

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

Muck Disposal: The excavated material shall be graded such that part can be re-used in construction; balance will be disposed. 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.

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

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

Labour Camp, welfare and Safety: The facilities to be provided by the Contractor are Water supply, waste water and sewage treatment; Solid Waste Management; Health care awareness and clinics; Shelter at Workplace, Canteen Facilities, and First aid facilities. Construction works shall be executed as laid down in the Safety Health and Environment (SH&E) Manual prepared by the Contractor and approved by the Implementing Agency.

Air Pollution and Noise Pollution Control: Mitigation measures as per SH&E manual shall be adopted during the construction period.

Vibration Control: Construction activities shall be scheduled such that demolition, earthmoving and ground-impacting operations do not occur in the same time period. At locations where the alignment is close to sensitive structures, the contractor shall prepare a monitoring scheme prior to construction at such locations.

Chance Finds: chance find of archaeological or heritage value might be discovered during excavation done for the purpose of construction of the Metro. Procedure to deal with antiquities discovered during archaeological excavations is given in The Ancient Monuments and Archaeological sites and Remains Act, 1958 amended in 2010.

Water pollution Control: Wash water shall be led through separate drains into precipitation chambers before discharging into the sewage drain to the standards prescribed for disposal.

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

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

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. Dewatering should be ensured as prescribed in the construction method statement.

9.3 EMP during Operation

Noise and Vibration Management: In addition to track-related measures, parabolic noise barriers are proposed on each side of the track. Even though the predicted noise levels due to metro operations are less than the existing ambient noise levels, noise barriers are proposed at sharp curved portion and at sensitive receptors like educational institutes and hospitals.

Water Supply and Sanitation at Stations: Water supply for drinking, washing of stations, air conditioning and other uses will be procured from municipal authorities. This will be supplemented by re-use of treated waste water generated by staff and passengers. The waste water will be treated by installing bio digesters at each stations and depots. Non-hazardous solid waste generated at stations will be collected, segregated and treated by in-situ bio composter.

Rain Water Harvesting: To conserve and augment the storage of groundwater, it has been proposed to construct roof top rainwater harvesting structure of suitable capacity at the elevated section.

9.4 Management Plan for Depot

Management plans are proposed for water supply, rain water harvesting, waste water treatment, oil pollution control, green belt development and solid waste disposal at both the Depot.

9.5 Disaster Management

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

9.6 Training

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

10. ENVIRONMENTAL MONITORING PLAN

Environmental monitoring will be carried out for air quality, noise levels, vibration, water quality and ecology during construction and operation phases of the project. The estimated cost towards environmental monitoring during construction will be part of civil contract and during operation phase will be the responsibility of Maha-Metro, Pune.

An Environment & Social Management Unit (ESMU) has been established at Maha-Metro, Pune with DGM Environment. This division is supported by General Consultant Senior Environmental Expert and R&R Expert. The GC Environmental Expert is monitoring the implementation of mitigation measures at site through inspections and audits, Similarly the R&R expert is monitoring the implementation of R&R aspects in consultation with Maha-Metro land team and reporting to Project Director/ED/CPM in sync with Maha-Metro ESMU.

11. COST ESTIMATE

The total estimated environmental management and monitoring cost for the proposed project is Rs 2294.07 Lakh. The cost towards environmental 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)

Chapter 1 : Introduction

1.1. BACKGROUND

The history of Pune City is closely related to the rise of Maratha Empire of the 17^{th} and 18^{th} 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 Gangadhar Tilak, 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 and Social Impact Assessment (ESIA) and preparation of Environmental & Social Management Plan (ESMP) for both the corridors (North-South and East-West) of Pune Metro Rail Project.

1.4. SCOPE OF ESIA and ESMP STUDY

The Environmental Impact assessment & hydraulic studies of 1.45 km alignment of Pune Metro Rail passing parallel to Mutha River is in progress. The consultant shall incorporate the baseline, impact and mitigation measures of this stretch from this report to incorporate in the

EIA report of the entire stretch. "The study for the same was completed by M/s Mitcon Consultancy and Engineering Services Ltd, Pune and the same has been incorporated in this report".

The EIA study will include the environmental management plan (EMP) and disaster management plan for design, construction and operation phases of project. The proposed EIA study shall cover following in detail.

- 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 local 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 with 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.
- To outline the entitlements for the affected persons for payment of compensation and assistance for establishing the livelihoods.
- To develop communication mechanism to establish harmonious relationship between PMRP and Project Affected Persons (PAPs)
- To ensure adequate mechanism for expeditious implementation of R&R.

1.5. ENVIRONMENTAL IMPACT ASSESSMENT

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

Table 1.1. Structure of ESIA ESMP Report

Chapter 1	Introduction	Introduction about the project, objectives and scope of work.
Chapter 2	Policies, Legal and Institutional Arrangement	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 and Hydraulic Studies of Mula Mutha River	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 7A	CWPRS Mathmetical Model Studies of Mula Mutha River (Whole Report is annexed as Annexure-1)	This study was intended to estimate the afflux for two river discharges of 60,000 ft3/s and 1,00,000 ft3/s and inundation of riverbanks caused by afflux in Mutha river due to the construction of metro pier and allied structures.
Chapter 8	Additional ESIA and ESMP For Revised Reach -3 Alignment Passing Adjacent to Dr. Salim Ali Bird Sanctuary	Study For Changed Reach -3 Metro Alignment (About 3 km in Length) on the Median of DP Road Passing Adjacent to Dr. Salim Ali Bird Sanctuary,
Chapter 9	Environmental Management Plan	Environmental strategy to offset/mitigate the probable adverse impacts has been outlined
Chapter 10	Environmental Monitoring Plan and Environmental Management System	Environmental monitoring and management systems are described
Chapter 11	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, 1986 to 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;	• Protection of Air Quality • Consent to Establish (CTE) for establishing and

LEGISLATION	ACTIVITY / FEATURE
Air (Prevention and Control of Pollution) Rules, 1981	• 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 • 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 bye laws 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 of waste 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	• Preservation of ancient and historical monuments and archaeological sites and remains of national

LEGISLATION	ACTIVITY / FEATURE
Ancient Monuments and Archaeological Sites and Remains (Amendment) Act, 2017.	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
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 water for 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 area beginning 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 protected archaeological monument/site and 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, 2017 defines “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	Government shall refer SIA report to an independent multi-disciplinary Expert Group. If this group finds that the project will serve / not serve any public purpose and the potential benefits outweigh social costs and adverse social impacts /social costs and adverse social impacts outweigh the potential benefits the group will recommend so. 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: However when amount of compensation is not paid on or before taking possession of the land or within one year from date of possession then interest is payable on amount awarded. 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		

Milestone Proceedings under the Act		
Stages	**Title**	**Description**
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 Schedule of Act 2013: With a view to help restore income opportunities the Act provides for assistance and cash allowances. If a house is lost in urban areas, a constructed house shall be provided which will not be less than 25 square meters in plinth area. *Replacement cost is not mandatory.*		
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 (Annexure 2.1) 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 2013 i.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

In accordance with Indian laws (EIA Notification 2006) railway projects are not listed among projects requiring prior environmental clearance. In recent Metro railway projects the 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 influence that 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 the incremental 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 should be as per Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 and Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996.

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.

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 procurement and 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 informed participation, 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, and differentiated 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.

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 are notified, 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/EIB - 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 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.*

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/EIB 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.

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 on Environmental and Social Sustainability describes International Finance Corporation (IFC) commitments, roles, and responsibilities related to environmental and social sustainability. The Performance Standards are directed towards clients, providing guidance on how to identify risks and impacts, and are designed to help avoid, mitigate, and manage risks and impacts as a way of doing business in a sustainable way, including stakeholder engagement and disclosure obligations of the client in relation to project level activities. Performance standards issued by IFC are given below:

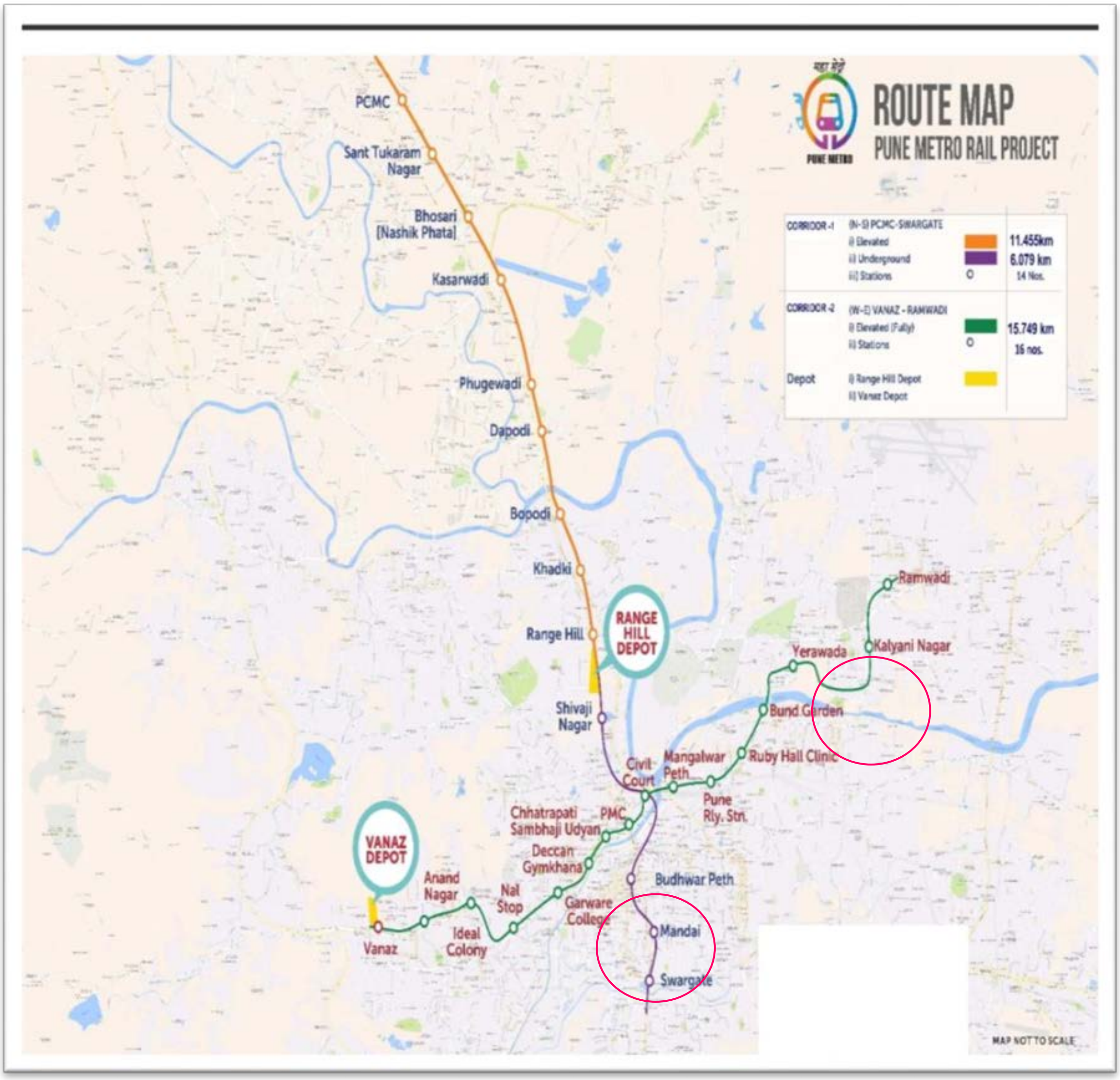
- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts
- Performance Standard 2: Labour and Working Conditions
- Performance Standard 3: Resource Efficiency and Pollution Prevention
- Performance Standard 4: Community Health, Safety, and Security
- Performance 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 (updated)



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 viz North – South Corridor (PCMC to Swargate) of length 18.45 km and East–West Corridor (Vanaz to Ramwadi) of length 14.58 km were 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	11.455	17.534	9
		Underground	6.079		5
2.	East–West Corridor (Vanaz to Ramwadi)	Elevated		15.749	16
			TOTAL	**33.283**	**29***

*Civil Court Metro Station - Interchange Station

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	3822	1272	Elevated
5	Phugewadi	4850	1028	Elevated
6	Dapodi	5716	866	Elevated
7	Bopodi	7338	1622	Elevated
8	Khadki	8215	877	Elevated
9	Range Hill	9612	1397	Elevated

S. No	Station Name	Chainage (m)	Inter Station Distance (m)	Elevated/ Underground
10	Shivaji Nagar	11729	2117	Underground
11	**Civil Court - *Interchange Station***	12849	1120	Underground
12	Budhwarpeth	14138	1289	Underground
13	Mandai	15002	864	Underground
14	Swargate	16538	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	15	-	Elevated
2	Anand Nagar	1150	1135	Elevated
3	Ideal Colony	1899	749	Elevated
4	Nal Stop	2788	889	Elevated
5	Garware College	3872	1084	Elevated
6	Deccan Gymkhana	4725	853	Elevated
7	Sambhaji Park	5258	533	Elevated
8	PMC	5960	702	Elevated
9	**Civil Court - *Interchange Station***	6603	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

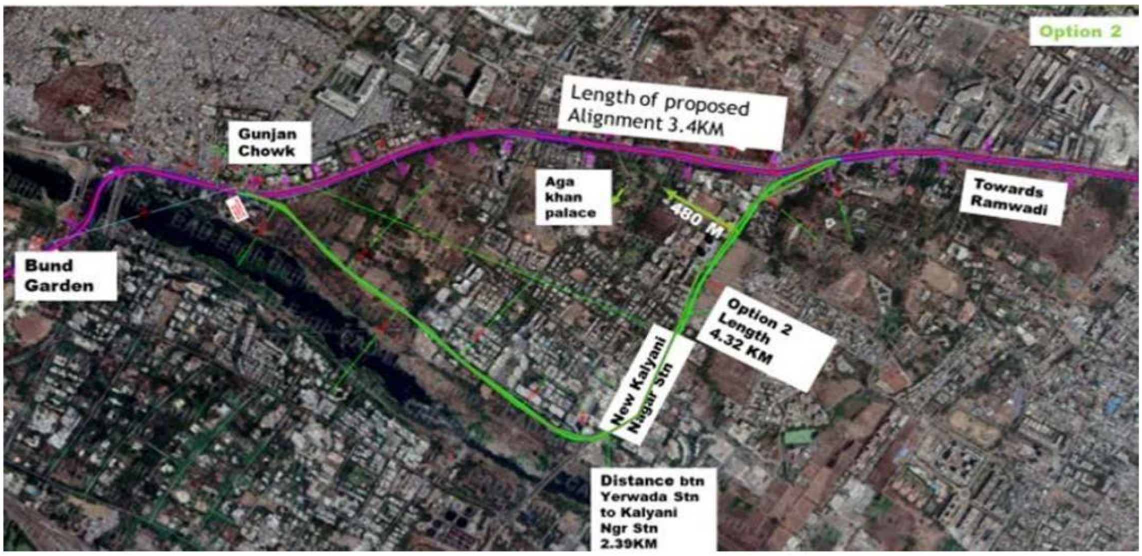
Source: Drawings of alignment provided by Maha-Metro for Pune Metro Rail Project

West–East Corridor: Vanaz to Ramwadi (Revised Reach-3 Alignment from Gunjan Chowk – Kalyani Nagar)

The original DPR alignment of the Pune Metro East West Corridor was aligned along the Pune-Ahmednagar Highway from Parna Kuti Yerwada Chowk. Alignment was provided in consort with the centre line of BRTS median and passing by the Aga Khan Palace (Ch:12575 to Ch:12675). The distance available from the elevated viaduct to the central core of the monument was 118.5m. Clear distance from the boundary wall of the monument to the edge of elevated viaduct was 19.80m. Area nearby the Monument surrounded by buildings with height of 28m and 90m in Prohibited and regulated area respectively.

As per the 2016 order issued by the Bombay High Court in response to a petition filed by the city-based NGO Parisar that construction of the Metro project should not proceed without getting permissions from the NMA. As Aga Khan Palace was declared as a Nationally Protected Monument in 2003, application for seeking NOC/Permission for construction of viaduct was submitted to RD & CA on 13 April 2018 and the proposal was forwarded to National Monuments Authority (NMA) on 31 August 2018.

The National Monument Authority (NMA) has rejected the permission sought by Maharashtra Metro Rail Corporation Limited (Maha-Metro) to undertake Pune Metro alignment from Civil Court to Ramwadi near Aga Khan Palace as it falls within the prohibited area of the monument. The NMA took the decision of diverted alignment in a meeting, as this section lies within the prohibited area of the Aga Khan palace. General Consultants of Maha Metro conducted feasibility studies and identified the following alignment. Starts at Ch:11015 (Gunjan Chowk), turns RHS near Garbage collection centre, runs along DP road and re-joins the main alignment at Ch: 13454.A small segment of this alignment runs on the median of DP road adjacent to Dr Salim Ali Bird Sanctuary. This has resulted in an increase of 920 m to the original alignment and relocation of Kalyani Nagar station.



The above revised alignment is approved by Board of Directors of Maha-Metro in the meeting held on 17th January,2019 and also by PMC on 18.12.2018 and GoM on 16.02.2019. The Govt. of India, Ministry of Housing and Urban Affairs vide Gazette notification S. O. 3706 (E) dated 14th October,2019 has also notified the revised alignment.All the related approvals and notification are presented in **Annexure- 3.1**

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

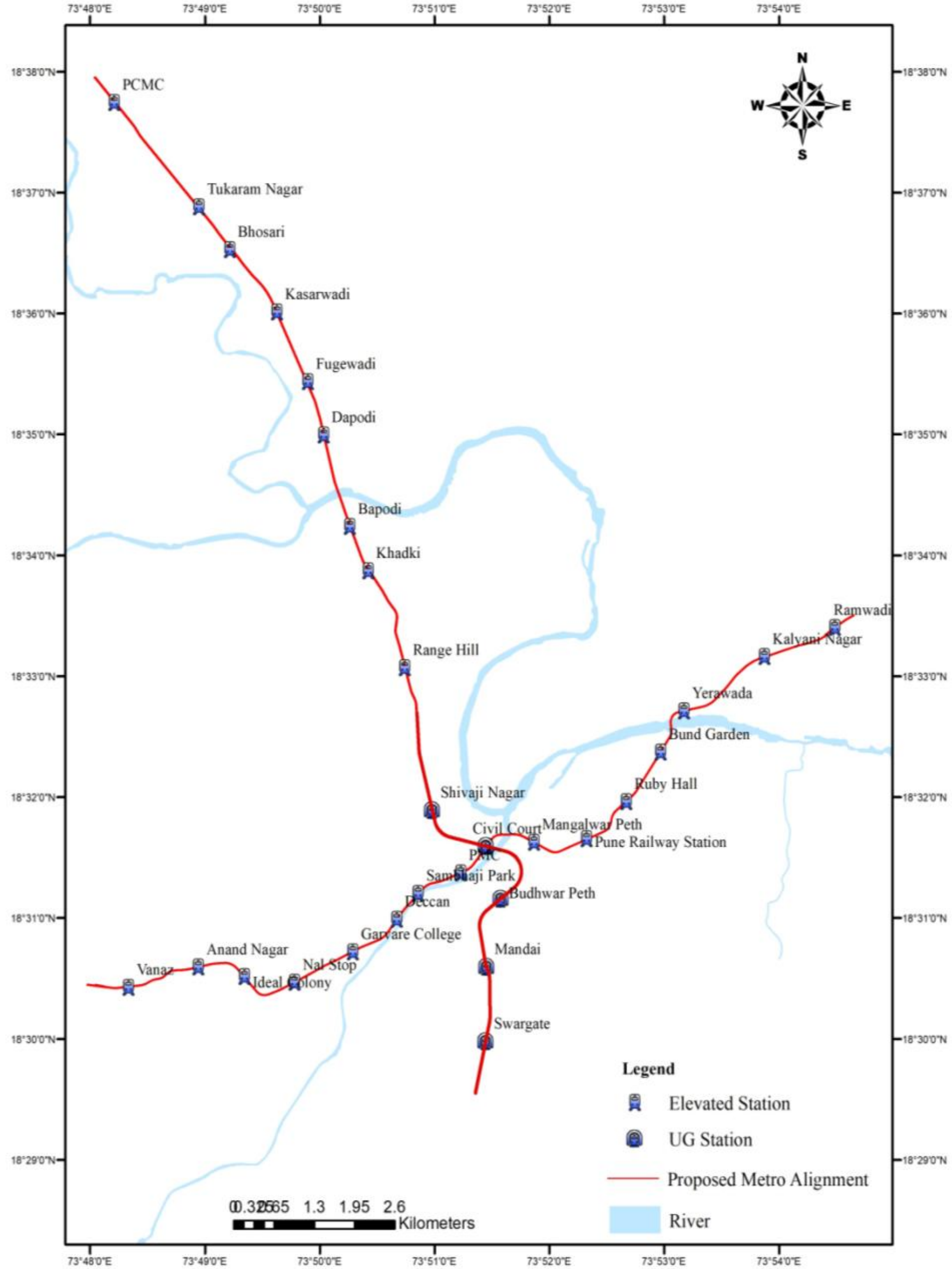
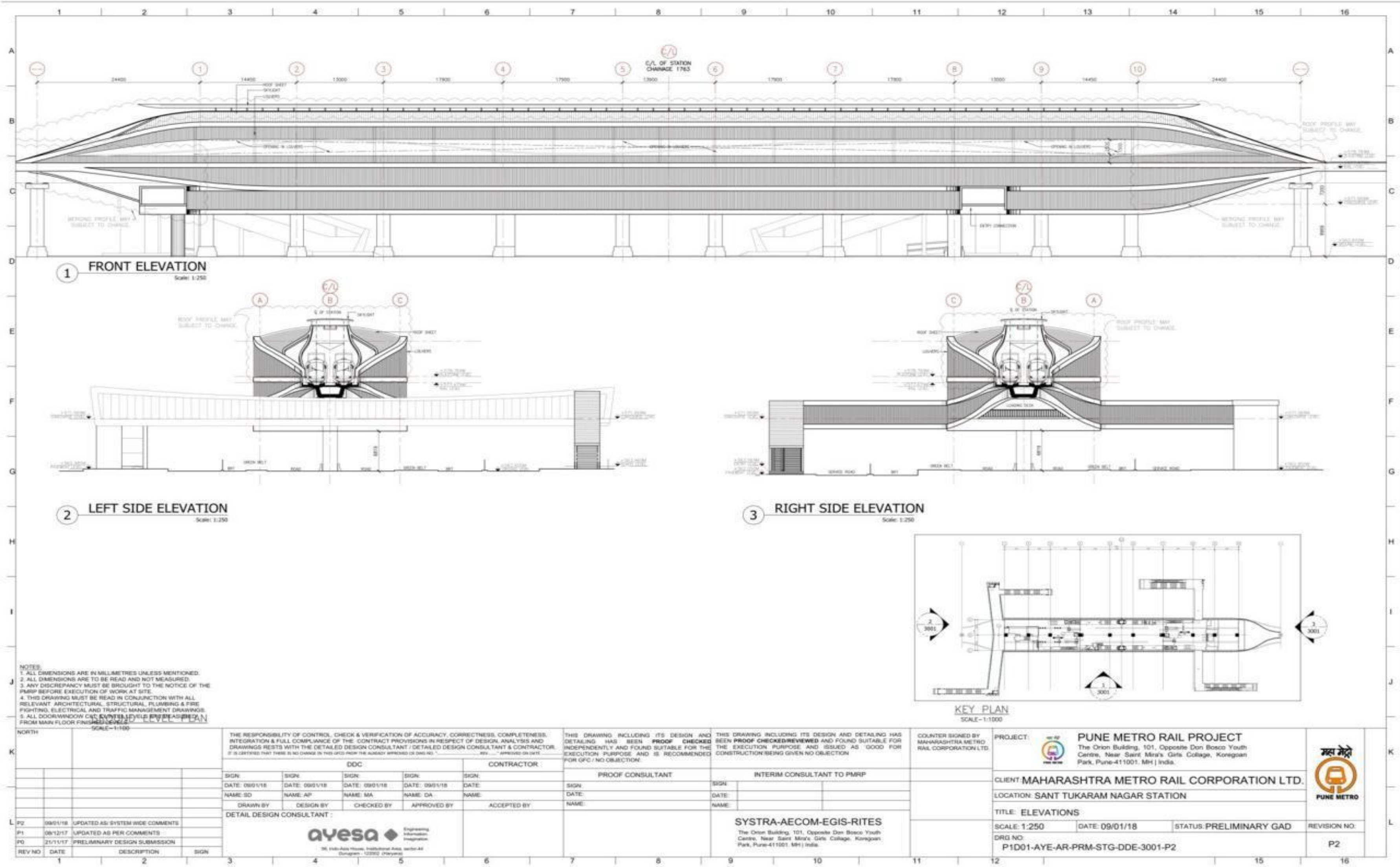
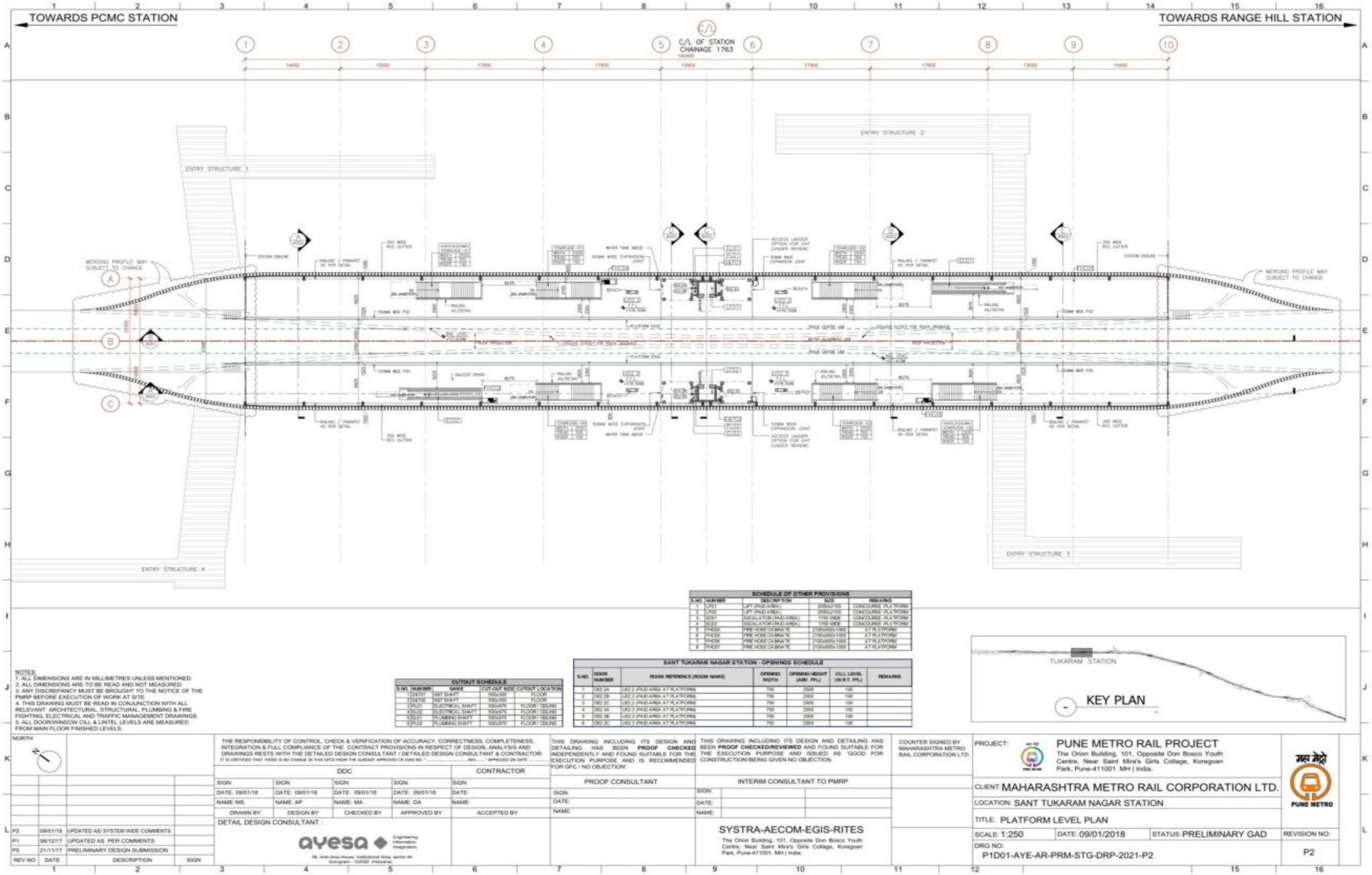


Figure 3.3. Typical Drawing of Elevated Station




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
SCHEDULE OF OTHER PROVISIONS
SANT TUKARAM NAGAR STATION - OPENINGS SCHEDULE
CUTOUT SCHEDULE
TUKARAM STATION
KEY PLAN
DDC
CONTRACTOR
PROOF CONSULTANT
INTERIM CONSULTANT TO PMRP
DETAIL DESIGN CONSULTANT :
ayesa
SYSTRA-AECOM-EGIS-RITES
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
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

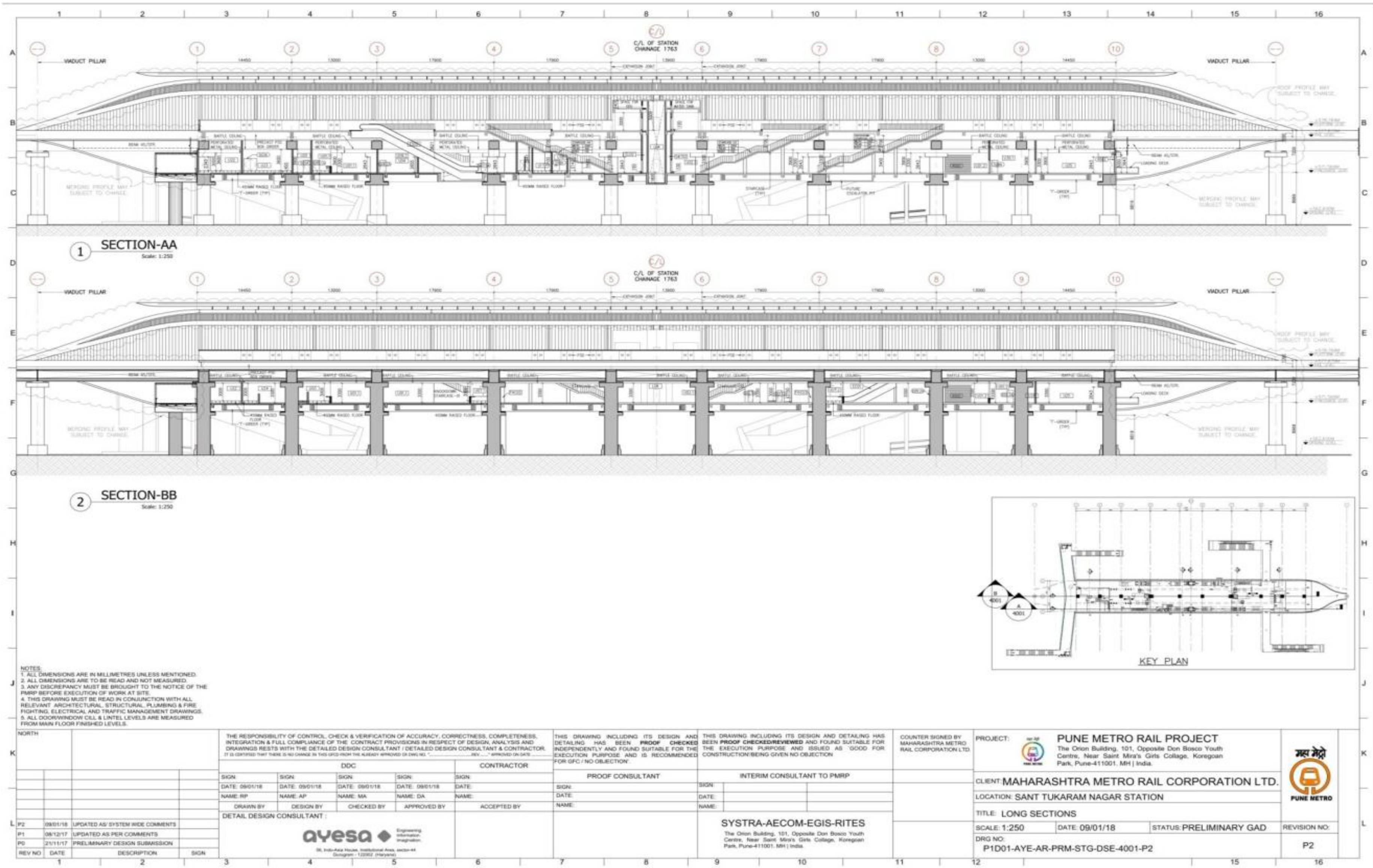

SECTION-AA
SECTION-BB
KEY PLAN
PUNE METRO RAIL PROJECT
CLIENT: MAHARASHTRA METRO RAIL CORPORATION LTD.
LOCATION: SANT TUKARAM NAGAR STATION
TITLE: LONG SECTIONS
SCALE: 1:250
DATE: 09/01/18
STATUS: PRELIMINARY GAD
DRG NO: P1D01-AYE-AR-PRM-STG-DSE-4001-P2
REVISION NO: P2
SYSTRA-AECOM-EGIS-RITES

Figure 3.4. Street Level Plan Drawing of Underground Station

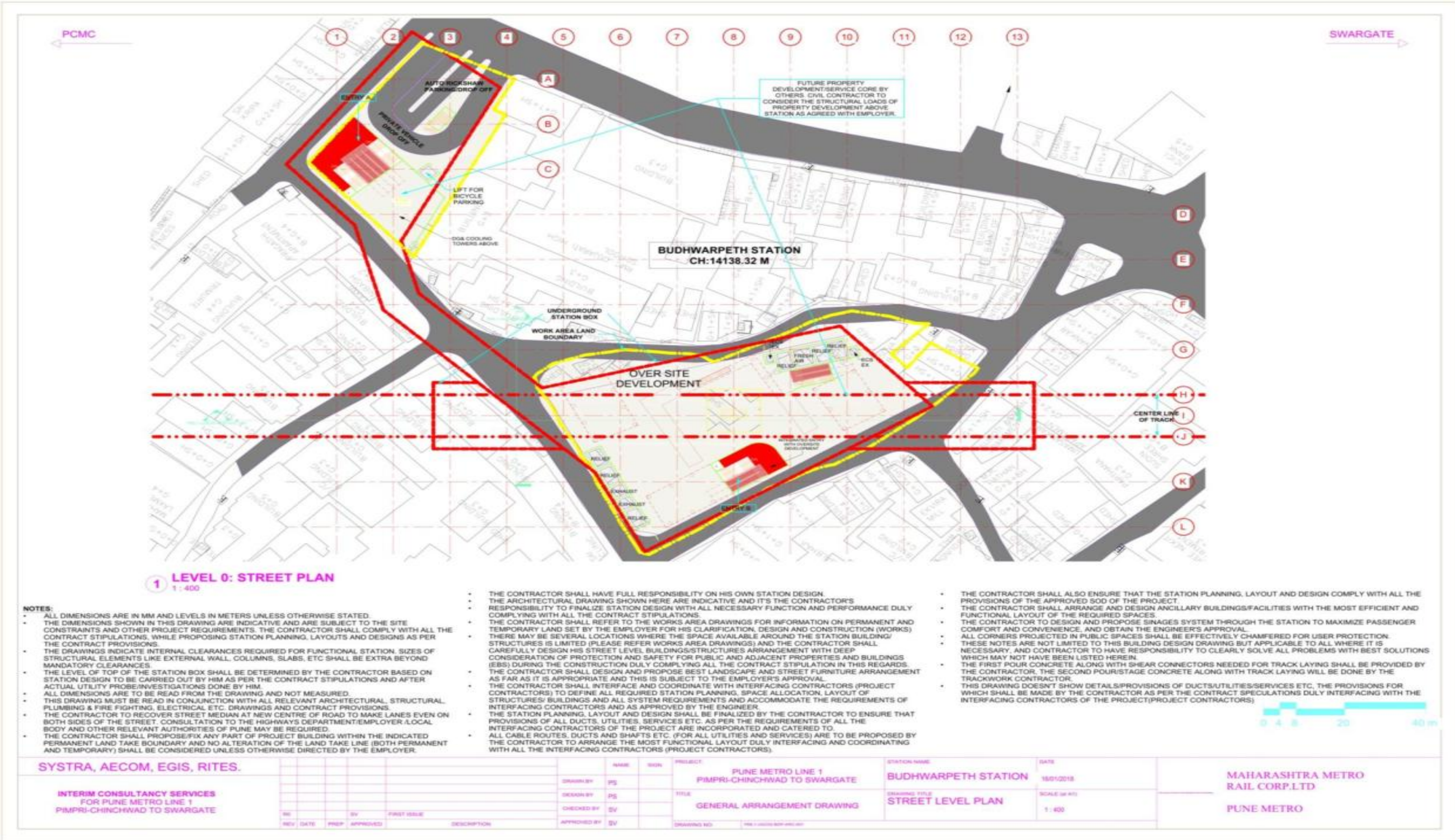
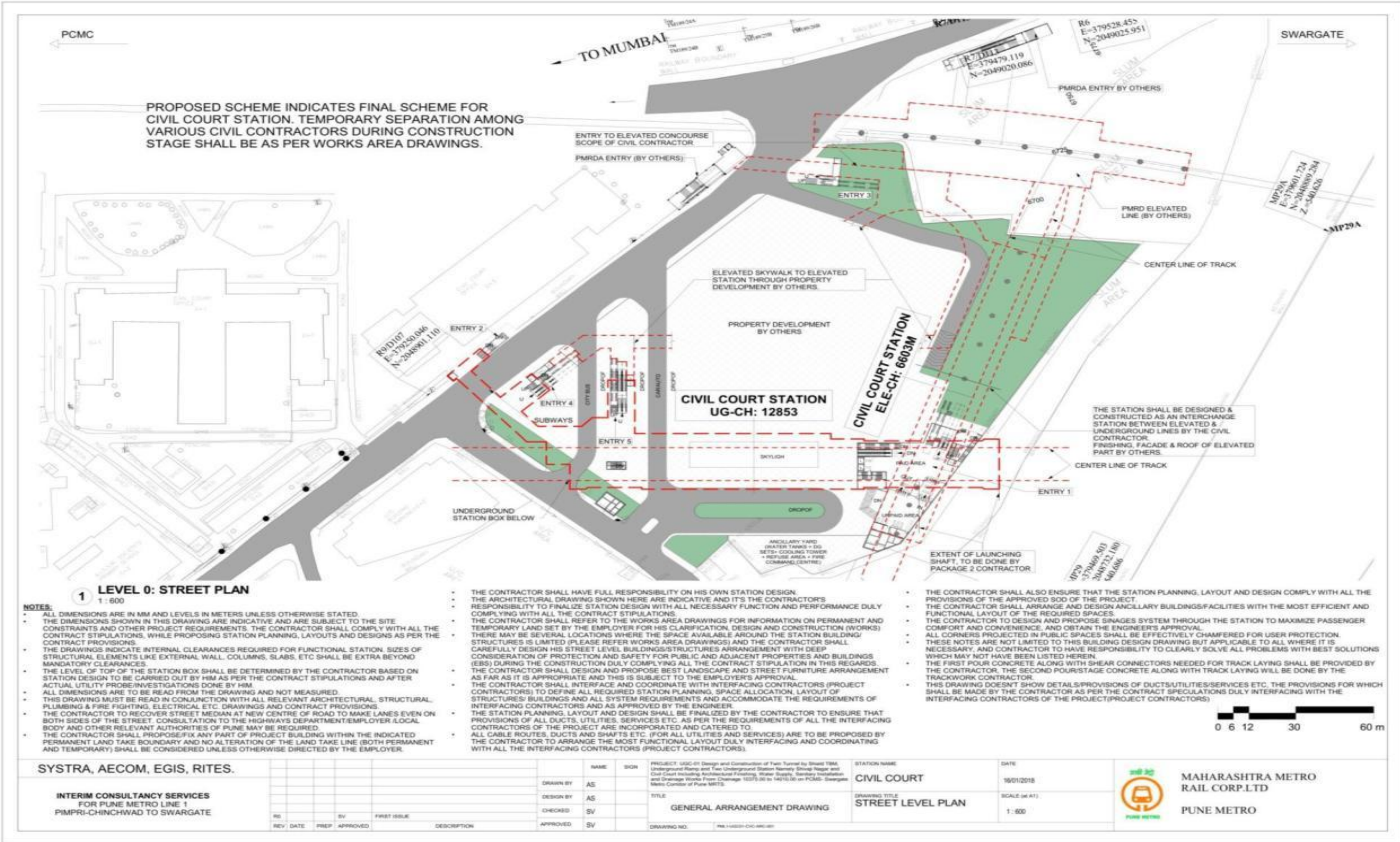
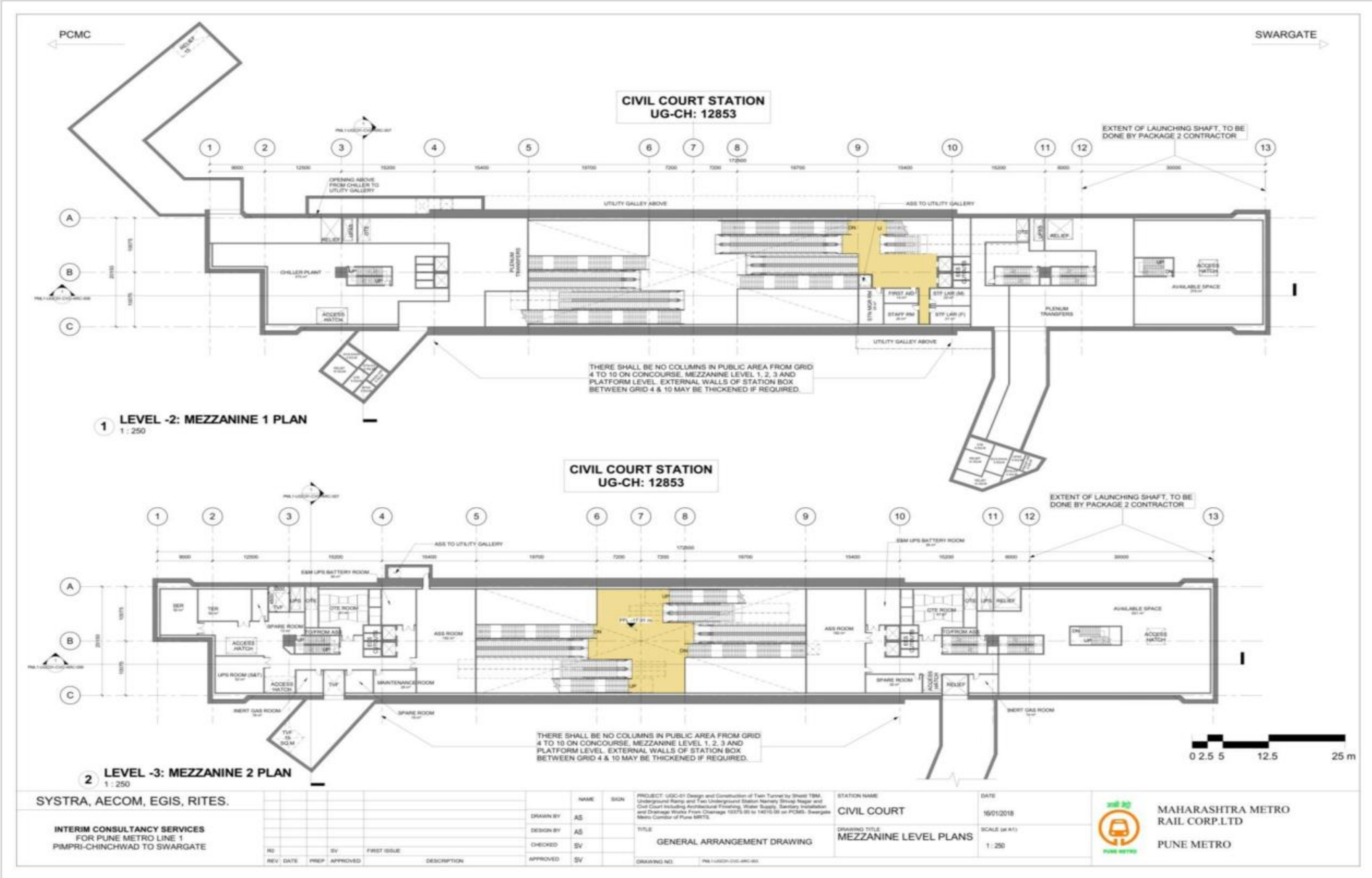


Figure 3.5. Typical Drawing of Interchange Station




PCMC
SWARGATE
CIVIL COURT STATION
UG-CH: 12853
EXTENT OF LAUNCHING SHAFT, TO BE DONE BY PACKAGE 2 CONTRACTOR
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
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
CIVIL COURT
GENERAL ARRANGEMENT DRAWING
MEZZANINE LEVEL PLANS
16/01/2018
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

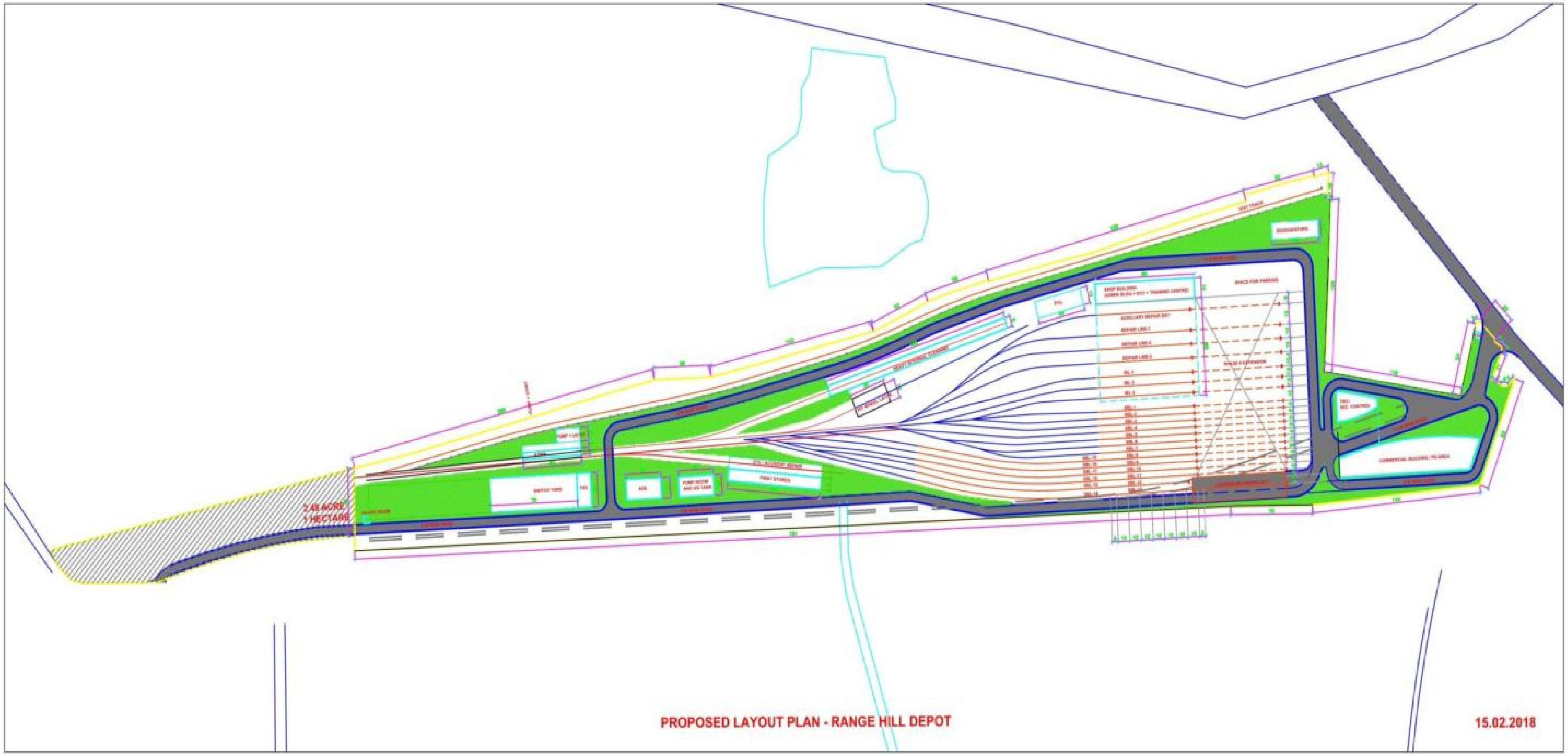


Figure 3.7. Layout Map of Vanaz Depot

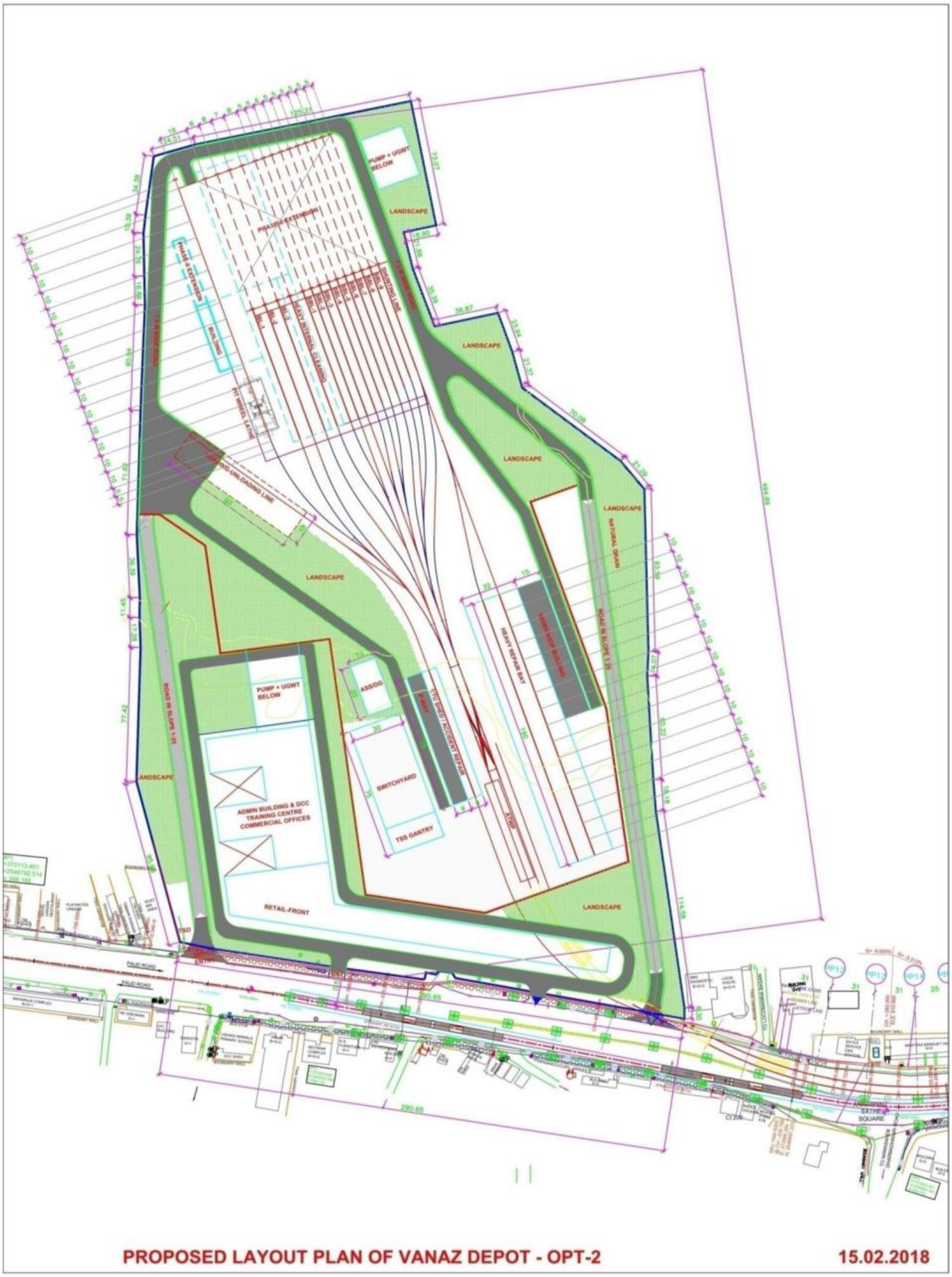


Table 3.4. Capital Cost Estimate: PCMC - Swargate

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 2015 price 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
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 Budhwar 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 Shaniwar wada, 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	13
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 13 numbers of trees.

Based on the above details, Alternative No. 3 i.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 13.

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	13
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 Khadki Railway 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	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	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

S. No	Modifications suggested by Metro Expert Committee and Maha Metro.	Modifications carryout by GC	Reason
	Deccan Gymkhana station need to be examined	along the road median up to Ch 4180.00m. Thereafter, the 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.	along the abutment, with 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 Quality and Noise Quality)
- Ecological Environment (Flora and Fauna)
- Socio-Economic environment (Demography and Socio-Economics, etc.)

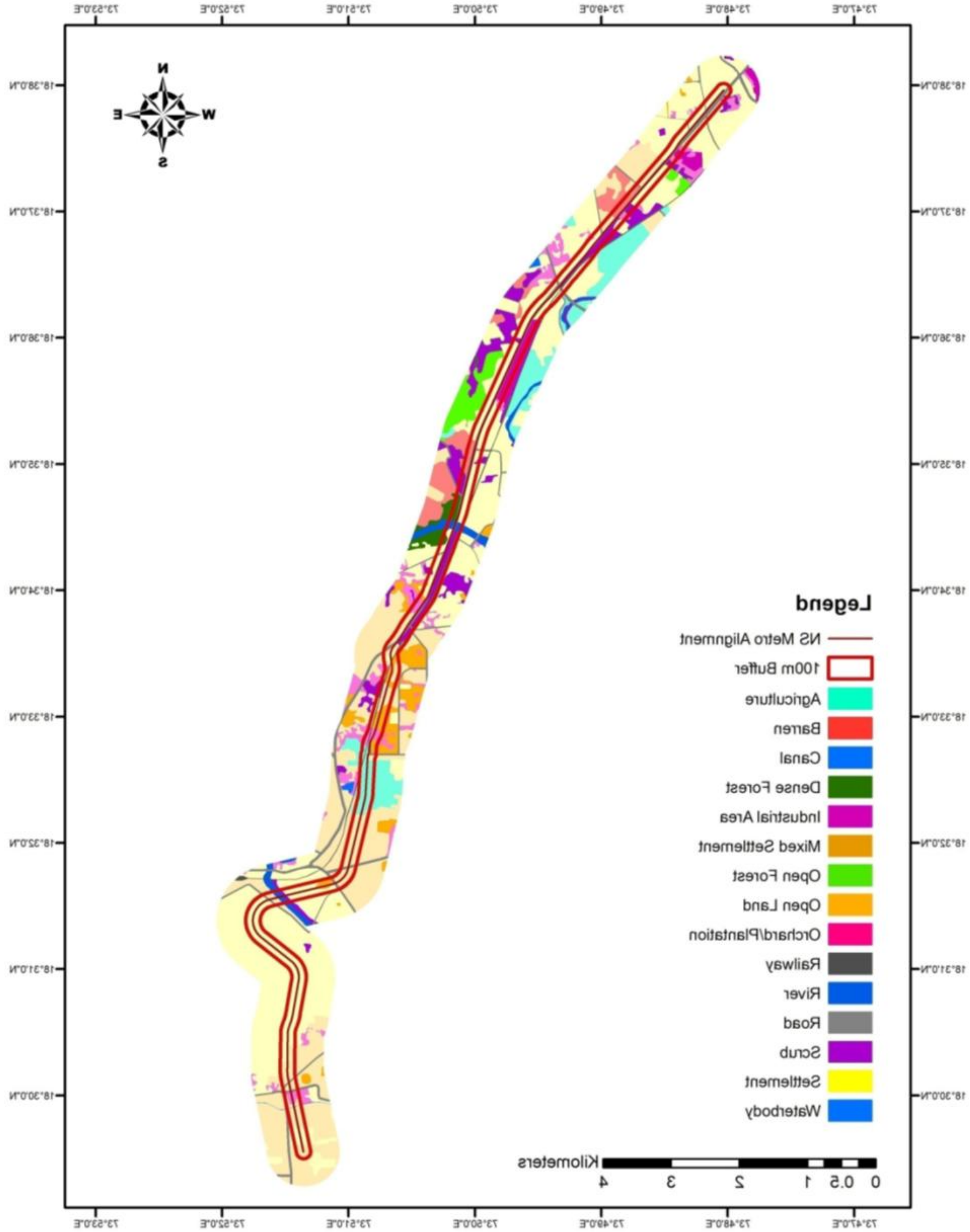
Environmental baseline data includes the physical, biological and socio-economic data. The data collection was carried out in the months from October 2017 to December 2017. A scoping matrix along with the frequency adopted for data collection for environmental attributes is summarized in Table 4.1. Based on environmental scoping matrix and project settings the attributes likely to be affected were identified for baseline data generation. Project influence area is considered as 100 m on either side of the proposed corridors as shown in Figure 4.1.

Table 4.1. Environmental Attributes and Frequency of Monitoring

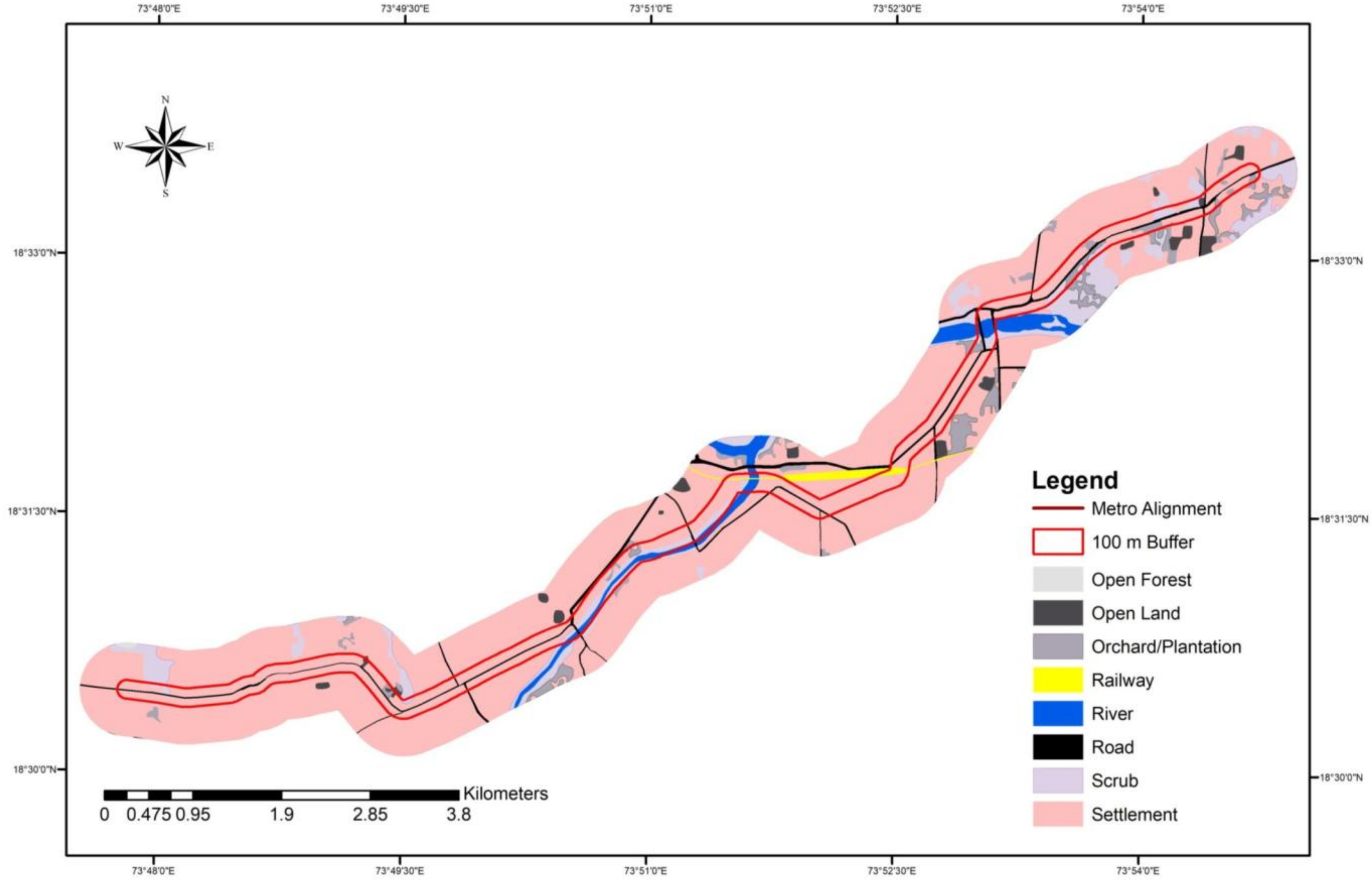
S. No	Attribute	Parameter	Frequency	Source
LAND ENVIRONMENT				
1.	Soil	Soil Characteristics	One Season	Field studies and Detailed project report
2.	Geology	Geological Status	---	Secondary Data
3.	Seismology	Seismic Hazard	---	Secondary Data
WATER ENVIRONMENT				
4.	Water Quality	Physical, Chemical and 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, RH, 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.

Figure 4.1. Influnce Area Map of Metro Corridors

PCMC - Swargate Corridor



Vanaz - Ramwadi Corridor



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 in Figure 4.2.

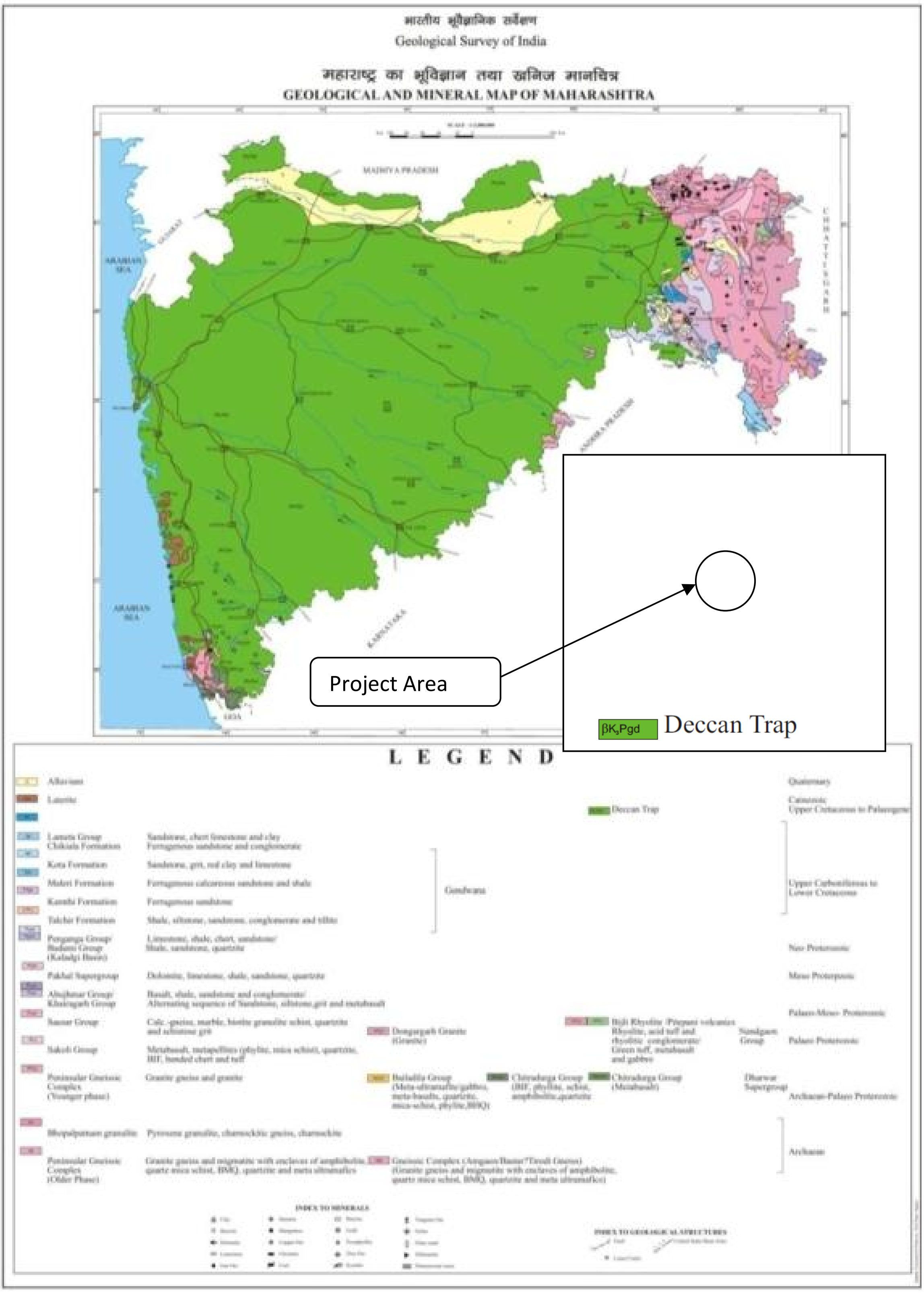
4.2.3. Soils

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 soils ie 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 4.3.

Figure 4.2. 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 SO_4-2 from the soil solution. The soils are deficient in sulphur content.

Figure 4.3. Environmental Monitoring Locations

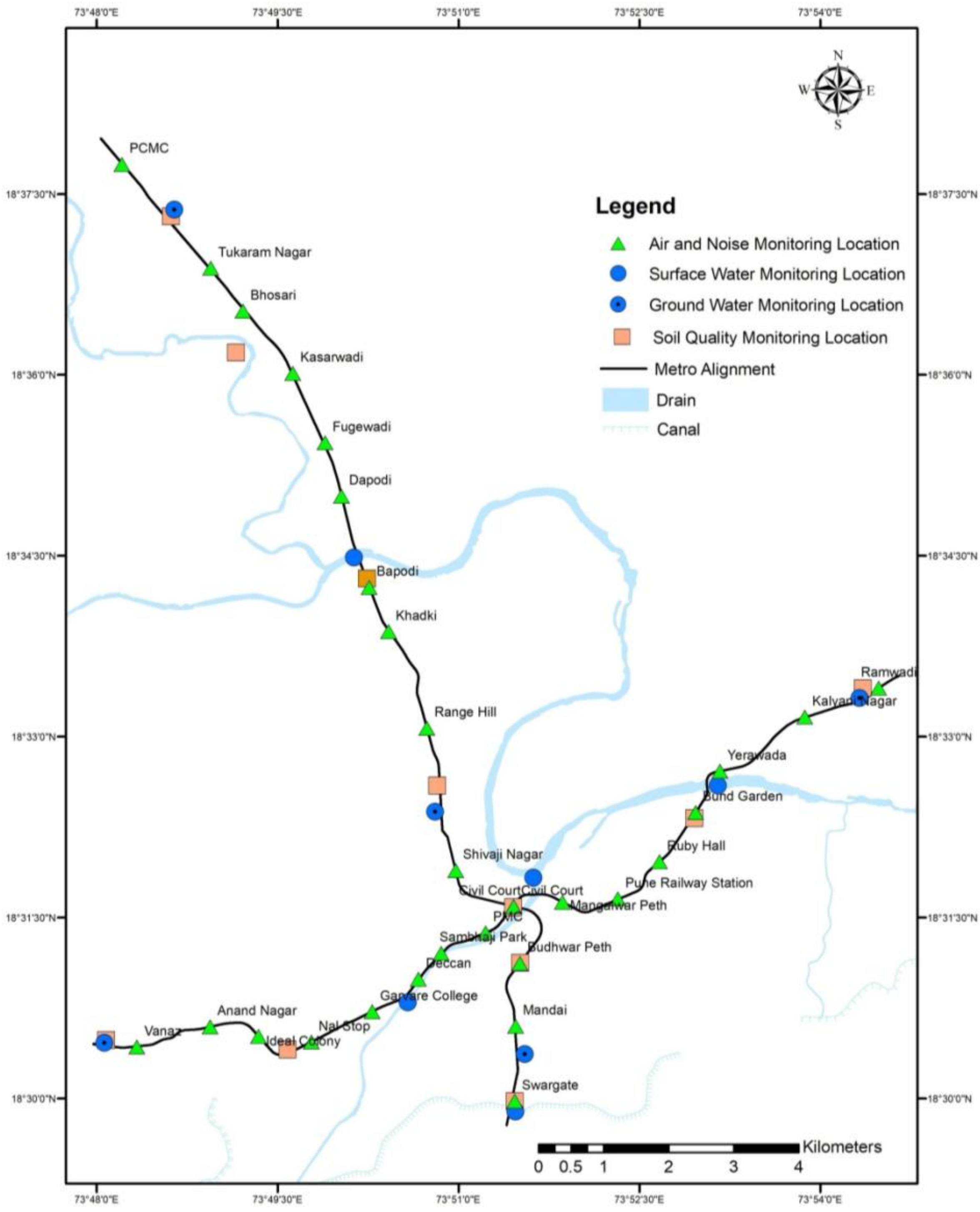


Table 4.3. Soil Quality Data

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 vermi compost 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

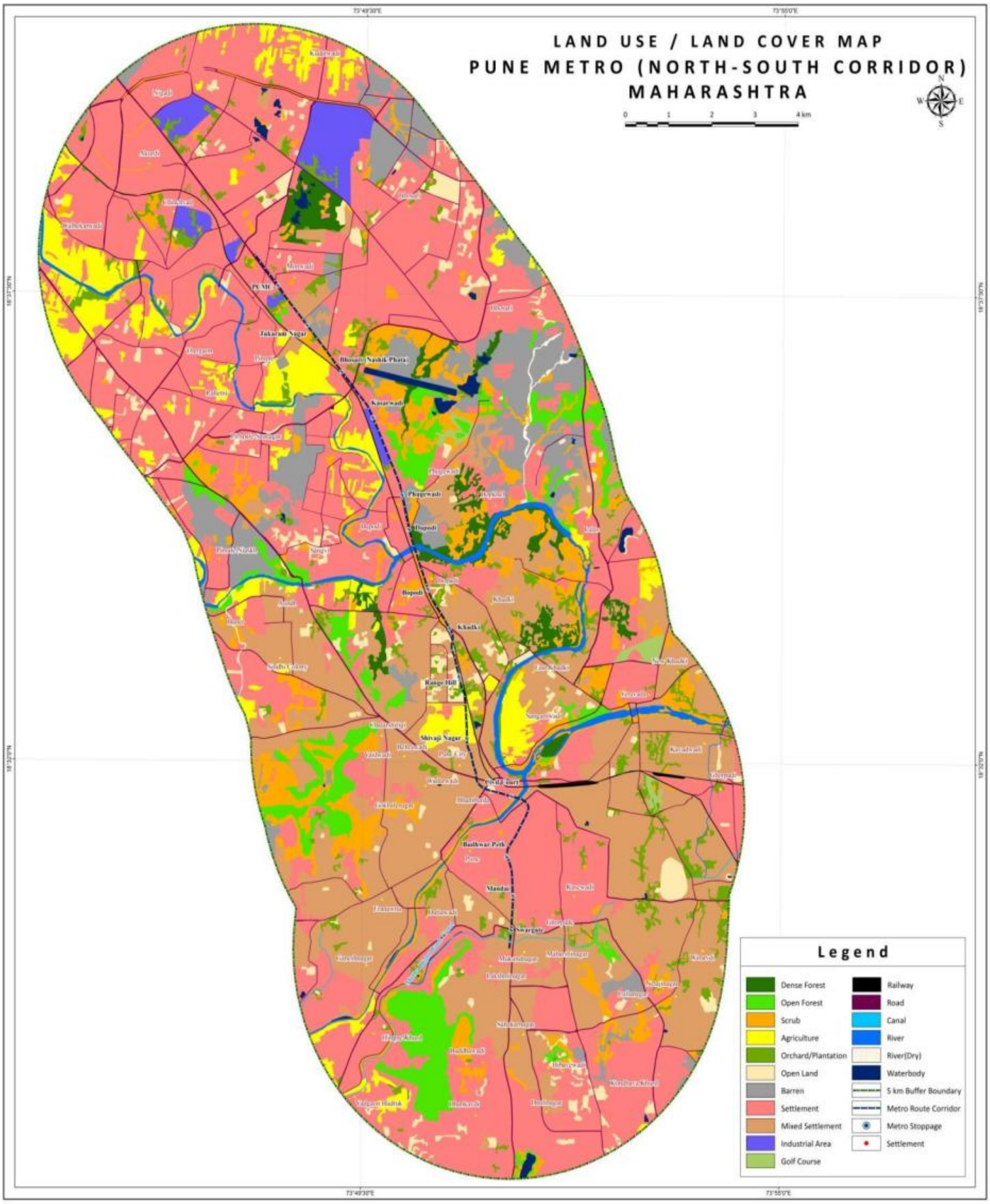
Source: Pune DEA report 2008, MPCB

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 4.4.

Figure 4.4. Land use Map 5 Km on Either Side of Metro Corridors

PCMC – RANGE HILL CORRIDOR



VANAZ – RAMWADI CORRIDOR

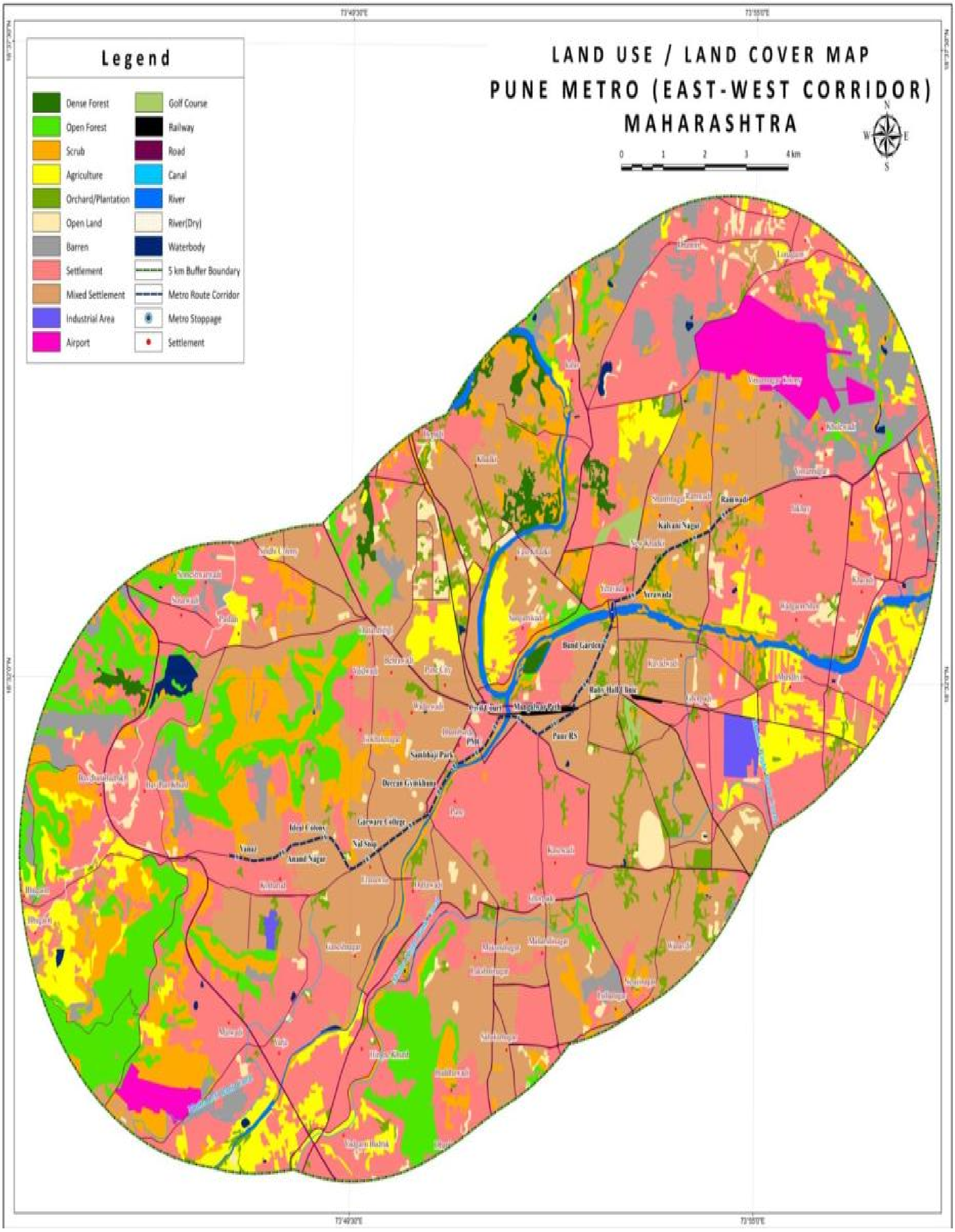


Table 4.5. Land Use Classification on 5 km on either side of Metro Corridor

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 proposed project corridors is given in Figure 4.5.

PCMC – Range Hill Corridor

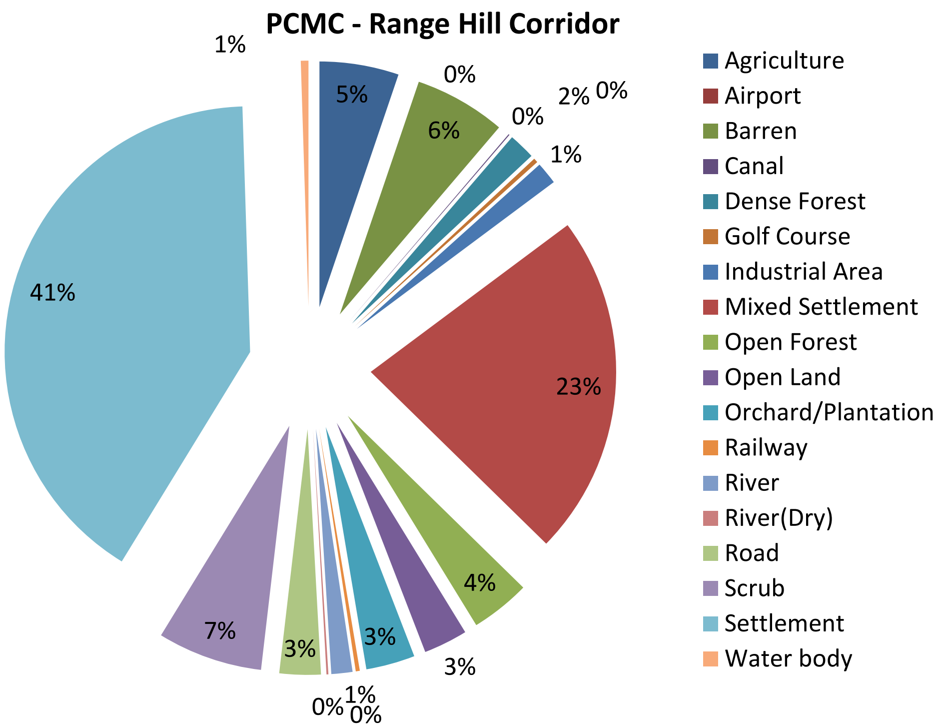
- Agricultural land and Plantation together contributes to about 8.4% of the study area.
- Settlements, Mixed settlements, and Industrial area cover about 40.7%, 22.5% and 1.5% respectively. The surrounding villages around the project site are well developed with road, electricity and water connectivity.
- 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.

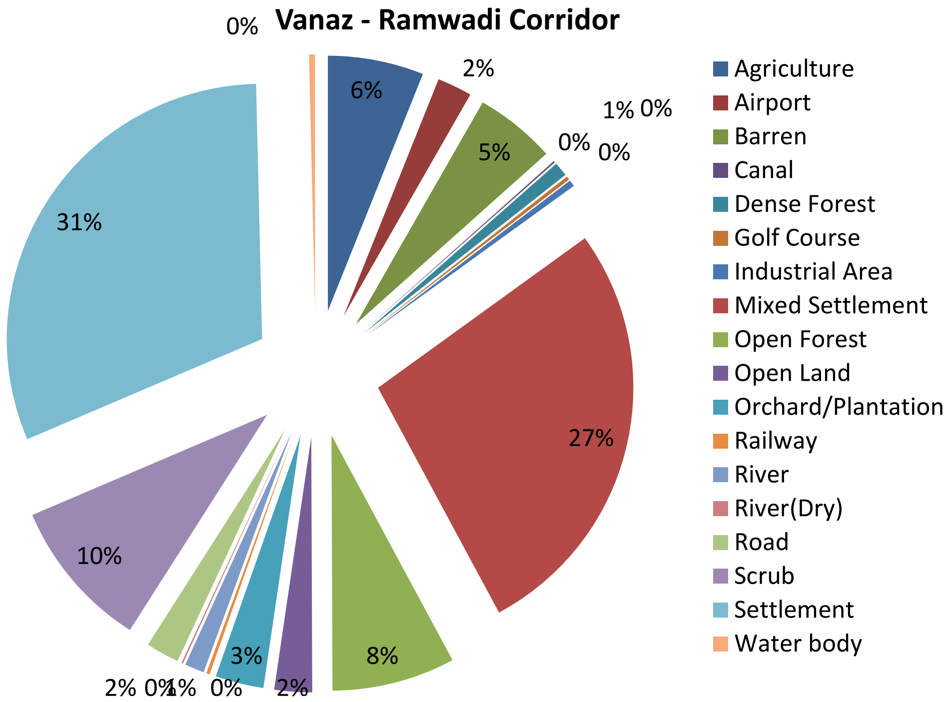
Vanaz – Ramwadi Corridor

- 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 4.5. Land Use Classification of the Proposed Project Corridors

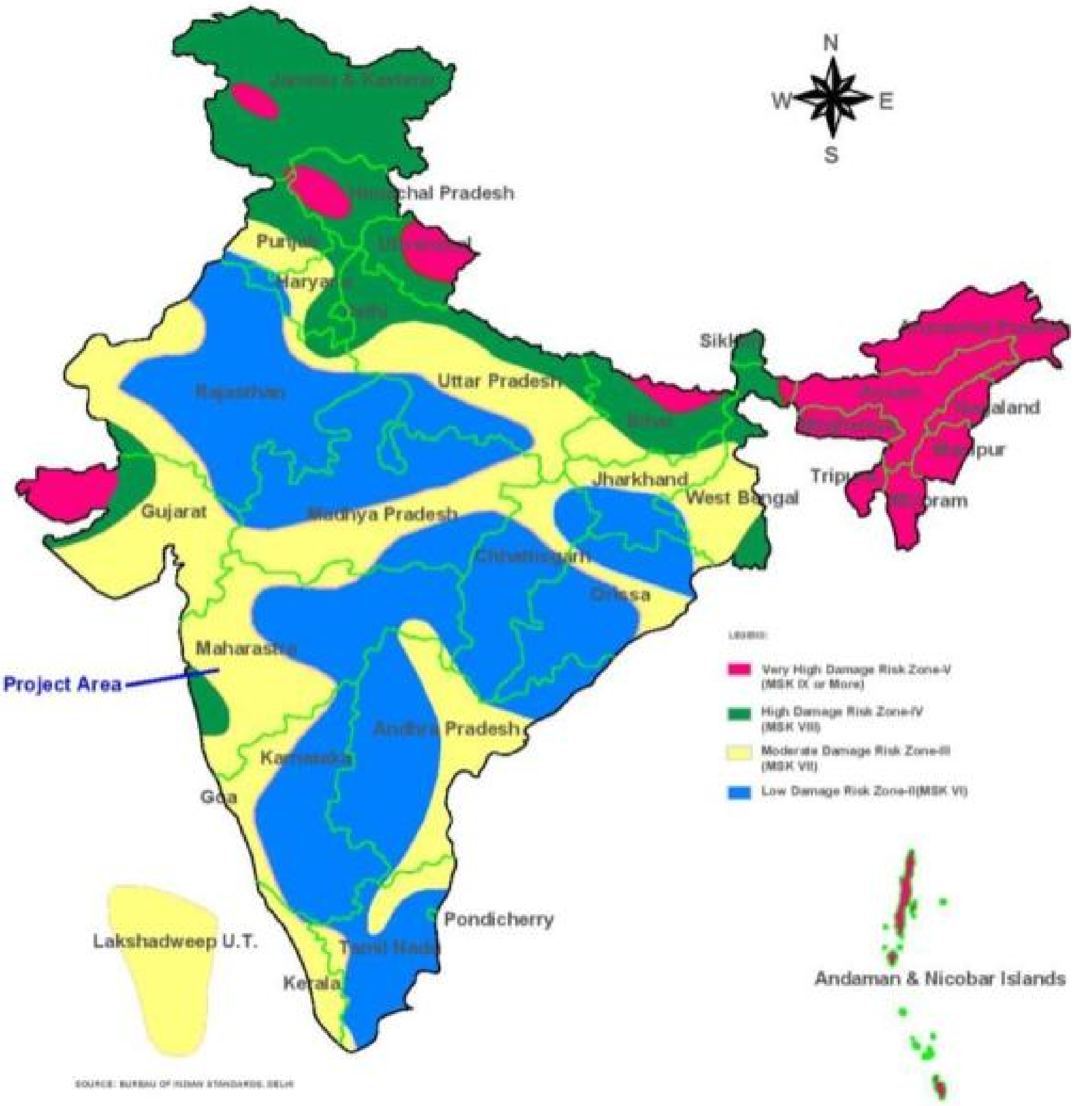




4.2.5. Seismicity

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 4.6.

Figure 4.6. 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 is primarily 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 Temghar supplement 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 Corporation supplies 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

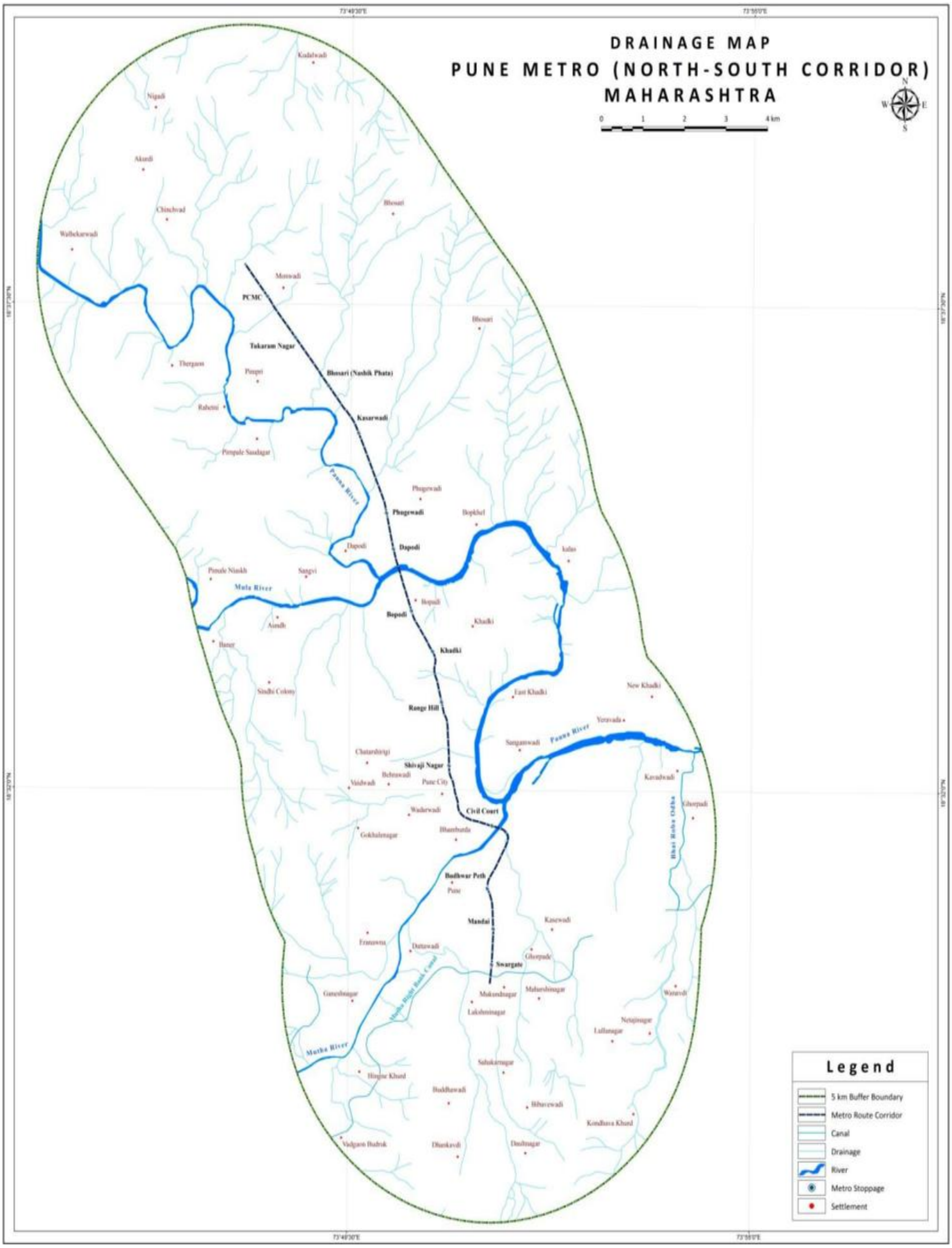
The district has three major drainage systems namely the Bhima-Ghod River System in northern, north-eastern and eastern part; Mula-Mutha River System covering the central part of the district; and Nira River system covers south, south-east and eastern part of the district. During rainy season, these 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 4.7. Mula Mutha River system is major source of drainage system along the project corridors.

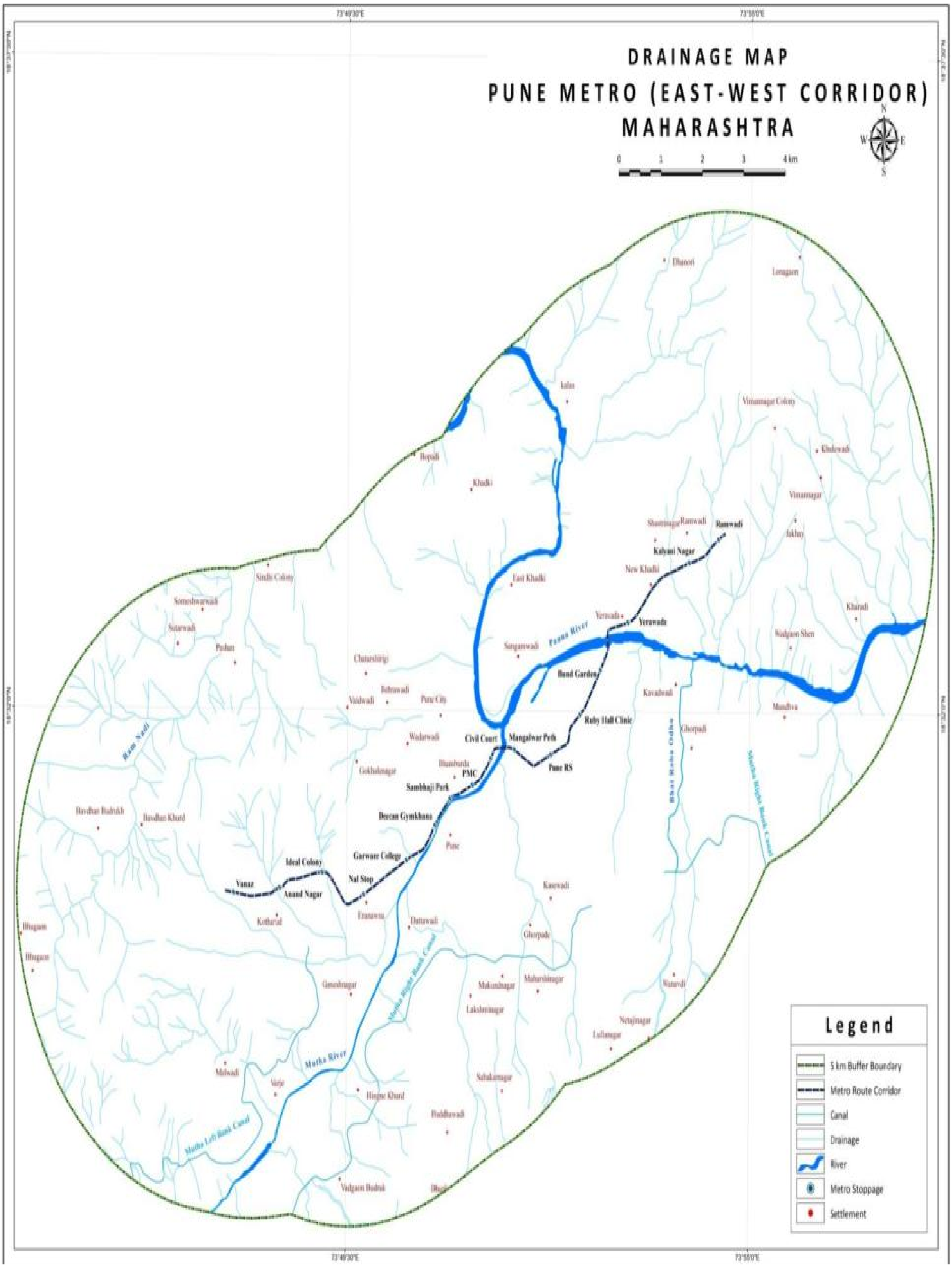
[1]City Development Plan for Pune City 2041, Pune Municipal Corporation, Year 2012

Figure 4.7. 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 4.3 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	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 of domestic 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 °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

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
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
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

Reliability, maintainability and safety of equipment significantly depend on the boundary conditions of weather in which the metro system operates. 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 Feb-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

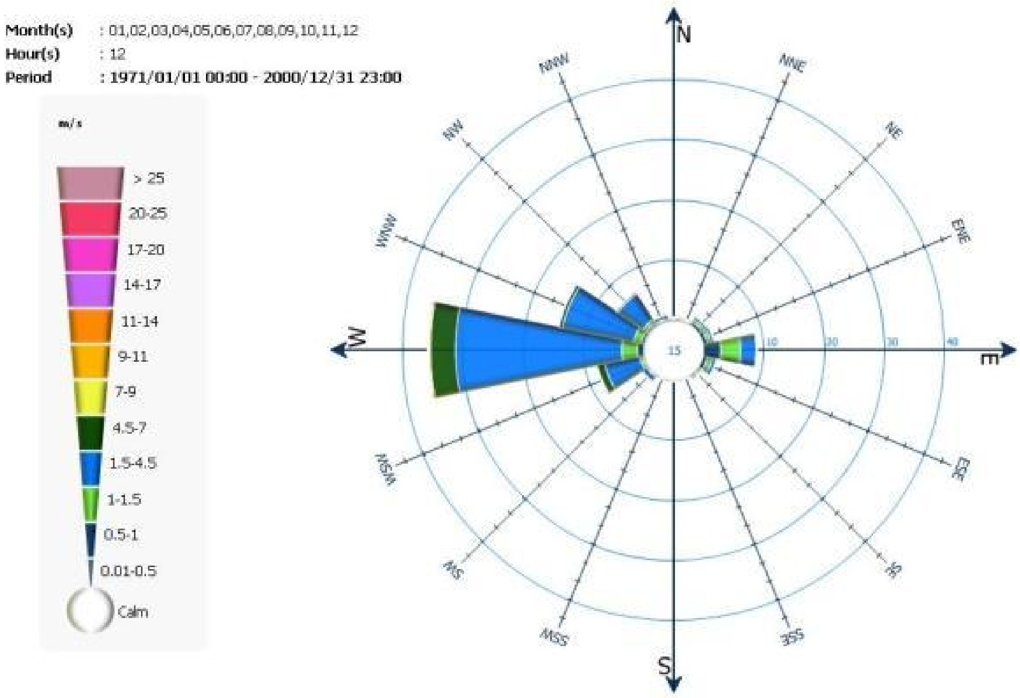
Month	Year								
	2007	2008	2009	2010	2011	2012	2013	2014	2015
Jun	22.3	20.4	20.4	17.6	20.5	21.1	20.8	21.4	20.8
Jul	20.2	21.3	21.7	21.6	21	21.2	21	21.1	20.3
Aug	20.5	19	21.6	21.3	20.5	19.2	NA	20.8	20.2
Sep	20.3	14.9	19.6	19.2	18.3	18.5	NA	18.9	17.7
Oct	13.4	11.6	12.6	15.9	12.6	12.7	NA	13.9	17.6
Nov	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

Month	Year								
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
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 4.8. 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 4.8. 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, 2 depots and 2 casting yards of the proposed project on two working days in the months of November and December 2017. The sample locations are shown in Figure 4.3.

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/m³**	**µg/m³**	**µg/m³**	**µg/m³**	**mg/m³**
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.	Budhwar 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

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
		03/11/17 to 04/11/17	5.3	5.30	325	81	2.6
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 in Figure 4.3 and 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.

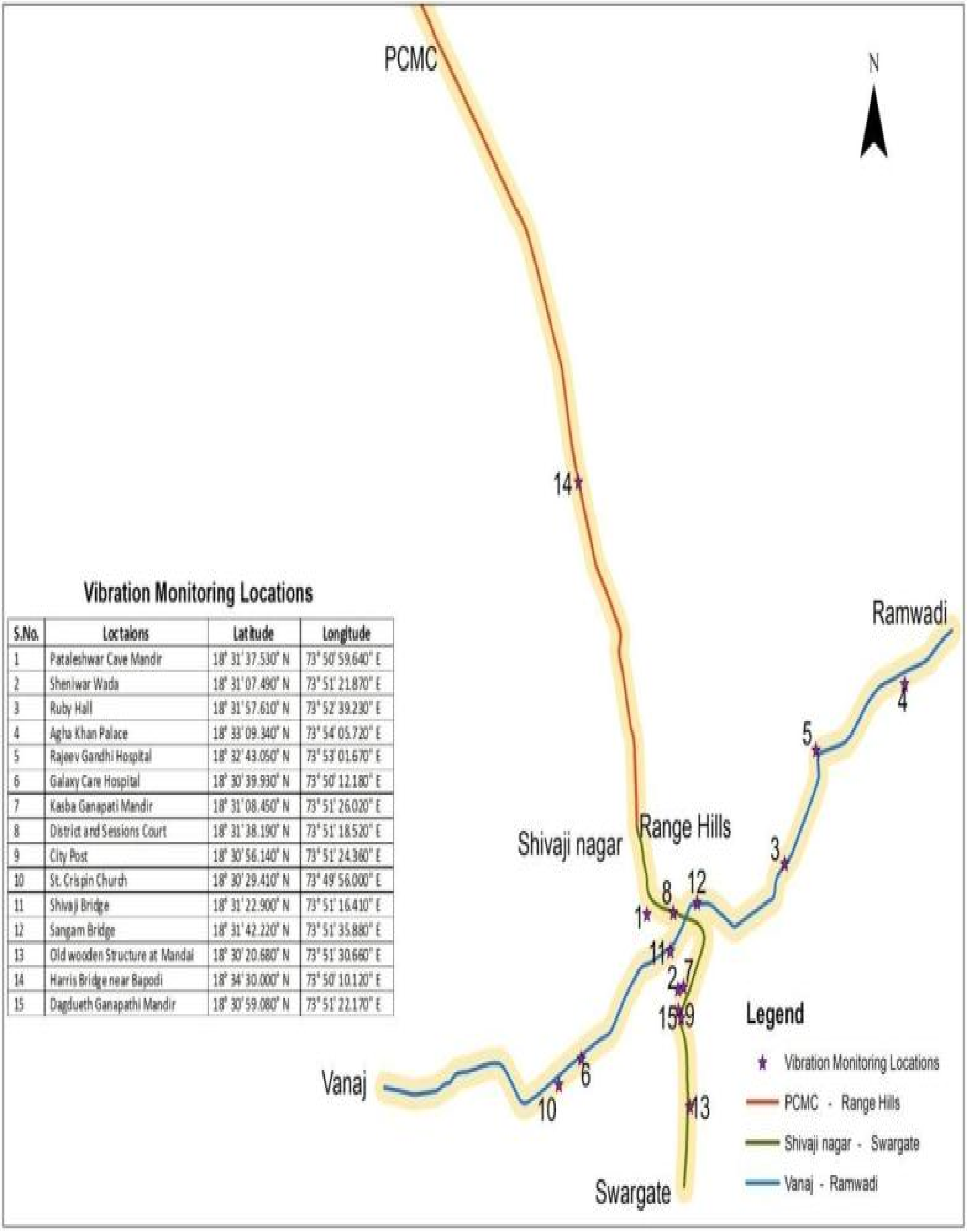
Ground-borne vibration can be a major concern for nearby neighbours of a transit system route or maintenance facility. Some common sources of ground-borne vibration are trains, buses on rough roads, and construction activities such as blasting, pile- driving and operating heavy earth-moving equipment.

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 4.9. 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	26^{h} Oct. 17	27th Oct. 17
15.	Agha Khan Palace	24th Oct. 17	25th Oct. 17

Figure 4.9. Vibration Monitoring Locations



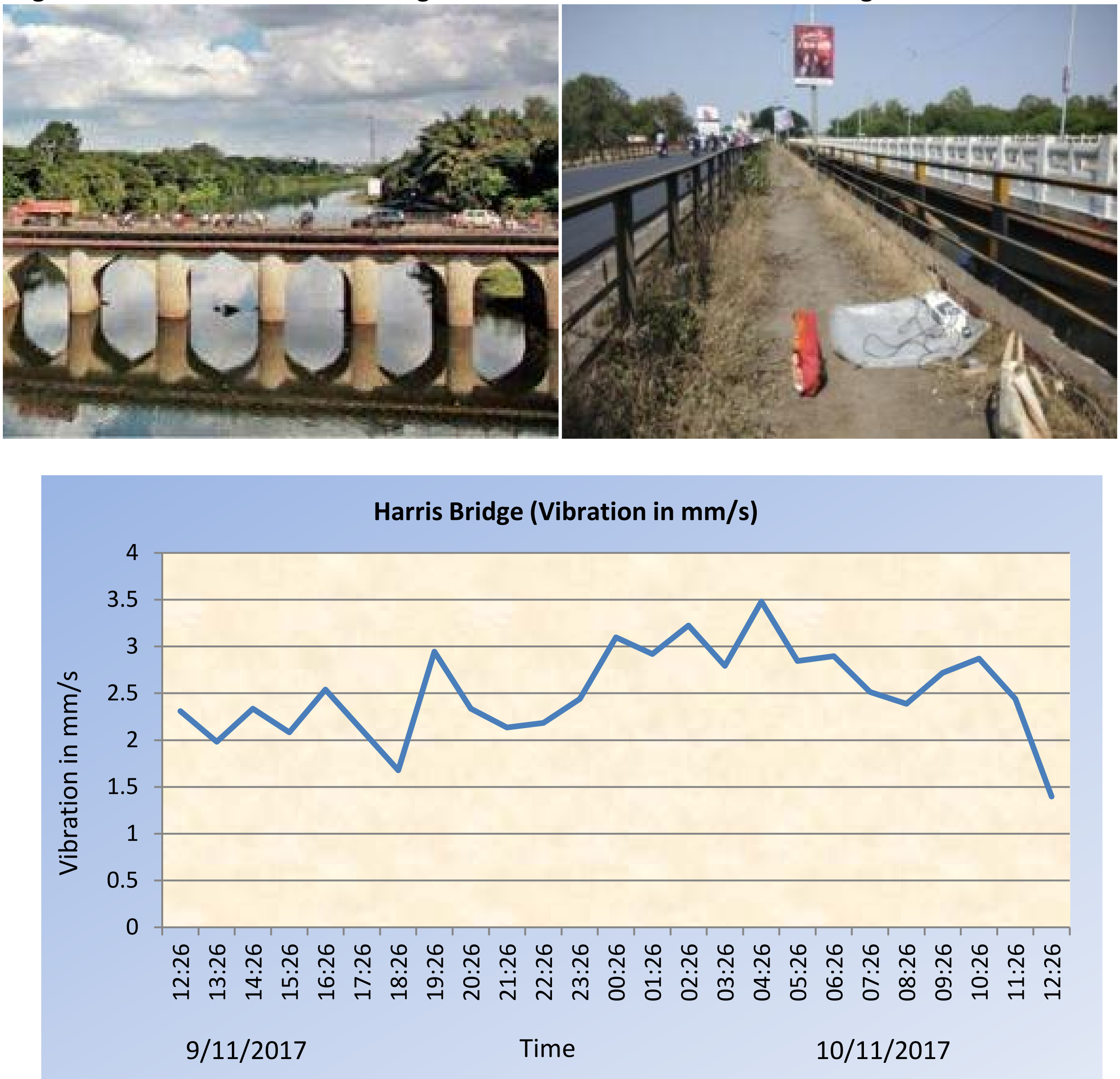
Vibration Monitoring Locations

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 Bridge are shown in Figure 4.10. The peak vibration is about 3.5 mm/s and the minimum vibration is around 0.4 mm/s.

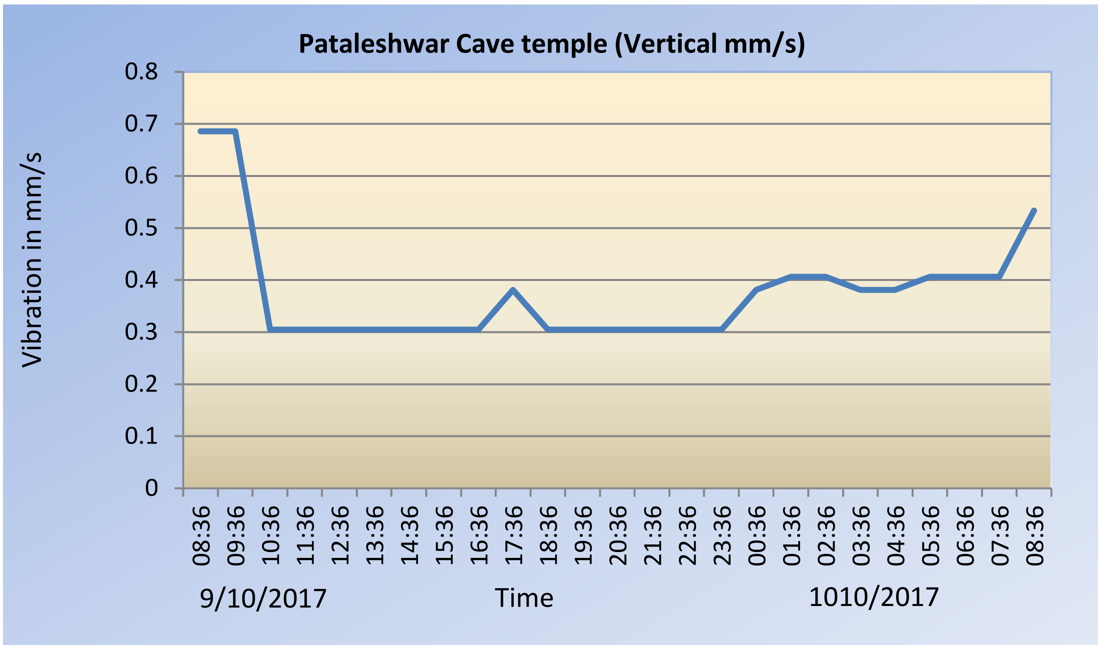
Figure 4.10. Vibration Monitoring Location and Results at Harris Bridge



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 4.11.

Figure 4.11. Vibration Monitoring Location and Results at Pataleshwar Cave Temple

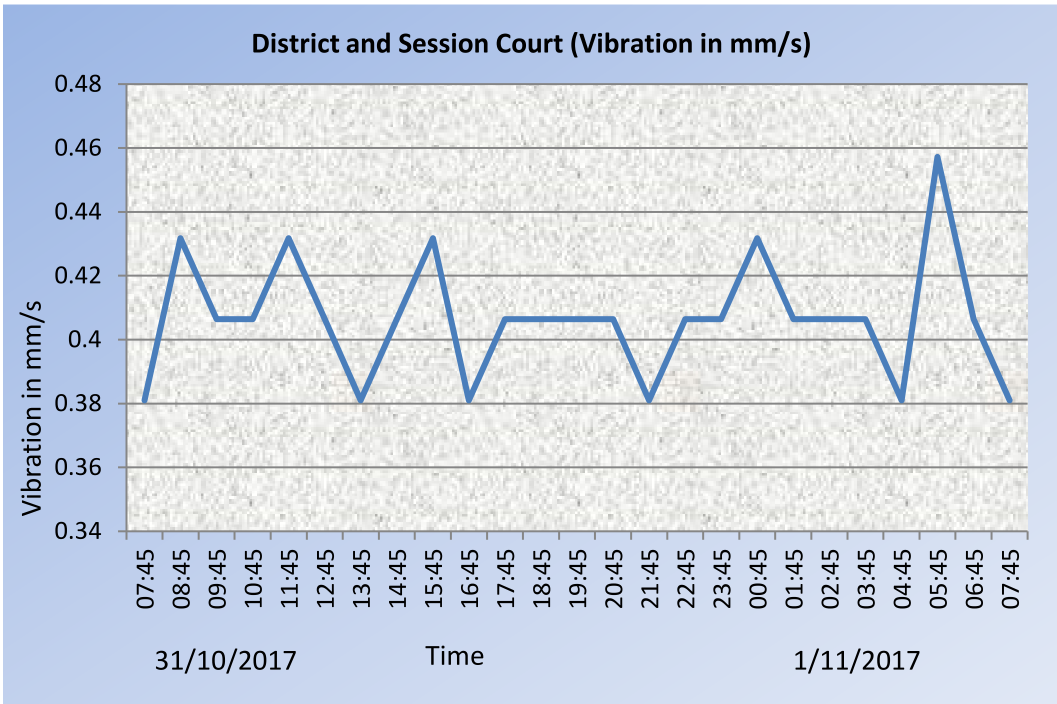


The result of the monitoring shows that, the vector sum vibration is between 0.3 to 0.7 mm/s, which is quite normal with regards to vibration levels due to road traffic. The Peak Vector sum vibration of the study location is found to be below o.69 mm/s.

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 4.12.

Figure 4.12. Vibration Monitoring Location and Results at District and Session Court



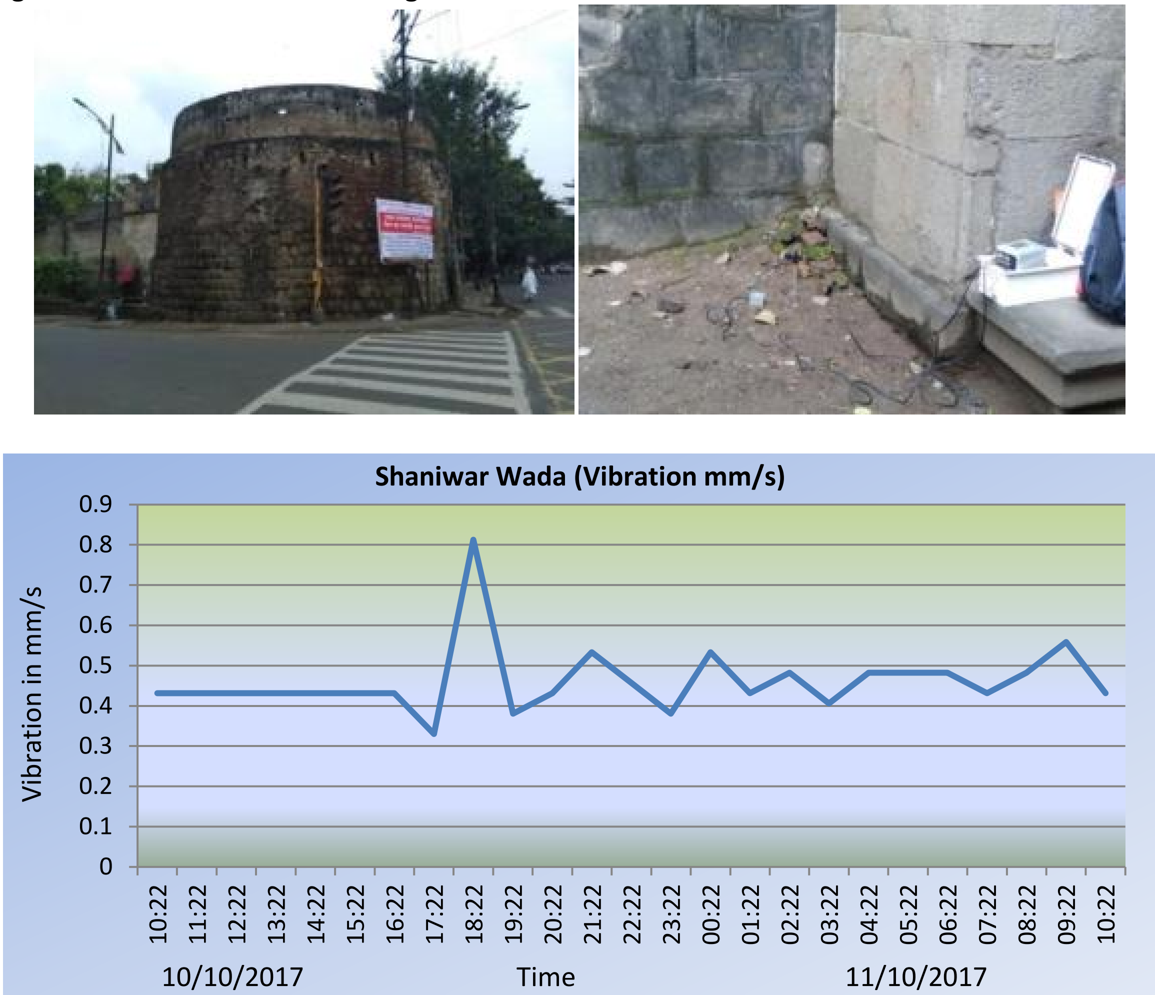
As can be seen from the graph, the peak vibration is about 0.45mm/s and the minimum vibration is around 0.38 mm/s.

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 4.13.

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.

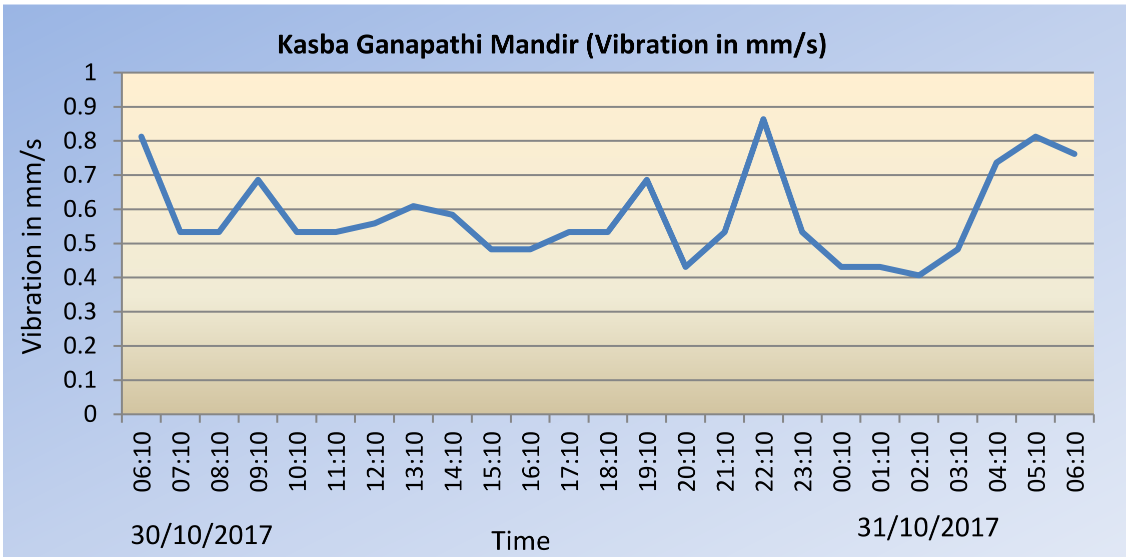
Figure 4.13. Vibration Monitoring Location and Results at Shaniwar Wada



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 Mandir are shown in Figure 4.14. The peak vibration is about 0.82mm/s and the minimum vibration is around 0.25 mm/s.

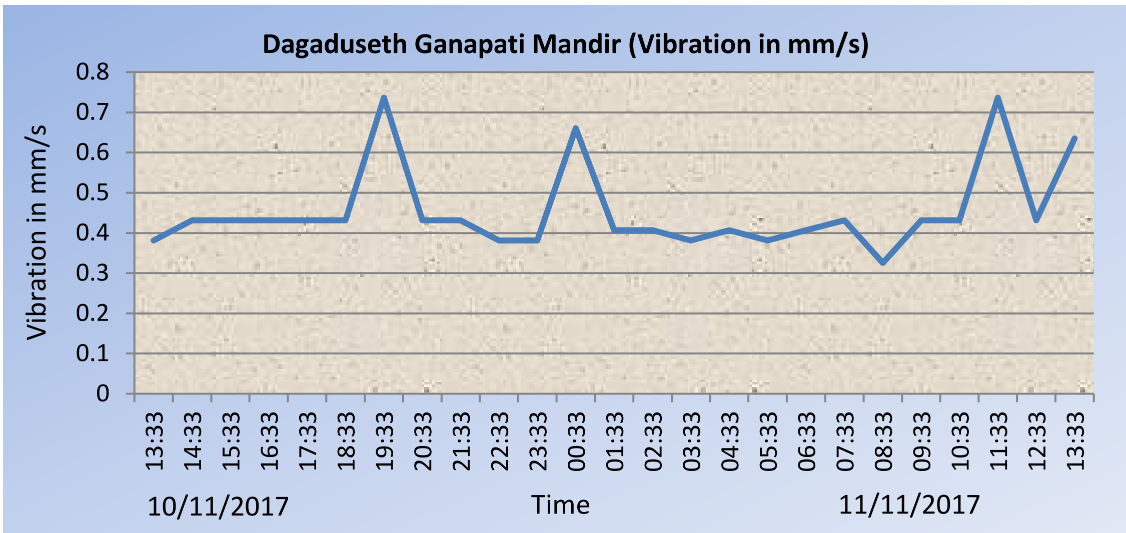
Figure 4.14. Vibration Monitoring Location and Results at Kasba Ganapati Mandir



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 Ganapati Mandir are shown in Figure 4.15. The peak vibration is about 0.75mm/s and the minimum vibration is around 0.3 mm/s.

Figure 4.15. Vibration Monitoring Location and Results at Dagaduseth Ganapati Mandir

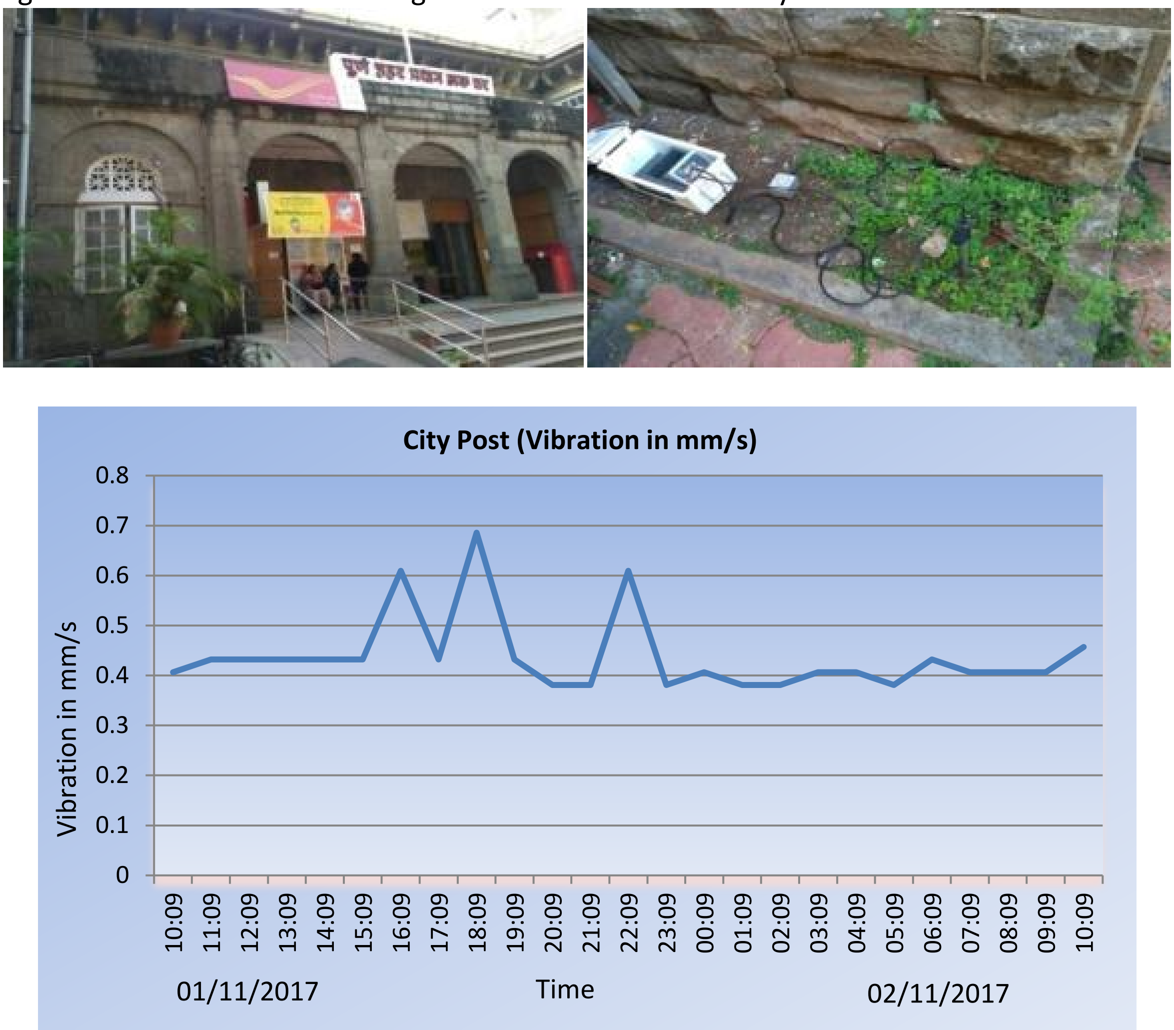


7. City Post

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 4.16.

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

Figure 4.16. Vibration Monitoring Location and Results at City Post

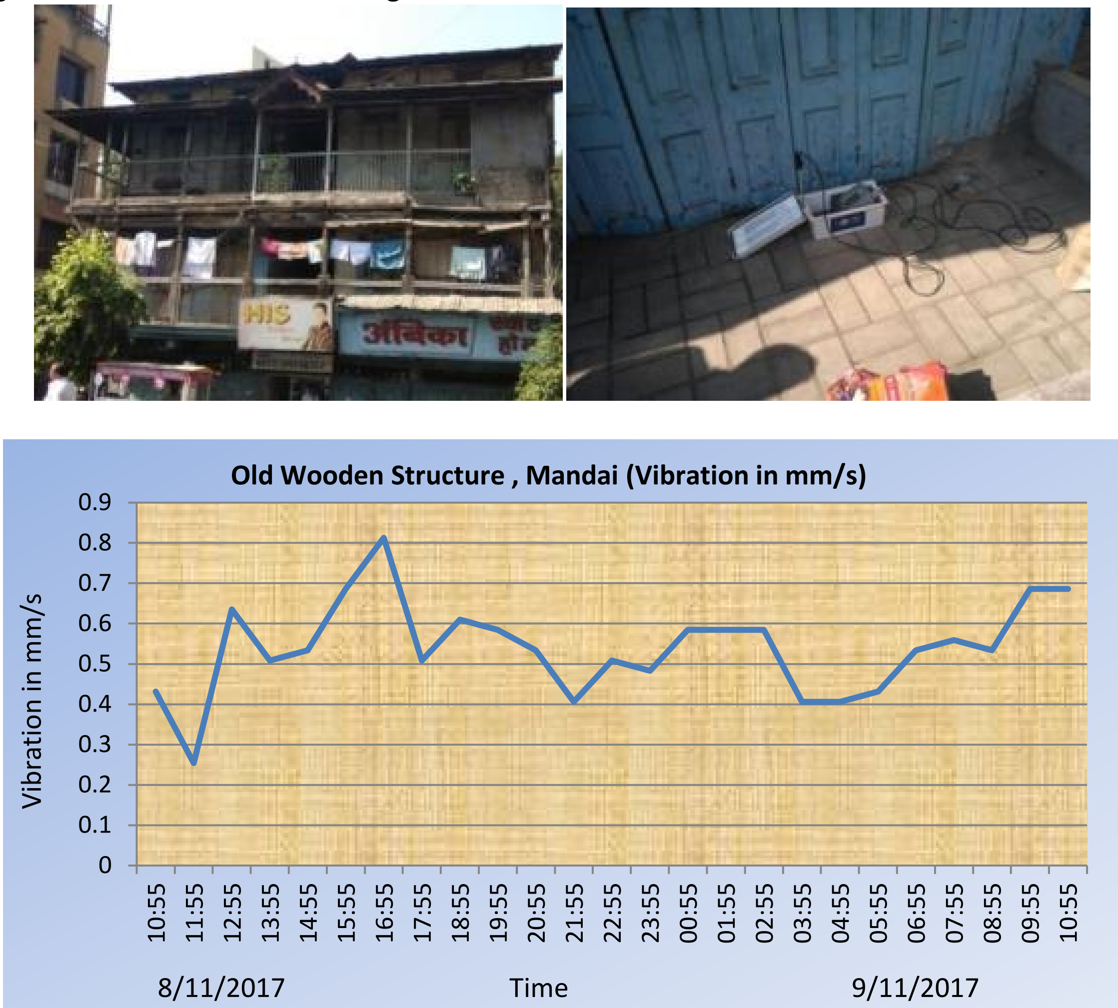


8. Old Wooden Structure at Mandai

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 Mandai are shown in Figure 4.17.

The peak vibration is about 0.8mm/s and 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.

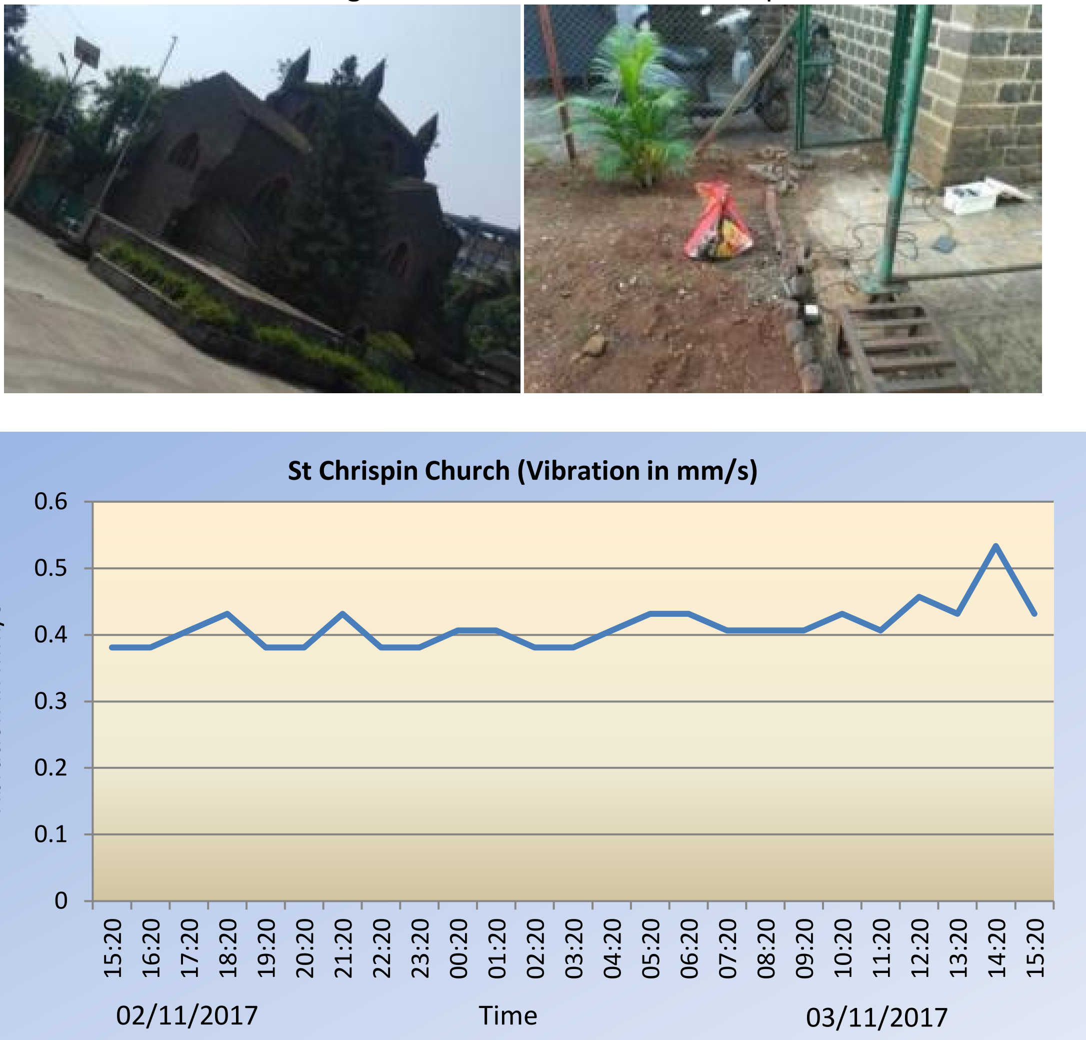
Figure 4.17. Vibration Monitoring Location and Results at Old Wooden Structure at Mandai



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 in Figure 4.18.

Figure 4.18. Vibration Monitoring Location and Results at St. Crispin Church



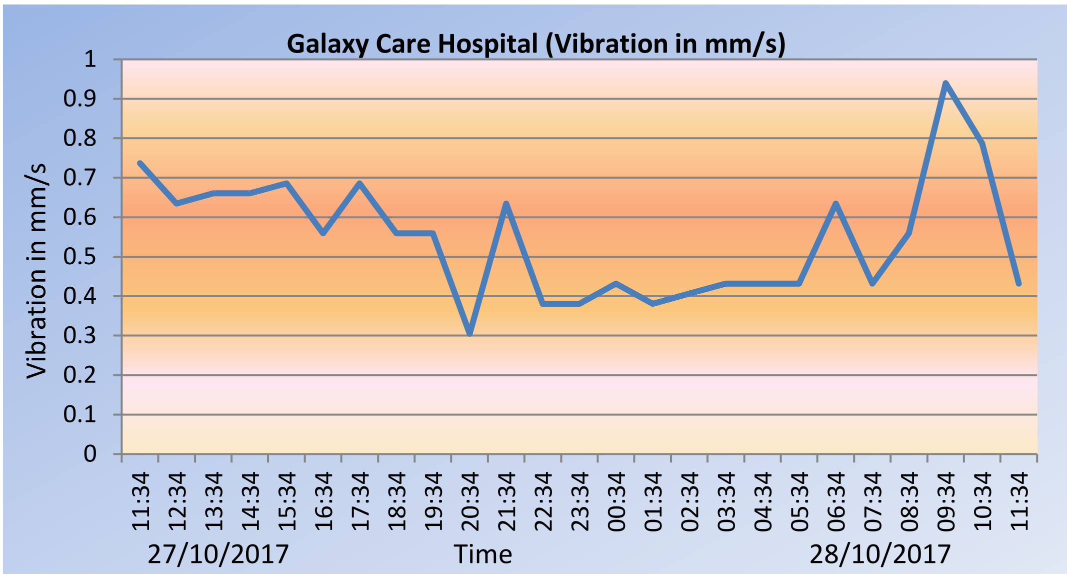
The peak vibration is about 0.54mm/s and the minimum vibration is around 0.25 mm/s.

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 in Figure 4.19.

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 4.19. Vibration Monitoring Location and Results at Galaxy Care Hospital

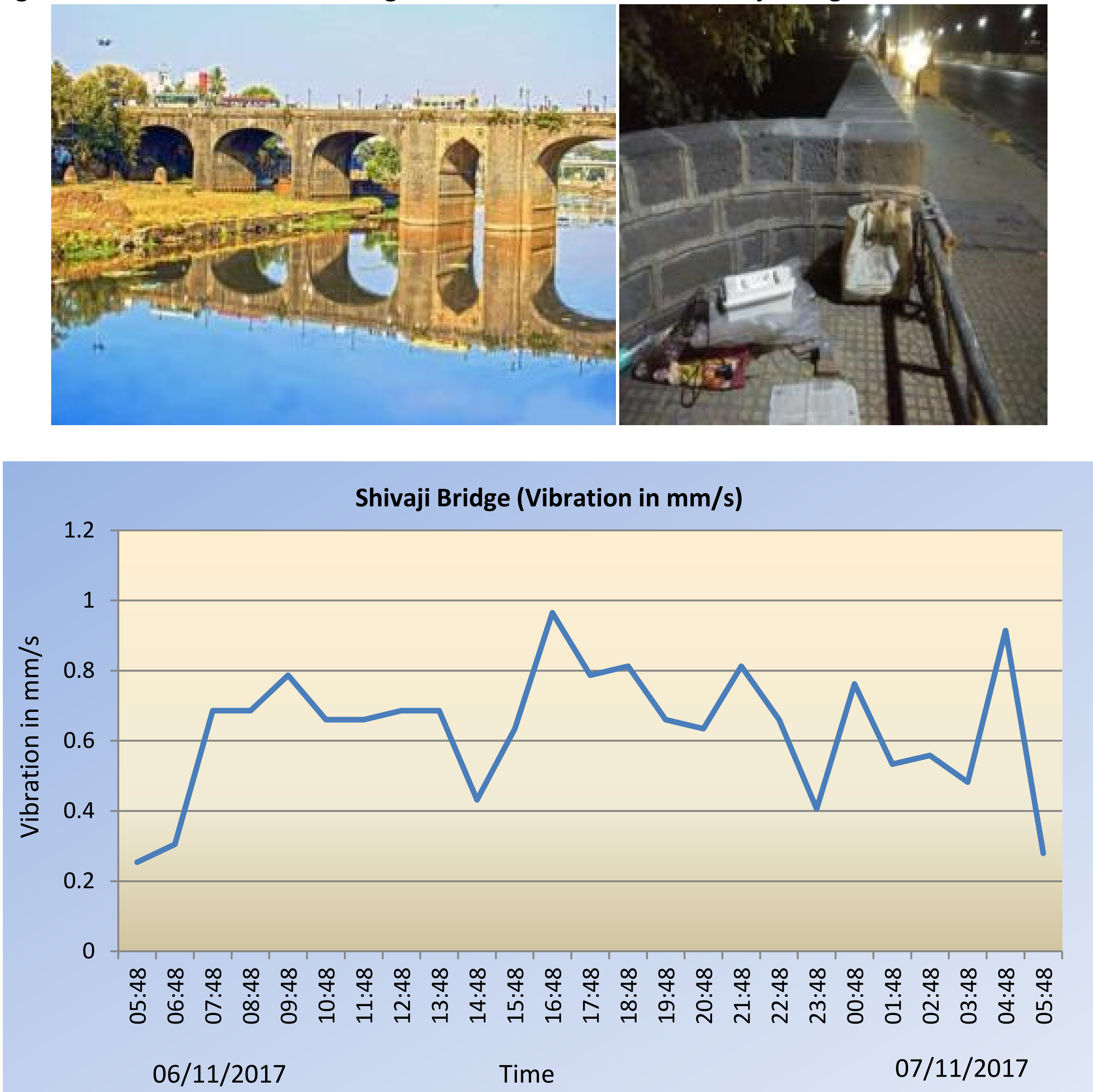


11. Shivaji Bridge

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 4.20.

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

Figure 4.20. Vibration Monitoring Location and Results at Shivaji Bridge

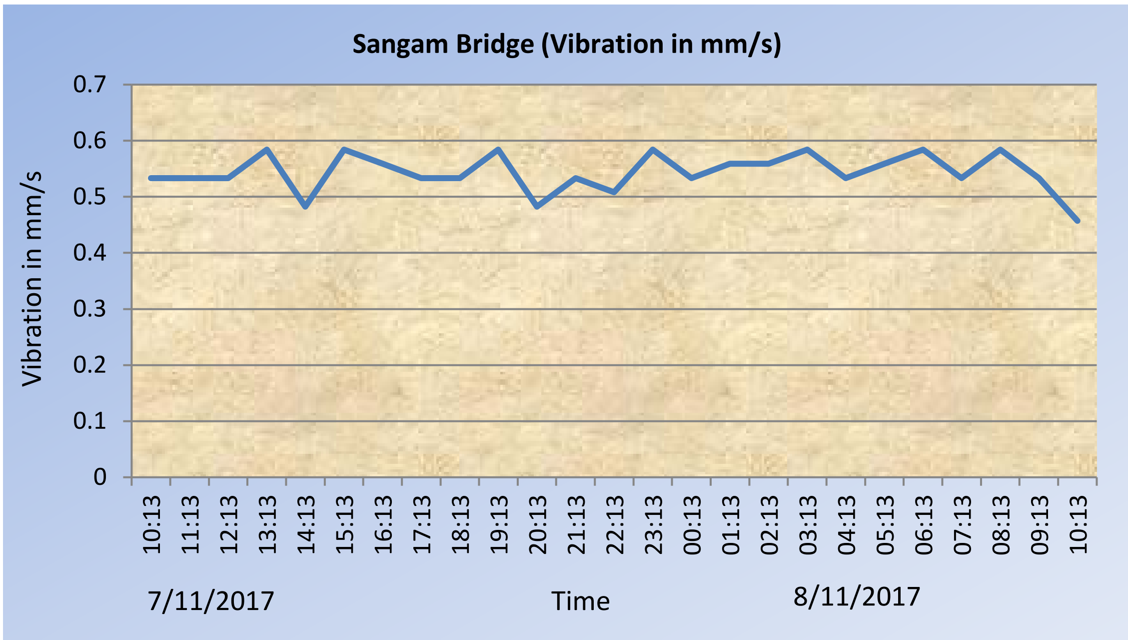


12. Sangam Bridge

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 4.21.

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

Figure 4.21. Vibration Monitoring Location and Results at Sangam Bridge

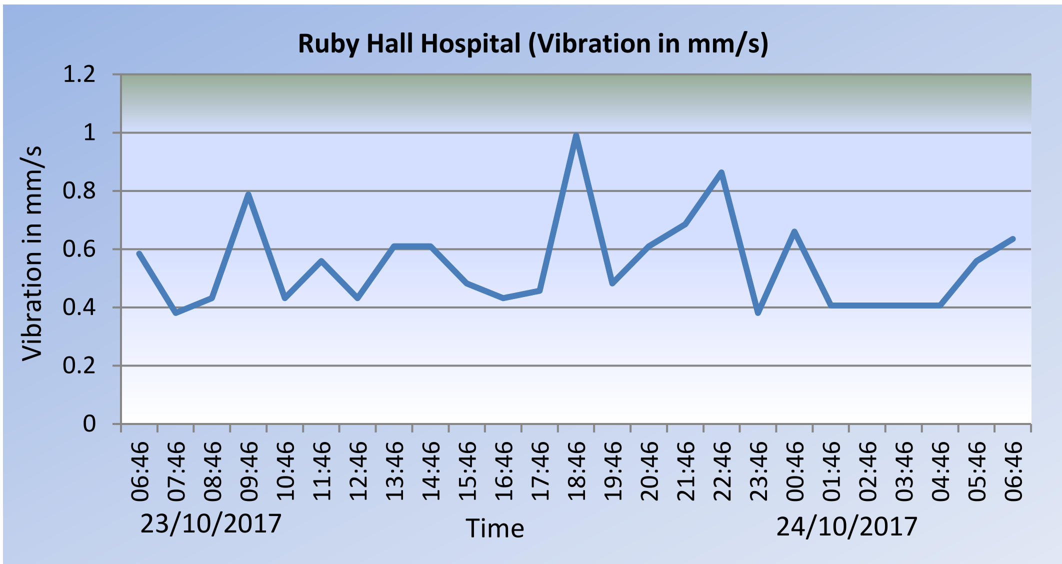


13. Ruby Hall Clinic

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 4.22.

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.

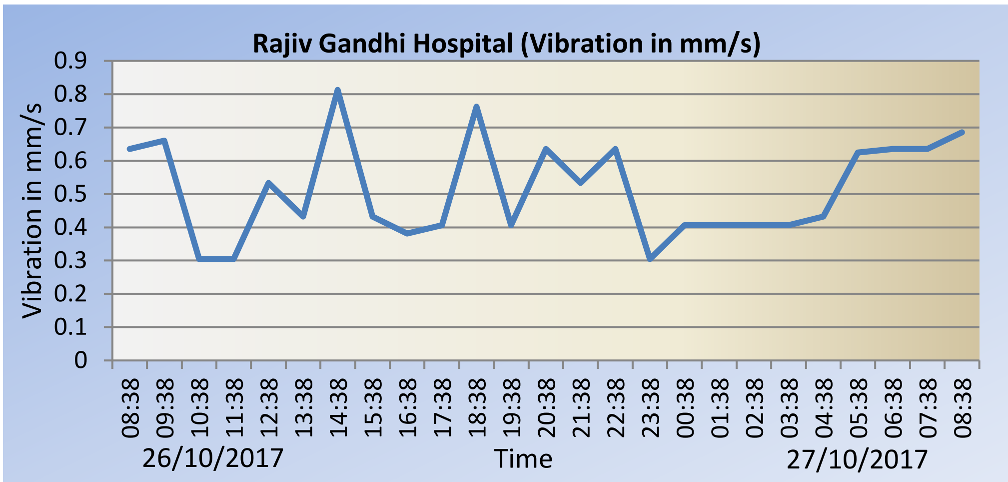
Figure 4.22. Vibration Monitoring Location and Results at Ruby Hall Clinic



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 Hospital are shown in Figure 4.23.

Figure 4.23. Vibration Monitoring Location and Results at Rajiv Gandhi Hospital

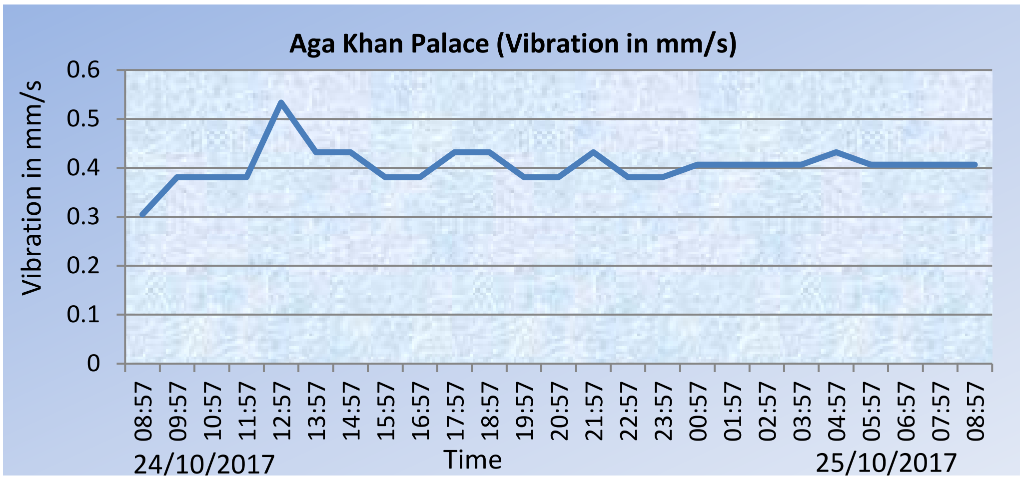


The graph shows that the vibration at Currency Building is 0.3 to 0.8 mm/s. The peak vibration is around 0.8 mm/s.

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 Palace are shown in Figure 4.24. 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 4.24. Vibration Monitoring Location and Results at Aga Khan Palace



4.5. ECOLOGICAL ENVIRONMENT AND BIO-DIVERSITY

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/Presence of Trees along the Corridors

The vegetation pattern of the city is conducive almost for all types of tropical species - indigenous and exotic both. Total 2452 no. of trees likely to be impacted against the earlier estimation of 1125 no. of trees. The impacted tree numbers has gone up due to change in alignment (to avoid the Agan Khan Palace) increase in alignment length and various other factors like R&R issues and design. Most of the site clearing and civil works has been completed hence further impact on trees are not envisaged. However, the new plantation is still balace and will be planted in coming months.

Out of 2452 impacted trees, 2264 to be transplanted at various locations of the City whereas 188 trees would be felled due to non feasibility of transplantation viz. age, safety concerns.

4.5.2. Bio-diveristy

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.

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

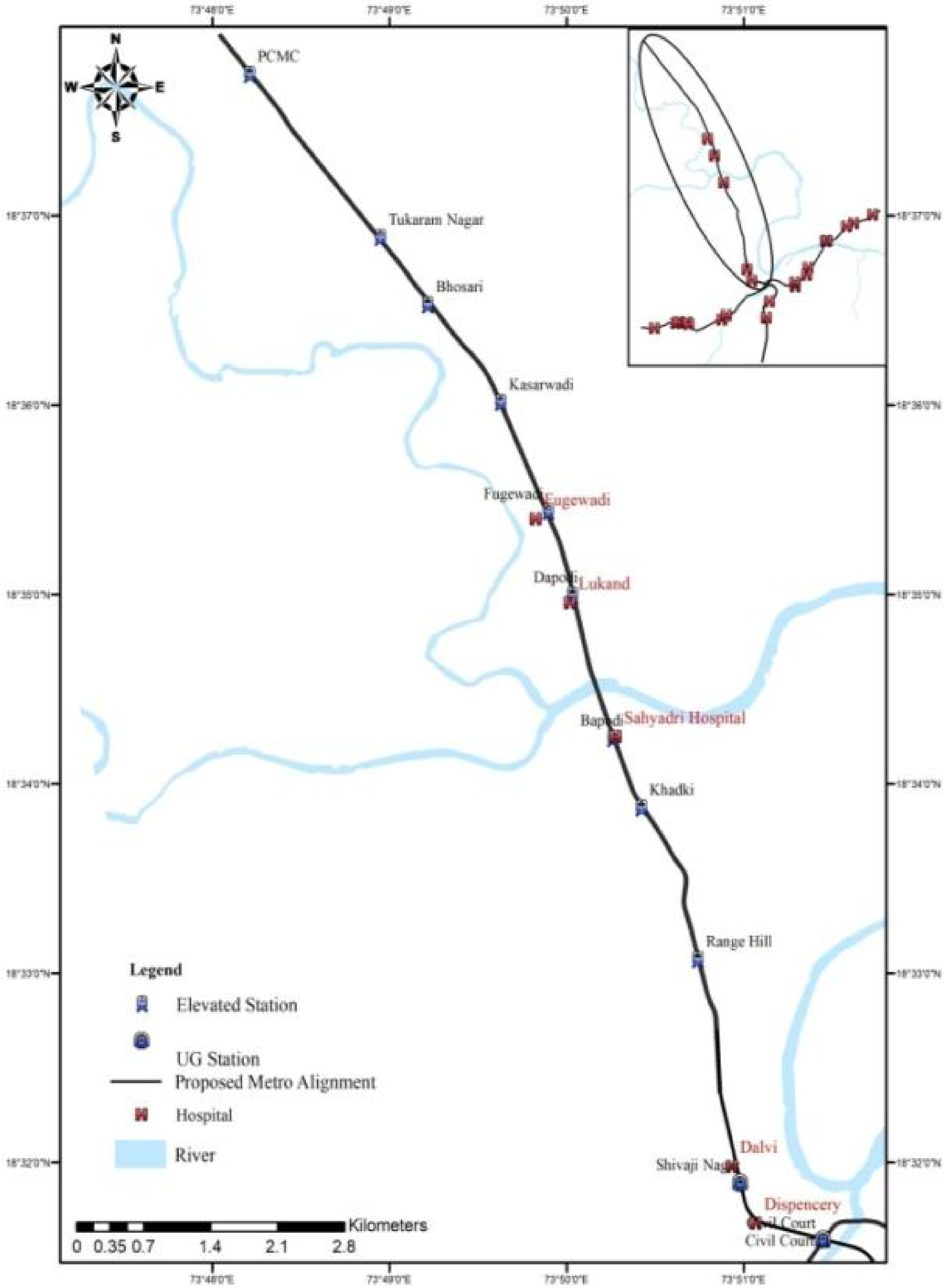
From the alignment drawings made available by Maha-Metro for Pune Metro Rail Project, the sensitive receptors were noted down corridor wise as given in Table 4.12. Details of VECs within ROW are given in **Annexure 5.1**. Map showing list of Hospitals and Educational Institutes along the proposed corridors are given in Figure 4.25 and Figure 4.26.

Table 4.12.VECs of Metro Corridors

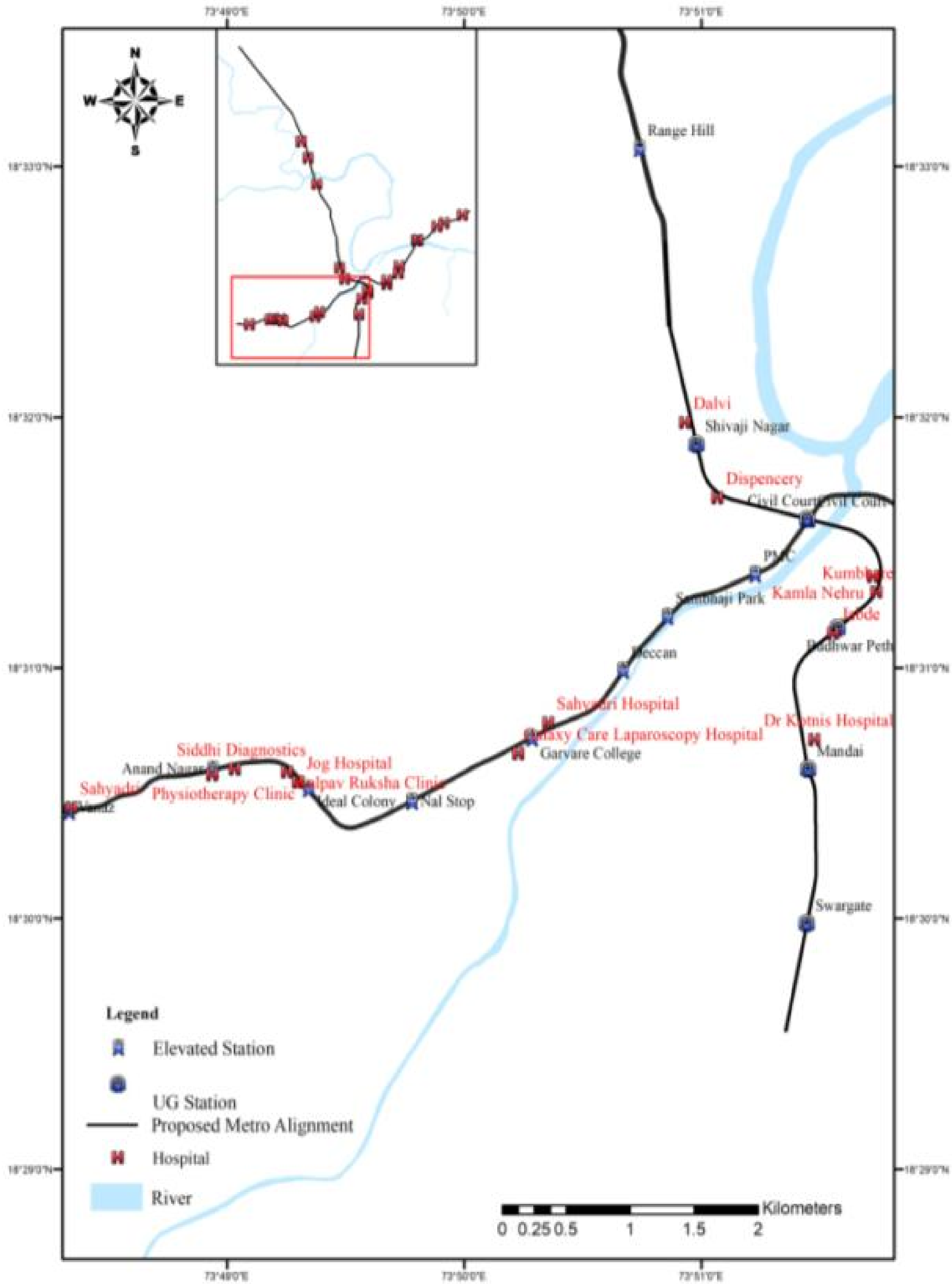
Alignment	**VECs within**									
	ROW				**100 m on either side of CL of alignment**					
	Temple	**Mosque /Dargah**	**School/ College**	**Hos pital**	**Temple**	**Mosque /Dargah**	**Church**	**School/ College**	**Hos pital**	**Grave Yard**
PCMC-Range Hill (Elevated Section)	1	1	0	0	30	0	1	4	4	1
Shivaji Nagar – Swargate (UG Section)	9	1	3	1	49	1	0	8	5	0
Vanaz – Civil Court (Elevated Section)	5	0	0	0	40	2	1	6	11	0
Civil Court – Ramwadi (Elevated Section)	2	0	0	0	21	5	0	4	12	2
Total	**17**	**2**	**3**	**1**	**136***	**8**	**2**	**22**	**32**	**3**

* Total is 136; of which 4 temples are common at Civil Court Intersection station between N-S & E-W corridors

Figure 4.25. Hospitals along the Proposed Alignments


73°48'0"E
73°49'0"E
73°50'0"E
73°51'0"E
18°37'0"N
18°36'0"N
18°35'0"N
18°34'0"N
18°33'0"N
18°32'0"N
N
S
W
E
PCMC
Tukaram Nagar
Bhosari
Kasarwadi
Fugewadi
Fugewadi
Lukand
Sahyadri Hospital
Khadki
Range Hill
Dalvi
Dispencery
Civil Court
Legend
Elevated Station
UG Station
Proposed Metro Alignment
Hospital
River
Kilometers
0 0.35 0.7 1.4 2.1 2.8

Contd. …


Range Hill
Dalvi
Shivaji Nagar
Dispencery
PMC
Kamla Nehru
Budhwar Peth
Deccan
Sahyadri Hospital
Dr Kotnis Hospital
Mandai
Garvare College
Siddhi Diagnostics
Anand Nagar
Jog Hospital
Physiotherapy Clinic
Nal Stop
Swargate
Legend
Elevated Station
UG Station
Proposed Metro Alignment
Hospital
River
Kilometers
0 0.25 0.5 1 1.5 2

Contd. …

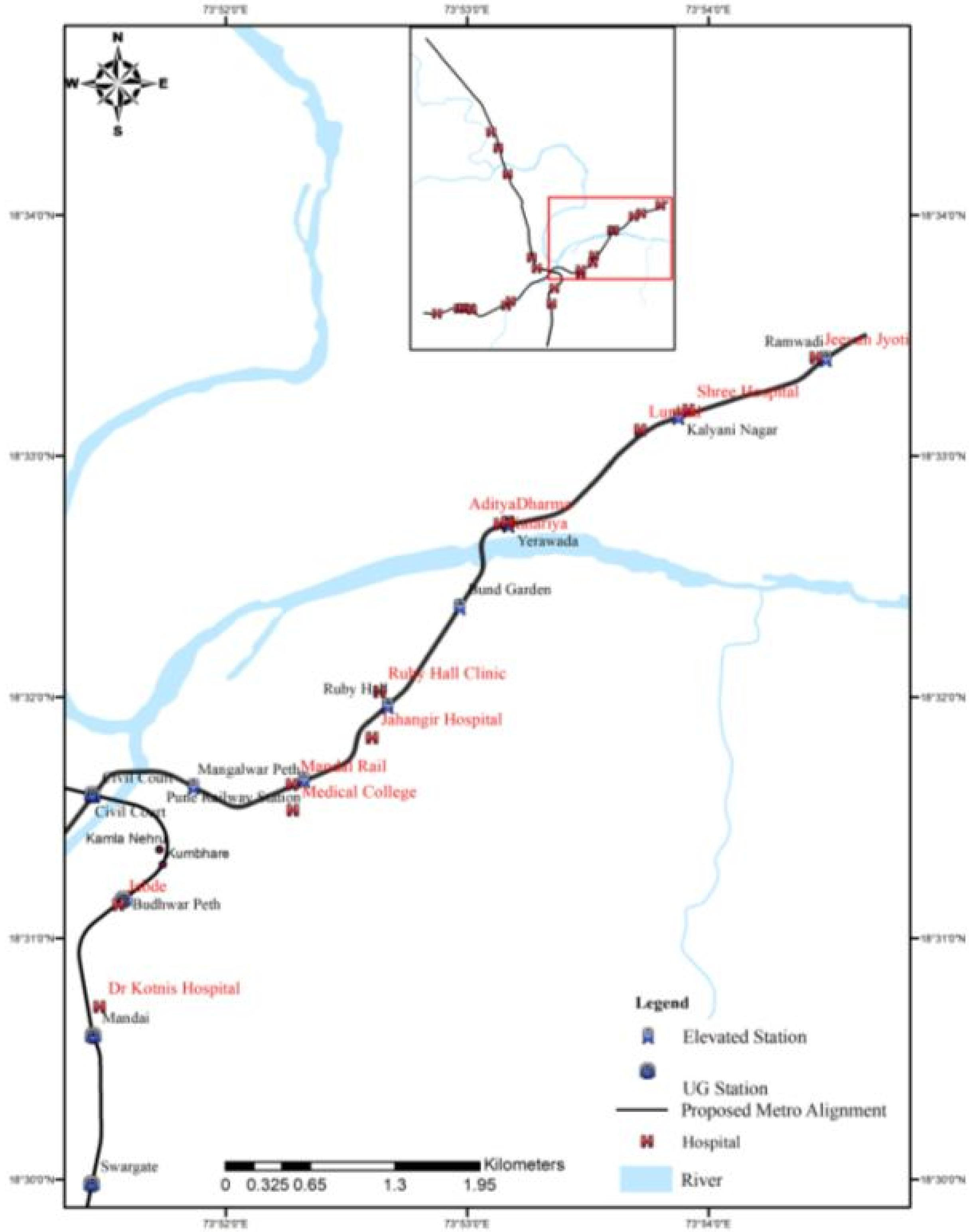
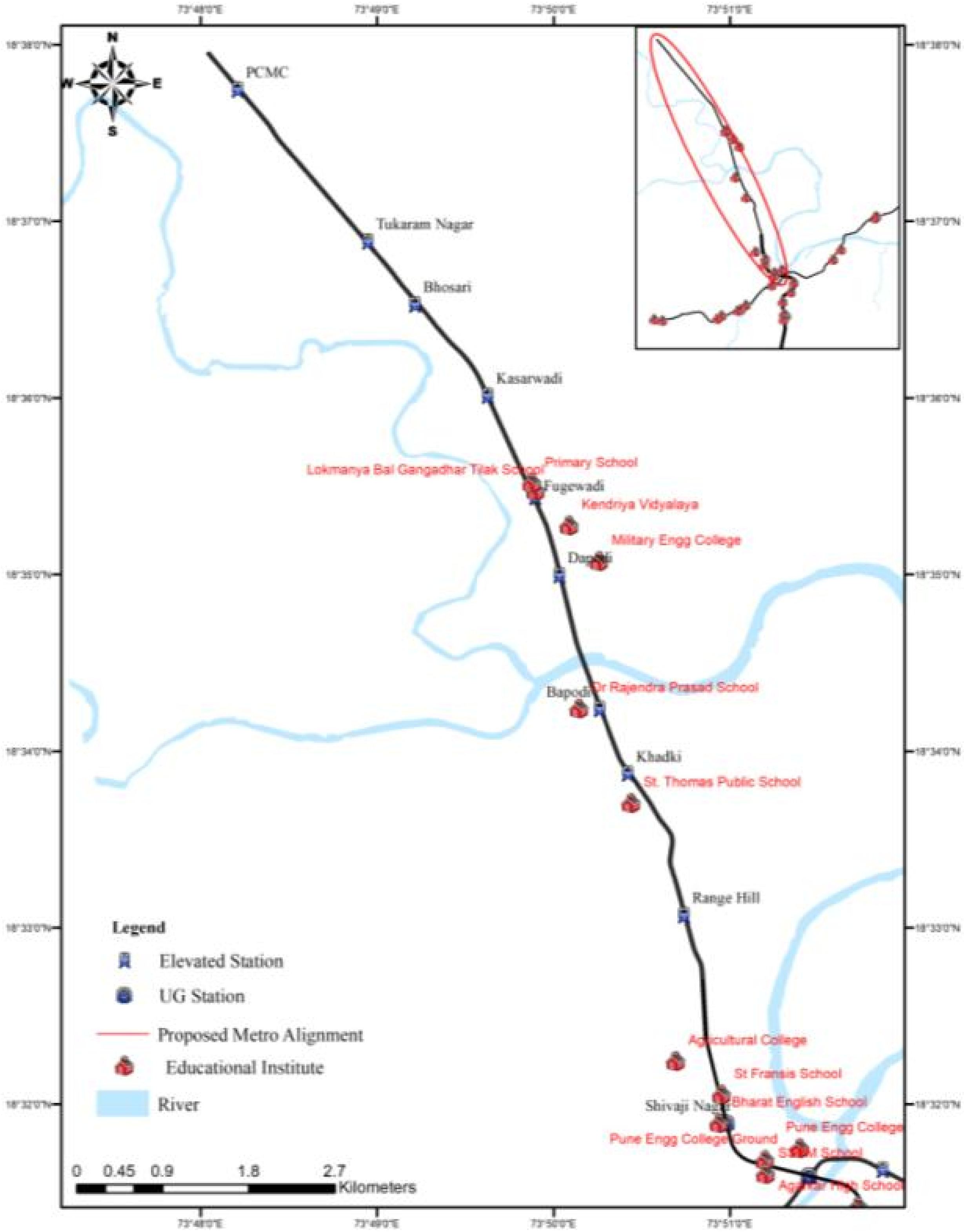

Ramwadi
Kalyani Nagar
Shree Hospital
Yerawada
Bund Garden
Ruby Hall Clinic
Jahangir Hospital
Mangalwar Peth
Medical College
Civil Court
Kamla Nehru
Kumbhare
Budhwar Peth
Dr Kotnis Hospital
Mandai
Swargate
Kilometers
0 0.325 0.65 1.3 1.95
Legend
Elevated Station
UG Station
Proposed Metro Alignment
Hospital
River

Figure 4.26. Educational Institutes along the Proposed Alignments



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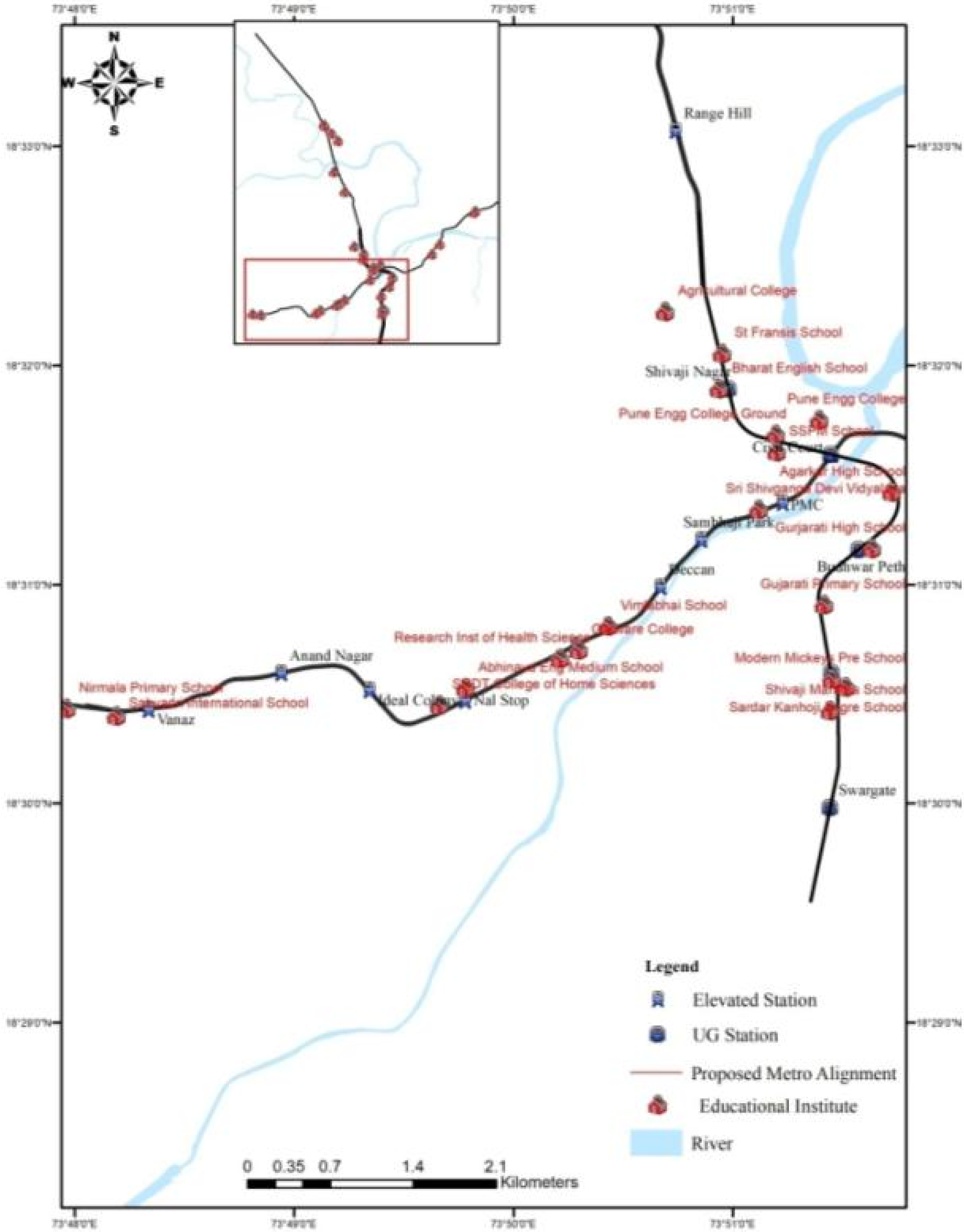
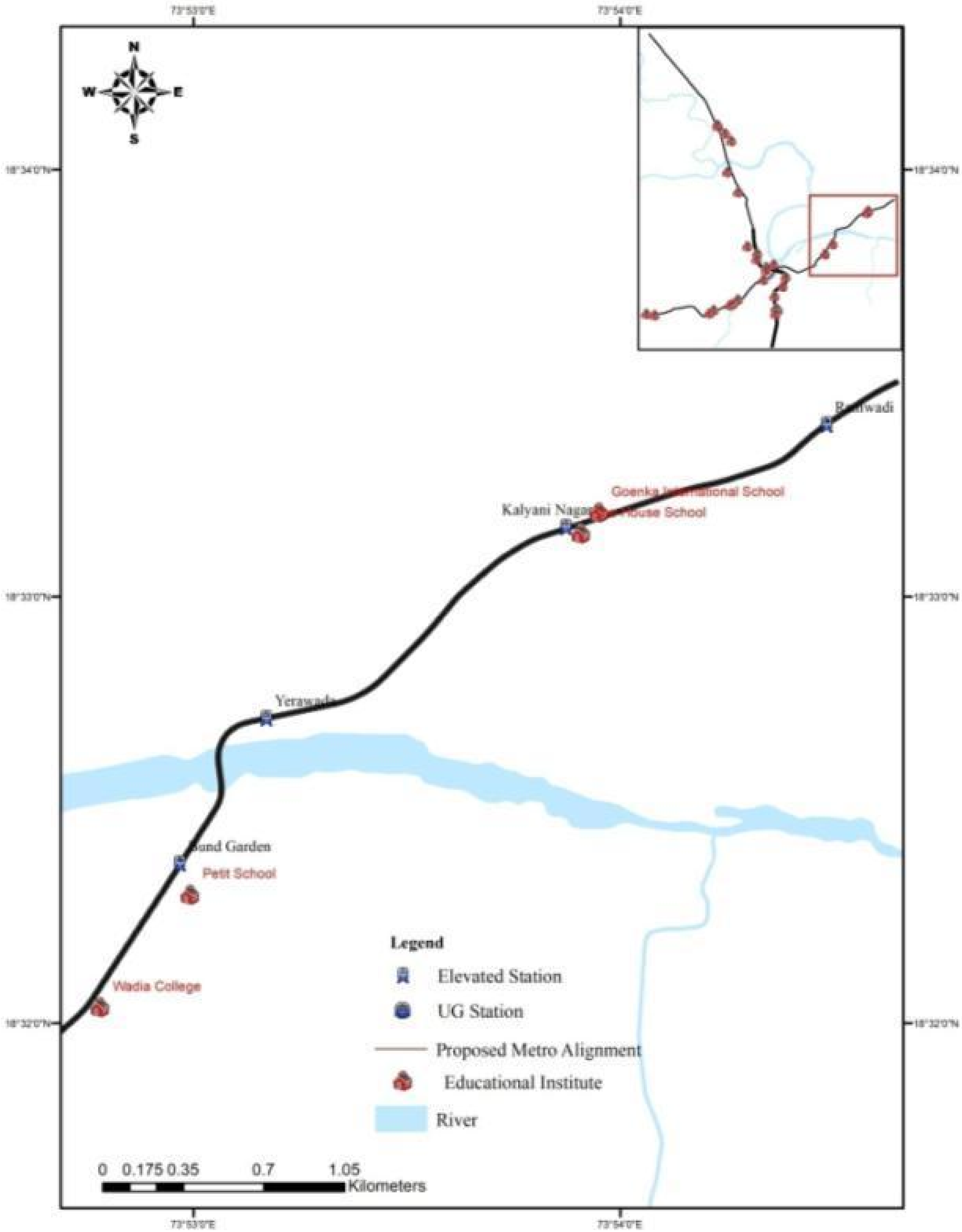

Range Hill
Agricultural College
St Fransis School
Shivaji Nagar
Bharat English School
Pune Engg College
Pune Engg College Ground
SSPM School
Agarkar High School
Sri Shivganga Devi Vidyalaya
PMC
Sambhaji Park
Gurjarati High School
Deccan
Budhwar Peth
Gujarati Primary School
Vimlabhai School
Research Inst of Health Sciences
Garware College
Anand Nagar
Abhinav Eng Medium School
SNDT College of Home Sciences
Modern Mickeys Pre School
Shivaji Maratha School
Sardar Kanhoji Angre School
Nirmala Primary School
Satyadev International School
Vanaz
Ideal Colony
Nal Stop
Swargate
Legend
Elevated Station
UG Station
Proposed Metro Alignment
Educational Institute
River
0 0.35 0.7 1.4 2.1 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 4.27. The metro corridors near the monuments fall in regulated area (The Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010) of monument as the distance from Metro alignment is between 100m to 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	178 m	Regulated Area
2.	Shaniwarwada	Budhwar Peth	168 m	Regulated Area
W-E Alignment				
3.	Agakhan Palace	Kalyani Nagar	116 m	Regulated Area

B. Heritage Buildings, Heritage Precincts and Natural Features

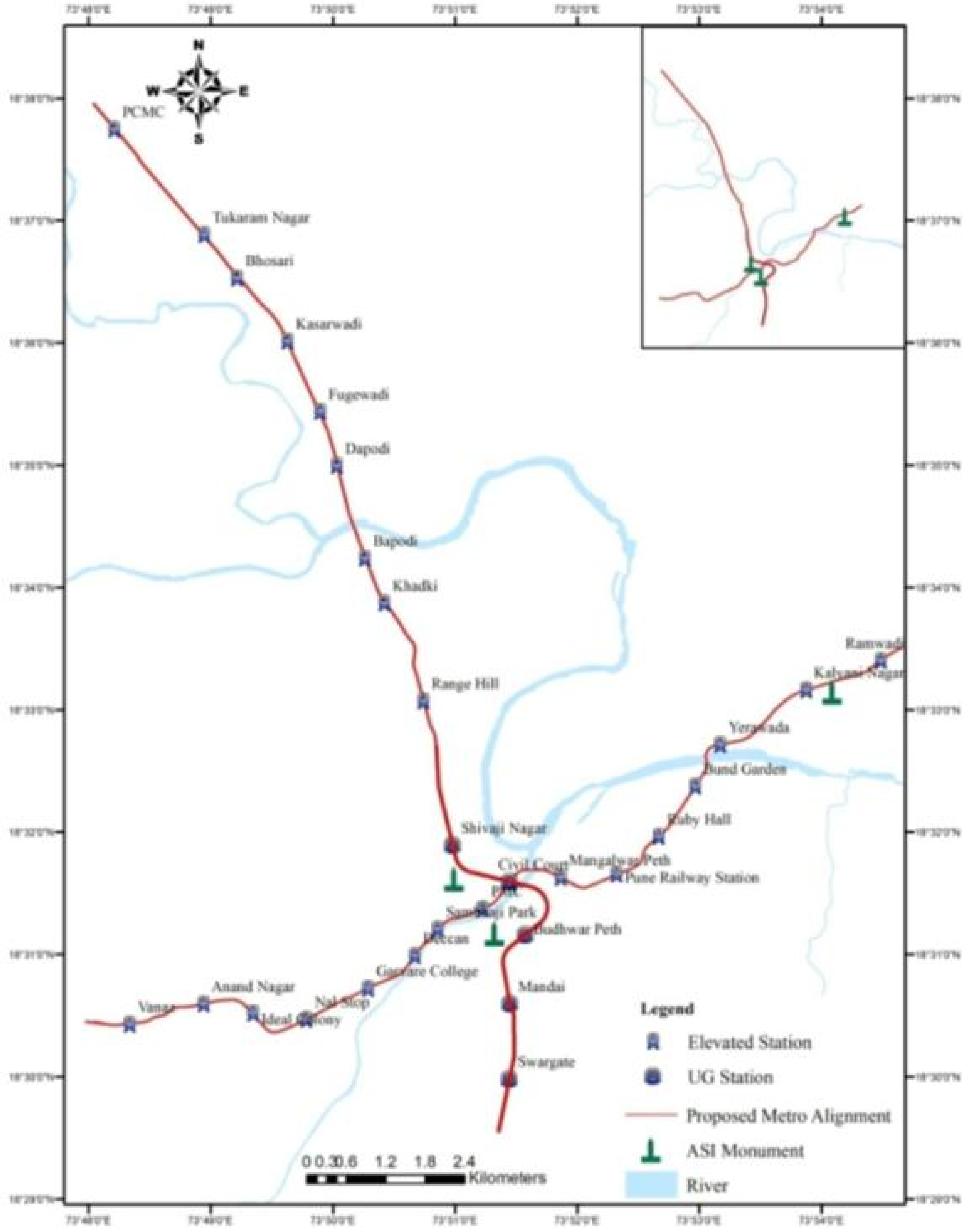
Pune Municipal Corporation has identified a list of heritage buildings, artifacts, structures, area and precincts of historic and/or architectural and/or cultural significance and those natural features of environmental significance including scared groves, hills, hillocks, water bodies etc.

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.

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.

Figure 4.27. ASI Monuments along the Proposed Alignments



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.

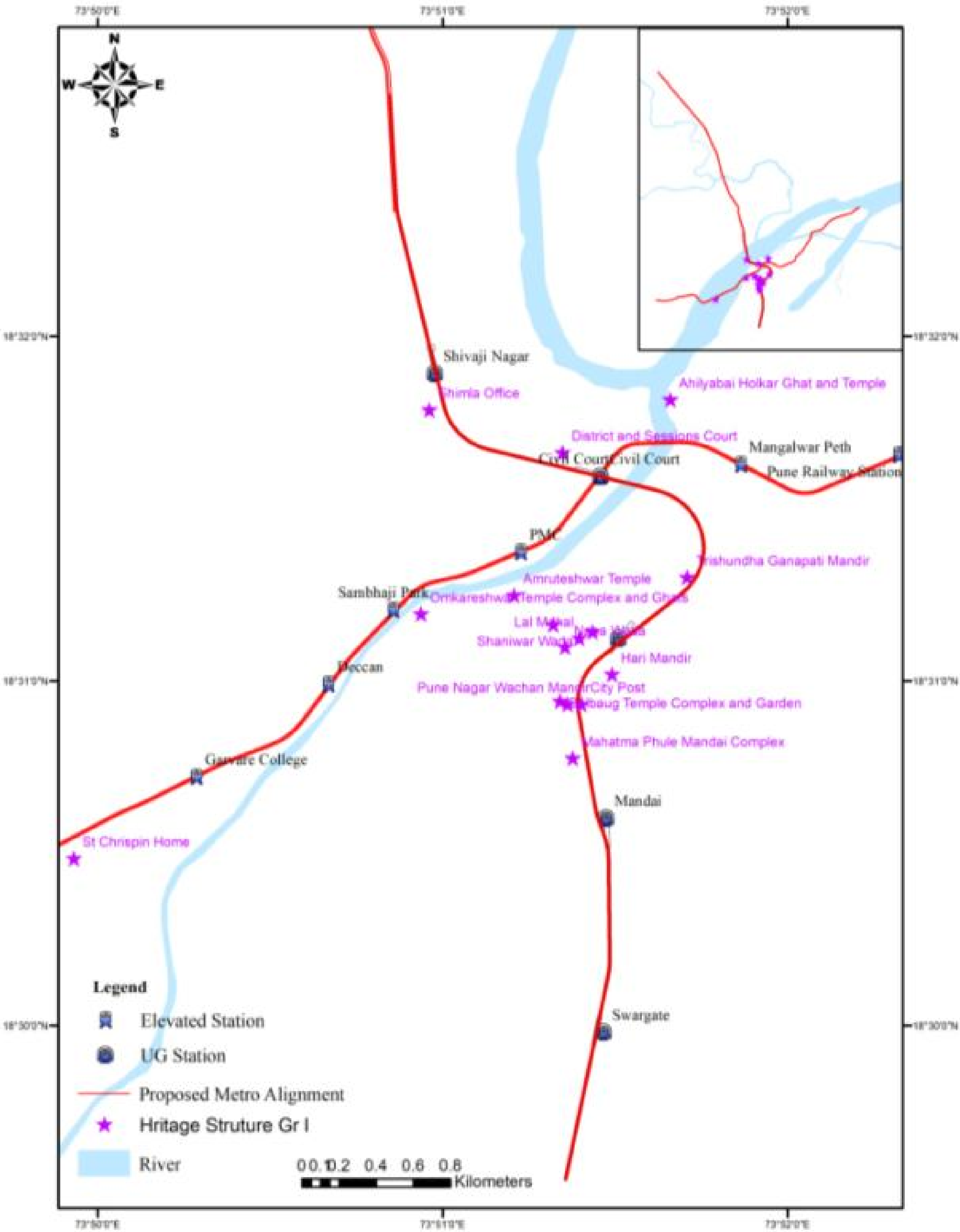
List of heritage assets near the proposed alignments is presented in Table 4.14 and shown in Figure 4.28. District and Sessions Court and City Post of Grade I List are located above the underground N-S alignment; elevated W-E alignment flies above Sambhaji Bridge and Shivaji Bridge and Vridheshwar Temple & 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

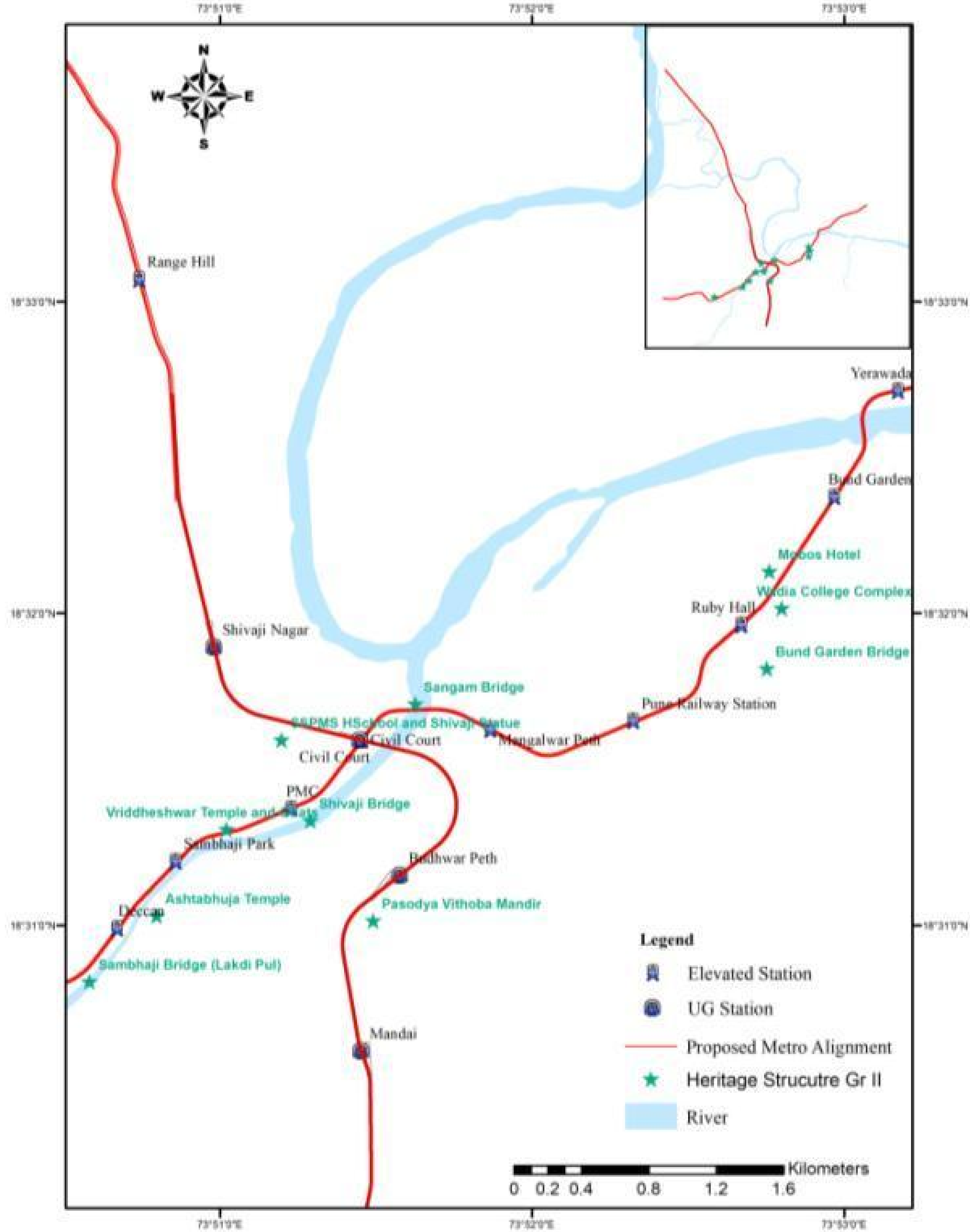
S. No	Name of the Monument	Nearest Metro Station	Distance from the Centreline of Metro Alignment	Remarks
PCMC - Range Hill				
		Grade I & II - Nil		
Range Hill – Swargate				
		Grade I		
1.	Shimla Office	Shivaji Nagar	84 m	UG Section
2.	District and Sessions Court	Civil Court	22 m	UG Section
3.	Trishundha Ganapati Mandir	Budhwar Peth	35 m	UG Section
4.	Kasba Ganapati Mandir	Budhwar Peth	108 m	UG Section
5.	Lal Mahal	Budhwar Peth	142 m	UG Section
6.	Shaniwar wada	Budhwar Peth	167 m	
7.	Nana Wada	Budhwar Peth	167 m	UG Section
8.	Hari Mandir	Budhwar Peth	110 m	UG Section
9.	City Post	Budhwar Peth	4 m	UG Section
10.	Pune Nagar WachanMandir	Budhwar Peth	51 m	UG Section
11.	Belbaug Temple Complex and Garden	Budhwar Peth	90 m	UG Section
12.	Mahatma PhuleMandai Complex	Budhwar Peth	30 m	UG Section
		Grade II		
13.	SSPMS HSchool and Shivaji Statue	Civil Court	49 m	UG Section
14.	PasodyaVithobaMandir	Budhwar Peth	115 m	UG Section
Vanaz - Civil Court				
		Grade I		
15.	St Chrispin Home	Nal Stop	111 m	Elevated
16.	Omkareshwar Temple Complex and Ghats	Sambhaji Park	102 m	Elevated
		Grade II		
17.	SNDT College	Nal Stop	35 m	Elevated
18.	Sambhaji Bridge	Deccan	0 m	Elevated
19.	Ashtabhuja Temple	Deccan	148 m	Elevated
20.	Vriddheshwar Temple and Ghats	Sambhaji Park	0 m	Elevated
21.	Shivaji Bridge	PMC	0 m	Elevated
Civil Court - Ramwadi				
		Grade I		
22.	AhilyabaiHolkarGhat and Temple	MangalwarPeth	188 m	Elevated
23.	Agakhan Palace	Kalyani Nagar	116 m	Elevated

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

Figure 4.28. 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.Table 4.1: 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.Table 4.2: 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

Total land requirement for both the corridors is 43.93 hectares. Out of this, 42.98 ha is Government land and balance 0.95 ha are private land. Ownership wise details of the land is given in below tables.

S.N	Ownership of the land	Area of Land (in ha)
9.	GoM	20.27
10.	PMC	16.71
11.	PCMC	2.21
12.	PMPL	0.01
13.	Railway	0.18
14.	Defence	3.47
15.	All India Radio	0.13
16.	Pvt land (Cor1 +Cor2)	0.95
Total		**43.93**

As per original plan total 688 families was affected permanently due to the N-S and W-E corridor. Out of the total 688 families, 628 are Non-Title Holders (NTH) and the 60 are Title Holders (TH). The details of the original PAF is presented in below table.

S.No.	Name of Location	Category of PAF		
		Title Holder	Non-Title Holder	Total
1.	Deccan Corner	0	28	28
2.	Ideal Colony	0	30	30
3.	Kaamgar Putla	0	132	132
4.	Nashik Phata	0	4	4
5.	Khadki	0	6	6
6.	Nal Stop	0	5	5
7.	Phugewadi	0	4	4
8.	Rajiv Nagar/Juna Topkhana	10	92	102
9.	Budhwarpeth	22	89	111
10.	Mandai	28	86	114
11.	Agriculture collage	0	33	33
12.	Shivaji Nagar Bus Stop	0	32	32
13.	Swargate	0	87	87
	Total	**60**	**628**	**688**

The Civil court area, to be developed as a multimodal integration hub wherein 2 lines of Maha Metro are interconnecting with the overhead and underground stations. The third line of PMRDA starting from Hinjewadi also culminates at Civil Court area. PMC will widen the roads for additional traffic load and the interconnectivity of the stations. The development of this area is being undertaken by these independent agencies as per their priority and timelines.

The original RAP report submitted in 2019 indicated that the Metro footprint on Kamgar Putla and Rajiv Gandhi Nagar slums was likely to affect about 234 families which is now 274 Subsequently, it was decided by the Govt. of Maharashtra that entire area of Kamgar Putla and Rajiv Gandhi Nagar is required for infrastructural development by multiple stakeholder's i.e., Pune Municipal Corporation (PMC), Pune Metropolitan Region Development Authority (PMRDA), Slum Rehabilitation Authority and Maha Metro. Due to involvement of Multiple Stake Holders at Kamgar Putla & Rajiv Gandhi Nagar a unified Rehabilitation policy was adopted by Divisional Commissioner, Pune who is the administrative head of Pune and thus the approved resettlement policy framework (RPF) and RAP of Maha-Metro could not be implemented to the letter. However, in lieu of cash compensation mentioned in approved RAP Livelihood Restoration program will be implemented.

The details of the revised PAFs are presented in below table.

S.No.	**Location**	**PAFs**	**PAPs**	**Remarks**
12.	Deccan	15	60	Out of 28 only 15 PAFs are getting impacted
13.	Shivaji Nagar	32	157	-
14.	Swargate	87	257	-
15.	Agri. College	33	130	-
16.	Mandai-Residential and Commercial	50 113	220	-
17.	Kaamgar Putla & Rajiv Gandhi Nagar	274	1370	
18.	Khadki	0	0	No impact due to reduction in land requirement.
19.	Budhwarpeth	2	10	Due to relocation of the Budhwarpeth station into defunct Dado ji Kondev school building, the no. of PAF has drastically reduced from earlier 111 to 2
20.	Ideal Colony	0	0	No impact due to change in design
10	Nashik Phata	0	0	No impact due to change in design
21.	Nal Stop	0	0	No impact due to change in design
22.	Phugewadi	0	0	No impact due to change in design
Total		**606**	**2769**	

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-economic that 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 and Station area including entry and exit	35	Number of Trees 2452
(ii)	Fauna	05	Number of Species 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

S. No.	Environmental Component	Weightage	Weightage Breakup
			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		
	More than 100	30	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**	2452	
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		

S. No	Environmental Parameters	Weightage Assigned	PCMC – Swargate	Vanaz - Ramwadi
	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**	**80**	**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 4.29. Views expressed, suggestion given or queries raised by the participants are given in Table 4.19.

Figure 4.29. 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 Metro Rail	Participants added that the metro rail should have all basic amenities such as toilet and 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 CO_2 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.

Place	Date	No. of participants	Issues	Suggestions/Opinions
			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 for rehabilitation of affected families	Adequate compensation need to be provided in order to reinstate the life of project 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		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.
		14	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.

Place	Date	No. of participants	Issues	Suggestions/Opinions
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 metro need 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.

In continuation with project level public consulation,Metro -Samwad -is being organized during project execution wherein a dialogue between the MahaMetro and the general public in the area through which the metro alignment will pass. Details of Metro Samwad organized by MMRCL along with photographs are as below:-

S. No.	Date	Venue
1.	18.12.2017	Sahkar Sudan Hall -Prabhat Road
2.	9.11.2017	Bedekar Ganpati Mandir Sabhagruh
3.	8.10.2017	Yasahwant Rao Chavan Natyagruha
4.	12.08.2017	Pimpri Chinchwad Science Park
5.	05-08-2017	Tikaram Jaganath College
6.	17.6.2017	Kadam Sabhagrah Nigdi
7.	03.02.2017	Maratha Chamber of Commerce
8.	21.01.2017	MCCIA Tilak Road

Quick Response Team Children Interacting With Maha Metro Offical Team

Regular meetings were held with land acquisition officials regarding information about details of Rehabilitation and Resettlement for PAPs. During September to December total 16 meetings were held on following dates.

S. No.	Date	Venue
1.	10/09/2017	Khadki Cantonment
2.	21/09/2017	Range Hill
3.	28/09/2017	Garwale College
4.	02/10/2017	Ideal Colony Paud Fata
5.	06/10/2017	Pateshwar Temple, Deccan Gymkhana
6.	16/10/2017	Rajeev Nagar, Civil Court
7.	25/10/2017	Range Hill, Labour Camp
8.	04/11/2017	PCMC
9.	15/11/2017	Bhosari Nasik Faata
10.	24/11/2017	Deccan Gymkhana
11.	30/11/2017	Nal Stop
12.	07/12/2017	Sambhaji Park
13.	17/12/2017	Agriculture College
14.	20/12/2017	Shivaji Nagar Bus Terminal
15.	24/12/2017	Sambha Ji Dhobhi Ghat
16.	26/12/2017	Swargate

During the public consultation, the target groups were made aware of :

- Project development and information on the various activities involved in the project including phasing of the project,
- The construction related issues, inconvenience to the public such as traffic jam, road condition, noise & dust due to the various activities of the project,
- Methodology adopted for planning to implementation of the project;
- The compensation and assistance as per the approved Rehabilitation and Resettlement Policy formulated for the affected families;
- The process for disbursement of compensation and assistances to be provided by District Collector & MMRCL.
- The facilities and services the project may offer to improve quality of life of the people living near the project corridor.
- The gender related issues – how they are being addressed to accommodate the facilities at the stations and inside the rolling stock.
- Adoption of modern IT enabled information and awareness of the project facilities, and other related activities for improving the quality of life of the affected communities and the people living near the project corridor; Any other issues that may be identified during the discussions.

The MMRCL could also decide to undertake further engagement activities, such as establishing a community advisory group during the construction & operation phase, setting up a project information social media network and conducting regular forums with local councils and business

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	Permanent, negative, irreversible, can be mitigated, small scale.
4.	Drainage and Utilities: Diversion/shifting	R2	Short term and/or permanent, negative, irreversible can be mitigated; small scale.

S. No	Parameter	Impact Rating	Short Term / Long Term
5.	Impact on Archaeological Monuments and Heritage Assets	R4	-
6.	Right of Way: Optimal choice of length of elevated and underground sections.	R1	Permanent, negative as well as positive, irreversible, can be mitigated, small scale.
7.	Alignment: • Route and design of alignment • Stations, Track design and Architecture	R1	Permanent, negative as well as positive, irreversible & can be mitigated, small scale.
8.	Inter Modal Integration	R1	Long term, negative as well as positive, irreversible, can be mitigated, small scale. Negative Impact on environment around station will be significant if integration of metro with other modes is not implemented.
9.	Use of Energy and Water at stations and depots	R1	Permanent, negative, irreversible & can be mitigated, small scale.
10.	Risk Due to Natural Hazards	R4	-
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	Temporary, negative, irreversible can be mitigated, small scale.
2.	Disposal of muck, C&D waste and hazardous waste; pre-casting and material yards	R1	Permanent, negative, irreversible, can be mitigated, small scale.
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	Permanent, negative, irreversible, can be mitigated, small scale.

S. No	Parameter	Impact Rating	Short Term / Long Term
2.	Energy and water supply at stations and depots	R1	Permanent, negative, irreversible, can be mitigated, small scale.
3.	Traffic congestions around stations	R1	Permanent if inter modal integration is not done, negative, reversible, can be mitigated, small scale.
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
- Ecological Environment
- 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 Family (PAFs)

As per original plan total 688 families was affected permanently due to the N-S and W-E corridor. Out of the total 688 families, 628 are Non-Title Holders (NTH) and the 60 are Title Holders (TH). The details of the original PAF is presented in below table.

S.No.	Name of Location	Category of PAF		
		Title Holder	Non-Title Holder	Total
1.	Deccan Corner	0	28	28
2.	Ideal Colony	0	30	30
3.	Kaamgar Putla	0	132	132
4.	Nashik Phata	0	4	4
5.	Khadki	0	6	6
6.	Nal Stop	0	5	5
7.	Phugewadi	0	4	4
8.	Rajiv Nagar/Juna Topkhana	10	92	102
9.	Budhwarpeth	22	89	111
10.	Mandai	28	86	114
11.	Agriculture collage	0	33	33
12.	Shivaji Nagar Bus Stop	0	32	32
13.	Swargate	0	87	87
	Total	**60**	**628**	**688**

The Civil court area, to be developed as a multimodal integration hub wherein 2 lines of Maha Metro are interconnecting with the overhead and underground stations. The third line of PMRDA starting from Hinjewadi also culminates at Civil Court area. PMC will widen the roads for additional traffic load and the interconnectivity of the stations. The development of this area is being undertaken by these independent agencies as per their priority and timelines.

The original RAP report submitted in 2019 indicated that the Metro footprint on Kamgar Putla and Rajiv Gandhi Nagar slums was likely to affect about 234 families which is now 274 Subsequently, it was decided by the Govt. of Maharashtra that entire area of Kamgar Putla and Rajiv Gandhi Nagar is required for infrastructural development by multiple stakeholder's i.e., Pune Municipal Corporation (PMC), Pune Metropolitan Region Development Authority (PMRDA), Slum Rehabilitation Authority and Maha Metro. Due to involvement of Multiple Stake Holders at Kamgar Putla & Rajiv Gandhi Nagar a unified Rehabilitation policy was adopted by Divisional Commissioner, Pune who is the administrative head of Pune and thus the approved resettlement policy framework (RPF) and RAP of Maha-Metro could not be implemented to the letter.

Due to development of entire area of Kamgar Putla and Rajiv Gandhi Nagar by different stakeholders, the Slum Rehabilitation Authority was assigned the task for conducting the survey to determine the number of families residing in Rajiv Gandhi Nagar and Kamgarputla slums.

Upon completion of survey, it was concluded that that 1264 families are residing in this area. These 1264 families to be rehabilitated by the three agencies and share of rehabilitation had been duly allocated i.e. Maha Metro -274, PMRDA -114, PMC -322 while another 554 families (distributed among all stake holders) directly not being affected but would be impacted by the other development facilities for the commuters and need to be rehabilitated. Maha-Metro footprint is only impacting 274 families at Kamgar Putla and Rajiv Gandhi Nagar slums hence the no. of PAF get revised.

The details of the revised PAFs are presented in below table.

S.No.	Location	PAFs	PAPs	Remarks
23.	Deccan	15	60	Out of 28 only 15 PAFs are getting impacted
24.	Shivaji Nagar	32	157	-
25.	Swargate	87	257	-
26.	Agri. College	33	130	-
27.	Mandai-Residential and Commercial	50 113	220	-
28.	Kaamgar Putla & Rajiv Gandhi Nagar	274	1370	
29.	Khadki	0	0	No impact due to reduction in land requirement.
30.	Budhwarpeth	2	10	Due to relocation of the Budhwarpeth station into defunct Dado ji Kondev school building, the no. of PAF has drastically reduced from earlier 111 to 2
31.	Ideal Colony	0	0	No impact due to change in design
10	Nashik Phata	0	0	No impact due to change in design
32.	Nal Stop	0	0	No impact due to change in design
33.	Phugewadi	0	0	No impact due to change in design
Total		**606**	**2769**	

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 Ecological Environment and Bio-Diversity

Total 2452 no. of trees have been impacted (includes 188 no. of felled trees) against the earlier estimation of 1125 no. of trees. The impacted tree numbers has gone up due to change in alignment (to avoid the Agan Khan Palace) increase in alignment length and various other factors like R&R issues and design. Further impact on trees are not envisaged.

Out of 2452 impacted trees, 2264 have been transplanted at various locations of the City whereas 188 trees have been felled due to non feasibility of transplantation viz. age, safety concerns.

Location wise details of transplanted and felled trees are presented in below tables :

Sr. No.	Project site including Stations	Trees Felled	Trees Transplanted	Transplantation Site
1.	Reach -1 (PCMC- Range Hill)	0	443	Kasarwadi STP
2.	Reach -2 (Vanaz-Civil Court) i.e.	7	158	Forest Area ARAI
3.	Reach- 3 (Civil court-Ramwadi) i.e.	17	427	Dr.Salim Ali Bird Sanctuary, Bund Garden. Nagar Road
4.	(Reach-4) – Swargate,Civil Court,Shivajinagar,Mandai ,Budhwar Peth and Are Dairy	164	569	Arey Dairy Bus Stand, Range Hill & Taljai Forest Area, Alandi MSRTC Bus Depot, Survey No.01Taljai & Survey No. 69, Dhanori & Range Hill/Command Hospital
5.	Range Hill Depot	0	506	Agriculture College, Range Hill-KCB
6.	Vanaz Depot	0	161	Vanaz Kachara Depot, ARAI
Grand Total		**188**	**+ 2264**	**= 2452**

Further, Location wise details of felled trees are as below.

S.No.	Locations	Trees Felled
1.	Budhwar Peth	10
2.	Mandai	7
3.	Shivaji Nagar	10
4.	Civil Court	13
5.	Are Dairy	123
6.	Swargate	1
7.	Garware College	7
8.	Mangalwar Peth	9
9.	Ruby Hall	7
10.	Kalyani Nagar	1
Total		**188**

Most of the impacted species are exotic and no fruit bearing trees are observed during field survey and no loss of bird habitat. No RET species are observed during the field study, hence Ecology and Bio-diversity of the project area may not be disturbed potentially.

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 4.13 and Table 4.14. However no impact is anticipated on these Archaeologcial Monuments due to construction and operation of the project.

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 ridership and decrease congestion inside and outside the stations. Negative Impact on environment around station will be significant if integration of metro with other modes is not implemented.

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
- Impacts due to traffic diversions
- Impacts due to Labour Camp
- Welfare of labour on site
- 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
- 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 by considering the BS III vehecles. 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 5.2. Total Emissions due to Truck Movement during Construction

Pollutant	Quantity (ton)	
	PCMC - Swargate	Vanaz - Ramwadi
Carbon Monoxide	22.0	15.0
Particulate Matter 2.5	1.0	0.5
Hydro-Carbons	0.7	0.5
Nitrogen Oxide	46.0	30.0
Carbon dioxide	2846	1890
Fugitive dust	5.4	3.6

5.5.2. Noise Pollution

During the construction phase of project, noise will be generated from the various sources. For noise prediction various combinations of equipment were assessed for different construction activities i.e Viaduct, Elevated Station, Underground station, at Grade Section, Construction Yard, Depot as listed in Table 5.4. For Prediction of Noise levels (leq), Model of US Department of Transportation has been used.

For prediction, no ground attenuation has been considered as ground was assumed to be undisturbed, consolidated and hard. Usage factor (number of hours of operation of different equipment) as per construction practices in metro projects in India and standard (FHWA,USA) noise emission levels of equipment are taken. The metal barricade used in construction is assumed to be shielding. Noise prediction has been carried out for two conditions a) without any shielding and b) with shielding which provides noise attenuation of 5 dB(A).

Table 5.3. Construction Equipment Noise Emission Level

Particular	Equipment	Equipment Noise level (in Leq dB(A) at 50 ft)	Number of hours of operation	Predicted Noise level (Leq) dB(A) at 50 ft
Case 1				
Viaduct Activity 1	Press Pile	70	0.5	69.07
	Auger drill	84	0.5	
	Generator	81	0.5	
Viaduct Activity 2	Rotatory Hydraulic rig	84	5	78.95
	Generator	81	5	
Viaduct Activity 3	Chiseling	88	2	78.00
	Generator	81	2	
Case 2				
Viaduct	Impact Pile Driver	101	12	98.01
	Crane	88	1	
Case 3				
Elevated Station Activity 1	Press Pile	70	0.5	69.07
	Auger drill	84	0.5	
	Generator	81	0.5	
Elevated Station Activity 2	Rotatory Hydraulic rig	84	5	78.95
	Generator	81	5	
Elevated Station Activity 3	Chiseling	88	2	78.00
	Generator	81	2	

Particular	Equipment	Equipment Noise level (in Leq dB(A) at 50 ft)	Number of hours of operation	Predicted Noise level (Leq) dB(A) at 50 ft
Case 4				
Elevated Station	Impact Pile Driver	101	12	98.01
	Crane	88	1	
Case 5				
Underground station	Excavator	81	24	86.06
	Concrete Pump truck	81	24	
	Generator	81	24	
	Crane	88	1	
Case 6				
At Grade Section	Dumper	76	24	89.19
	Dozer	85	24	
	Compactor	82	24	
	Grader	85	24	
Case 7				
Construction yard	Concrete mixer	85	24	91.98
	Truck	88	24	
	Truck	88	24	
Case 8				
Depot	Dumper	76	24	92.21
	Dumper	76	24	
	Grader	85	24	
	Grader	85	24	
	Compactor	82	24	
	Compactor	82	24	
	Dozer	85	24	
	Dozer	85	24	

Estimation of noise levels during construction phase has been done as per guidelines specified in “Transit Noise and Vibration Impact Assessment, May 2006 by Federal Transit Administration (FTA)”. Noise Levels for each activity up to 250 m have been estimated for two scenarios – with out shielding and with shielding as given in Table 5.5. Various distances at which these noise levels equal to or less than the average base line monitored noise levels i.e 71.1 dB(A) are also estimated and given in the report. The data considered for the modeling are as follows:

- Ground Factor G for ground attenuation is considered as 0.4
- Attenuation due to Shielding between source and receptor is considered as 5 dB (A).

These levels are typical and will vary with specifications of the equipment, usage pattern, number of construction agencies, existing structures/trees which act as barrier to noise transmission.

Table 5.4. Construction Equipment Noise Level upto 250 m with and without Shielding

Activity	Equipment Noise (Leq) in dB (A) at various distances - with out Shielding						Equipment Noise (Leq) in dB (A) at various distances - with Shielding							Distance at Which Leq less than Ambient Noise - with out Shielding	Distance at Which Leq less than Ambient Noise - with Shielding
	25	50	100	150	200	250	25	50	100	150	200	250			
Viaduct Activity 1	63.91	56.69	49.46	45.24	42.24	39.91	58.91	51.69	44.46	40.24	37.24	34.91		13	8
Viaduct Activity 2	73.79	66.57	59.34	55.12	52.12	49.79	68.79	61.57	54.34	50.12	47.12	44.79		33	21
Viaduct Activity 3	72.84	65.62	58.39	54.17	51.17	48.84	67.84	60.62	53.39	49.17	46.17	43.84		30	21
Viaduct	92.85	85.63	78.40	74.18	71.18	68.85	87.85	80.63	73.40	69.18	66.18	63.85		202	125
Elevated Station Activity 1	63.91	56.69	49.46	45.24	42.24	39.91	58.91	51.69	44.46	40.24	37.24	34.91		13	8
Elevated Station Activity 2	73.79	66.57	59.34	55.12	52.12	49.79	68.79	61.57	54.34	50.12	47.12	44.79		33	21
Elevated Station Activity 3	72.84	65.62	58.39	54.17	51.17	48.84	67.84	60.62	53.39	49.17	46.17	43.84		30	21
Elevated Station	92.85	85.63	78.40	74.18	71.18	68.85	87.85	80.63	73.40	69.18	66.18	63.85		202	125
Underground station	80.90	73.68	66.45	62.23	59.23	56.90	75.90	68.68	61.45	57.23	54.23	51.90		64	40
At Grade Section	84.03	76.81	69.58	65.36	62.36	60.03	79.03	71.81	64.58	60.36	57.36	55.03		87	54
Construction yard	86.82	79.60	72.37	68.15	65.15	62.82	81.82	74.60	67.37	63.15	60.15	57.82		113	77
Depot	87.05	79.83	72.60	68.38	65.38	63.05	82.05	74.83	67.60	63.38	60.38	58.05		116	79

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. Transportation and Construction Vibration Guidance Manual, Caltrans, September 2013) specified threshold criteria for various structures are listed in Table 5.6. 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 5.7.

Table 5.5. Guideline Vibration Damage Threshold Criteria

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

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

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

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			

Source: Transit Noise and Vibration Impact Assessment, Federal Transit Administration, May 2006

A. Vibration Impact due to Impact Pile Driver

Impact pile driver will be used in case of hard rocks only. Vibration amplitudes produced by Impact pile drivers can be estimated by the following empirical equation

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

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.

Table 5.7. 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

* Standards as per Transportation and construction Vibration Guidance Manual, Caltrans, Secptember 2013

It is understood that the predicted PPV from the Impact pile driver is very higher than other type of pile drivers. Auger Displacement Piling (ADP) system offers a quick, quiet and virtually vibration free alternative to driven type piles[2]. Hence, Impact Piles should be used in case of hard rock only and for other areas Auger displacement piling system should be used.

B. 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 5.8. Tunneling Methods

[2] Auger Displacement Piles, Cementation Skanska, 2010

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
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.

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

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.

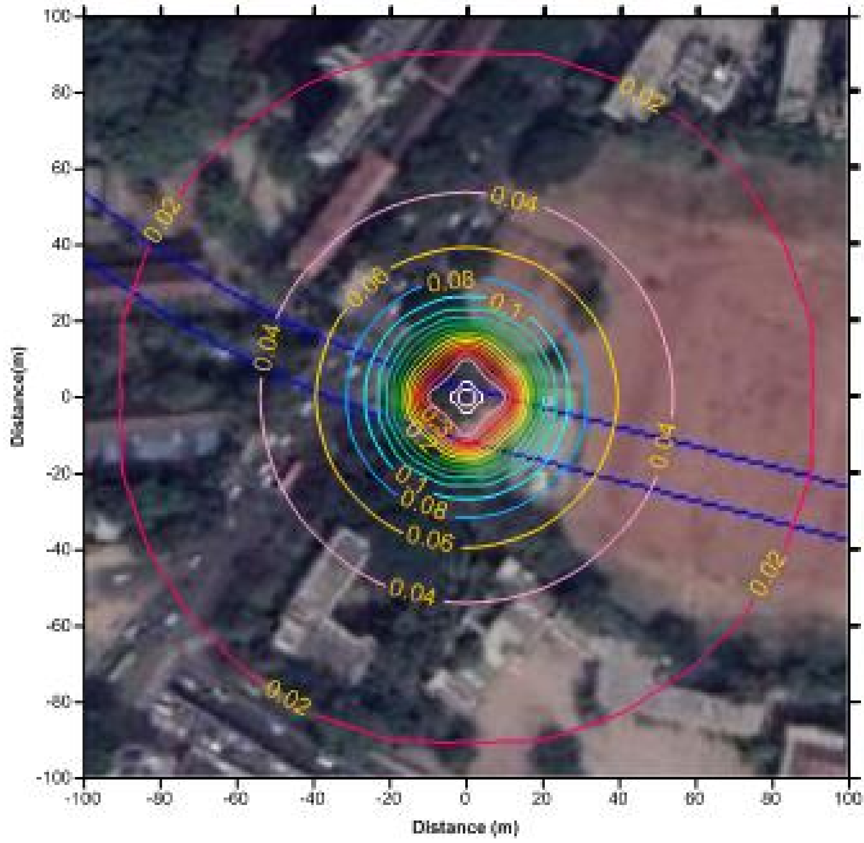
Using the above empirical propagation equation, peak particle velocity (PPV) due to TBM has been predicted and presented in Table 5.10 & shown in Figure 5.1. Maximum predicted PPV of 0.193 in/sec is estimated at City Post.

Table 5.9. Vibration due to TBM

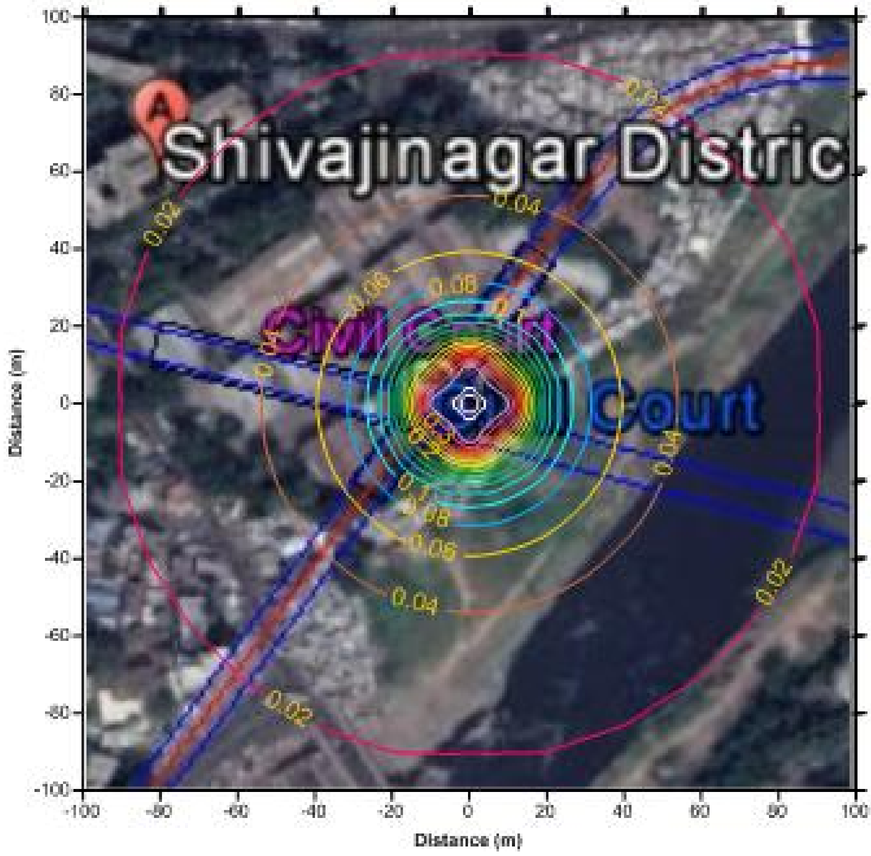
S. No	Location	Radial Distance* from UG Alignment in m	PPV (in/sec)			
			Monitored	Predicted	Resultant	Permissible **
1.	Pataleswar Cave Mandir	179	0.028	0.008	0.035	0.25
2.	District and sessions court	36	0.018	0.067	0.085	0.25
3.	Shaniwar wada	168	0.031	0.009	0.040	0.25
4.	Kasba Ganapati mandir	110	0.030	0.016	0.048	0.1
5.	Dagduseth Ganapathi Mandir	43	0.032	0.053	0.083	0.1
6.	City post	16	0.027	0.193	0.221	0.25
7.	Old wooden structure near Mandai	47	0.031	0.048	0.079	0.08

* Radial distance assuming depth of top of tunnel is 15m below ground
** Standards as per Transportation and construction Vibration Guidance Manual, Caltrans, Secptember 2013

Figure 5.1. Vibration at monitoring locations due to TBM

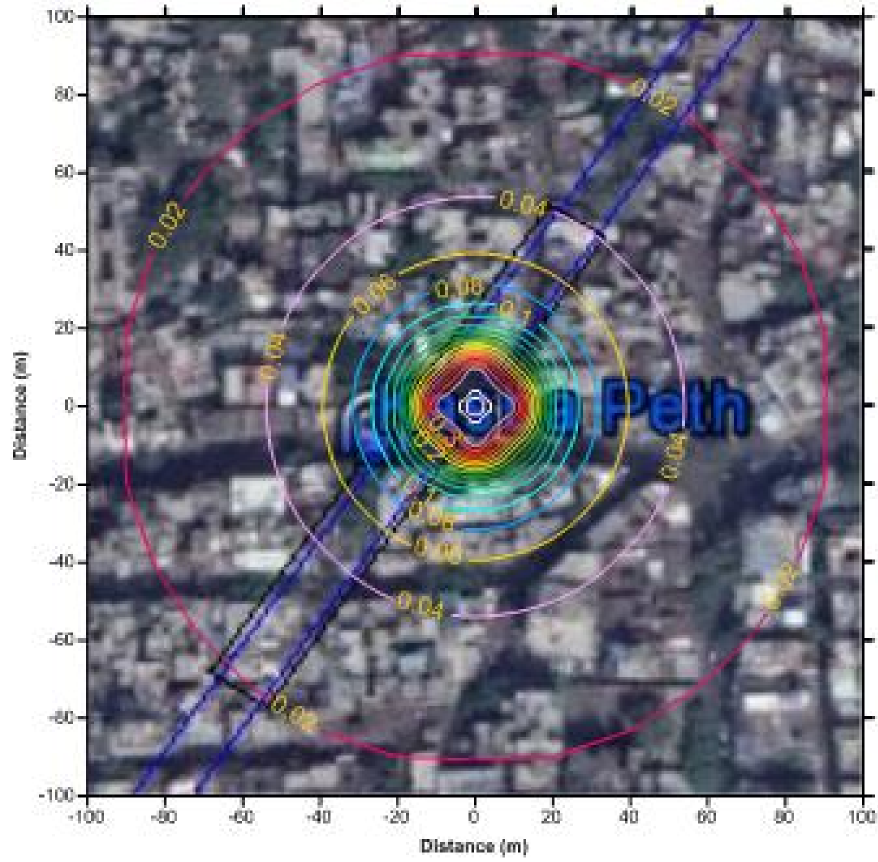


1. Pataleshwar Cave Mandir

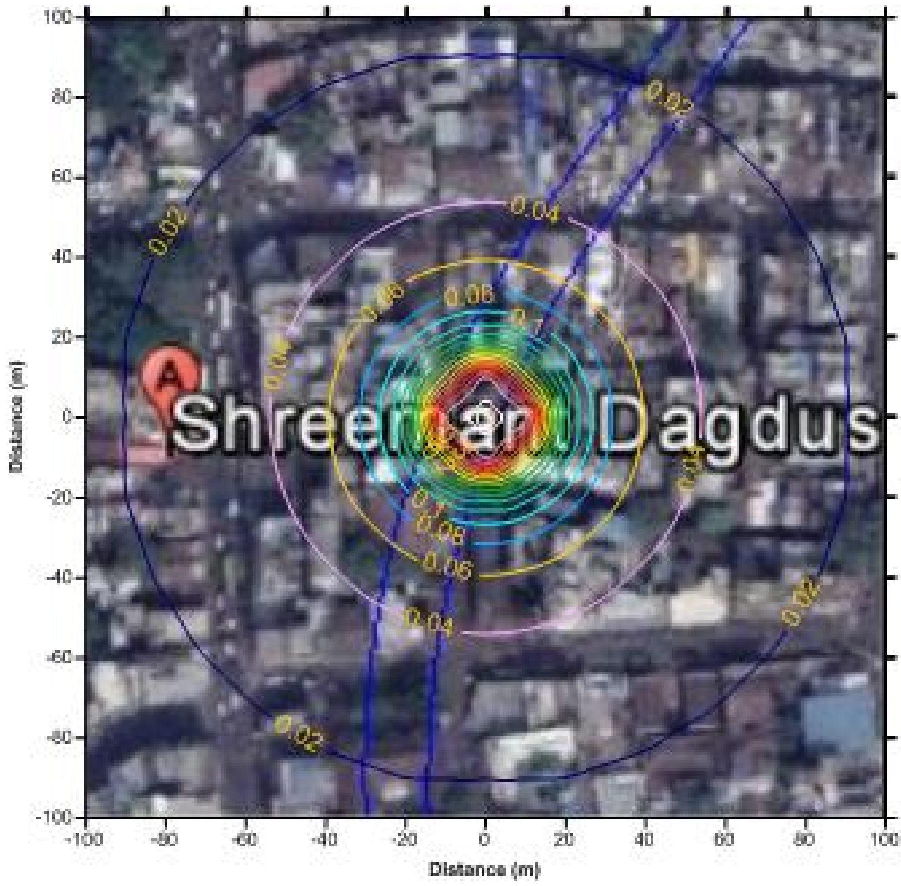


2. District & Session court

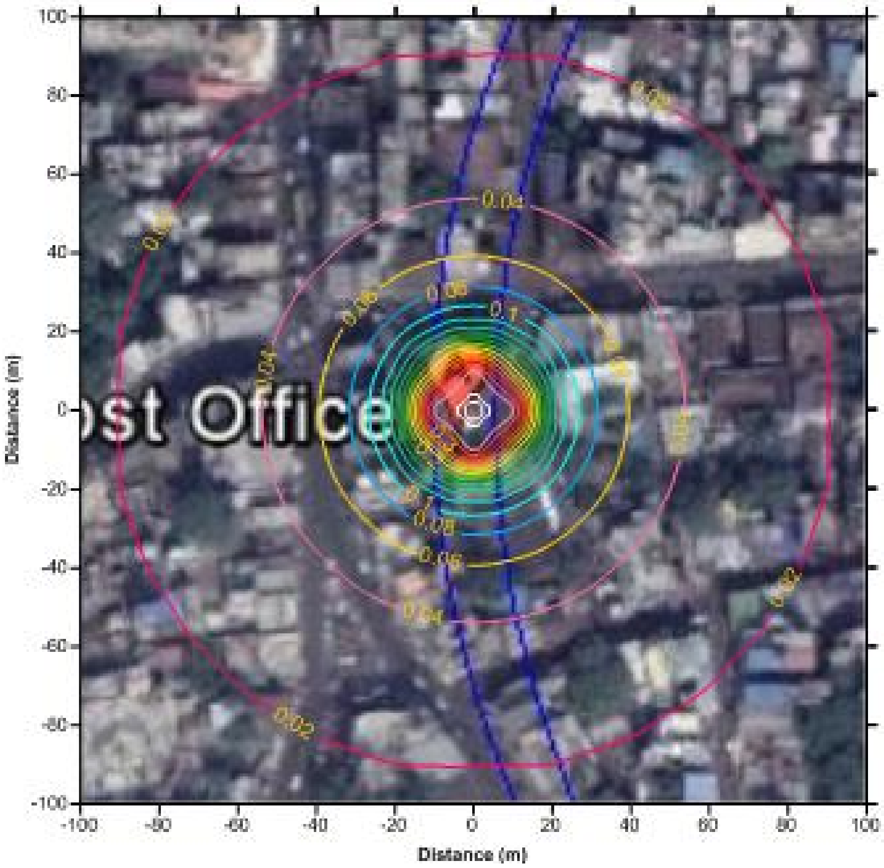
3. Shaniwar wada



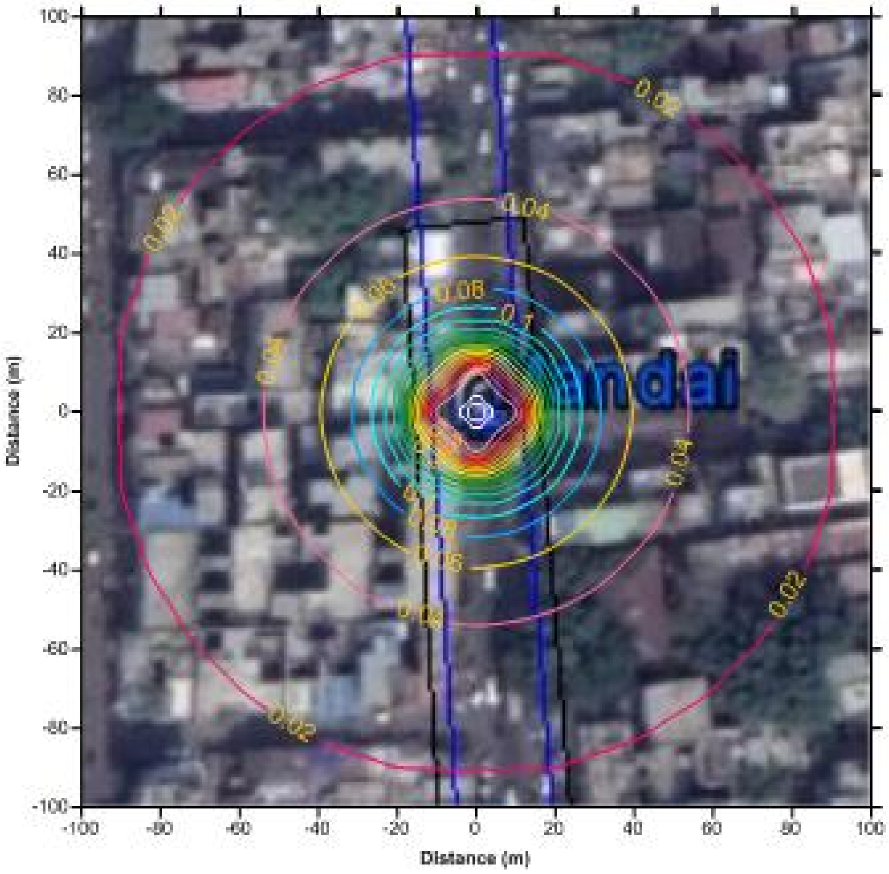
4. Kasba Ganapati Mandir



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 monitored locations without considering any mitigation measures. However, prior building condition survey should be taken up before commencing the TBM operation.

C. Vibration Impact 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 station locations are presented in Table 5.11. Vibration results at each UG station is shown in Figure 5.2.

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

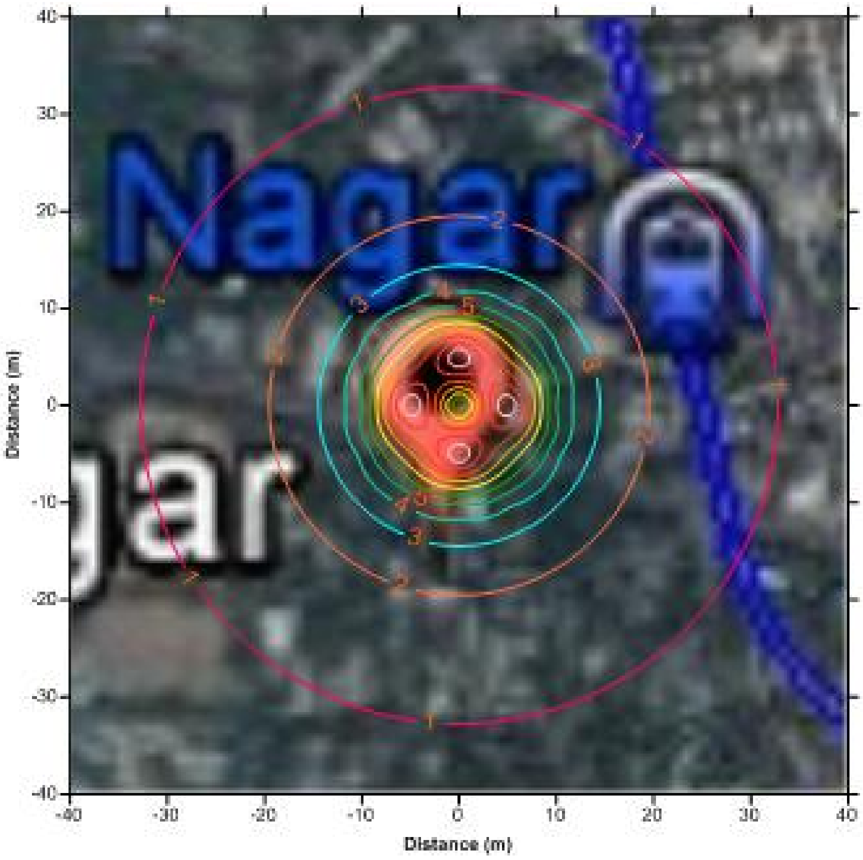
Where:

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),

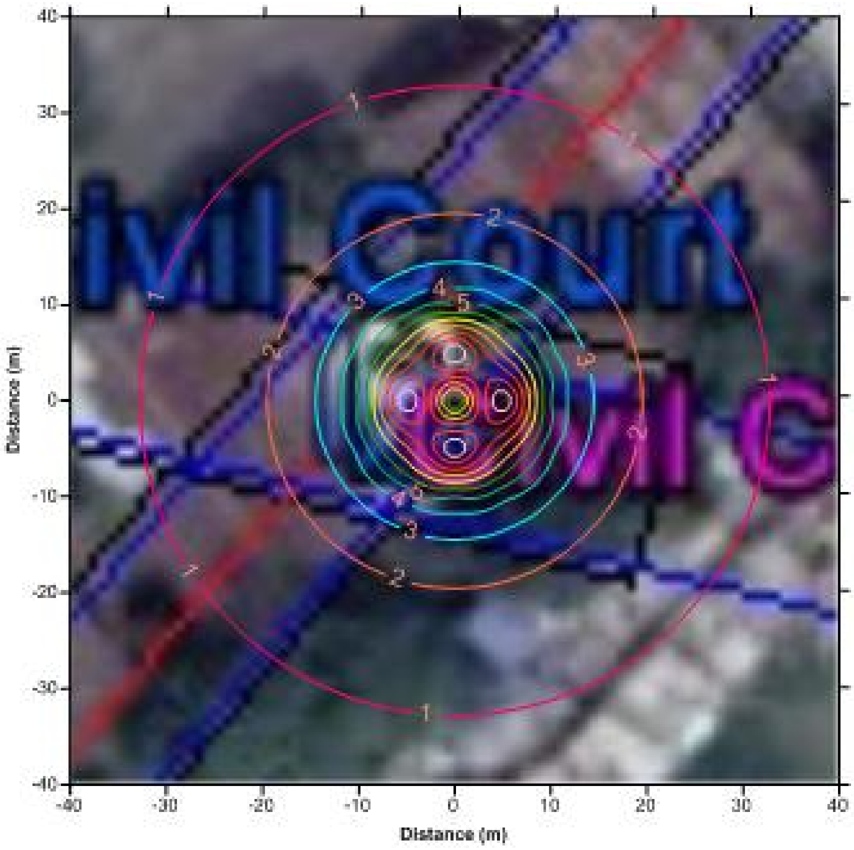
Table 5.10.Vibration due to Controlled Blasting

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	350	Shivaji Nagar	0.6858	0.042	0.728
2.	District and Sessions Court	30	Civil Court	0.4572	1.11	1.56
3.	Shaniwar Wada	350	Budhwar Peth	0.7874	0.04	0.84
4.	Kasba Ganapati Mandir	216	Budhwar Peth	0.8128	0.08	0.9
5.	Dagduseth Ganapathi Mandir	208	Budhwar Peth	0.762	0.08	0.83
6.	City post	117	Budhwar Peth	0.7112	0.18	0.88
7.	Old wooden structure near Mandai	469	Mandai	0.7874	0.03	0.83

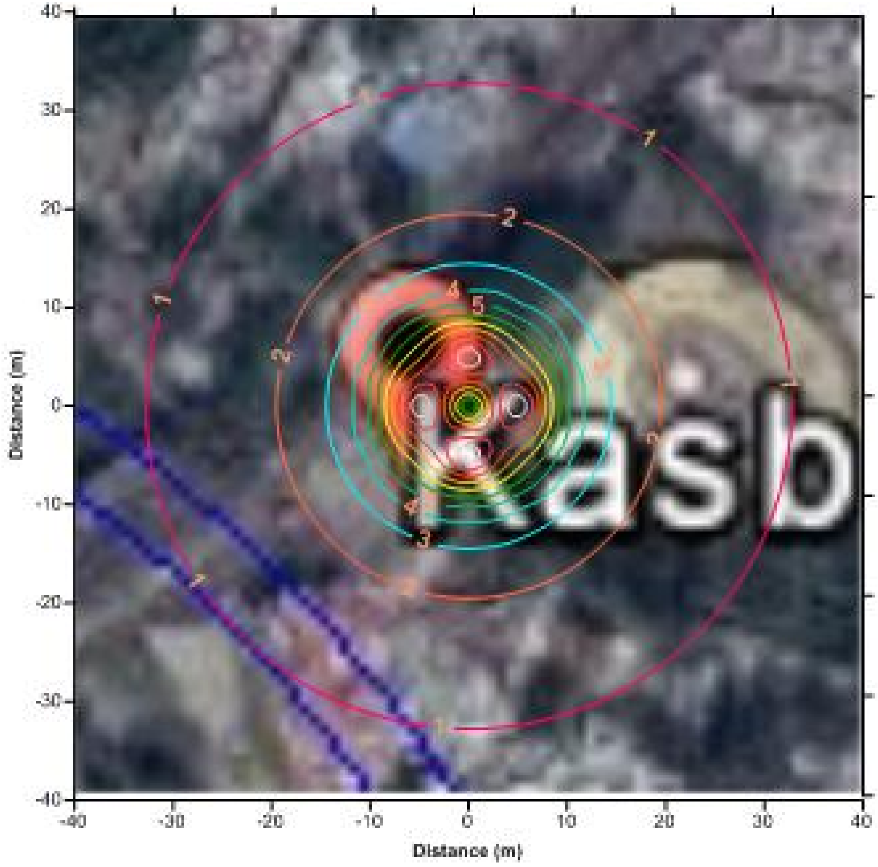
Figure 5.2. Vibration due to Controlled Blasting



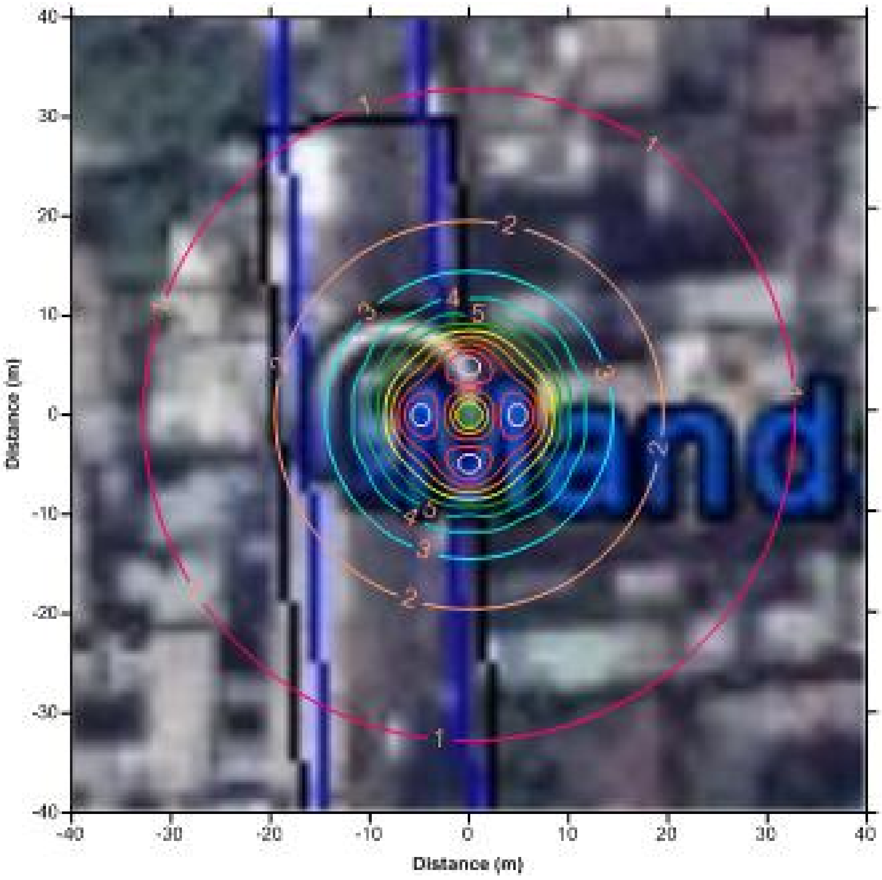
1. Shivaji Nagar: Controlled Blasting Construction Phase



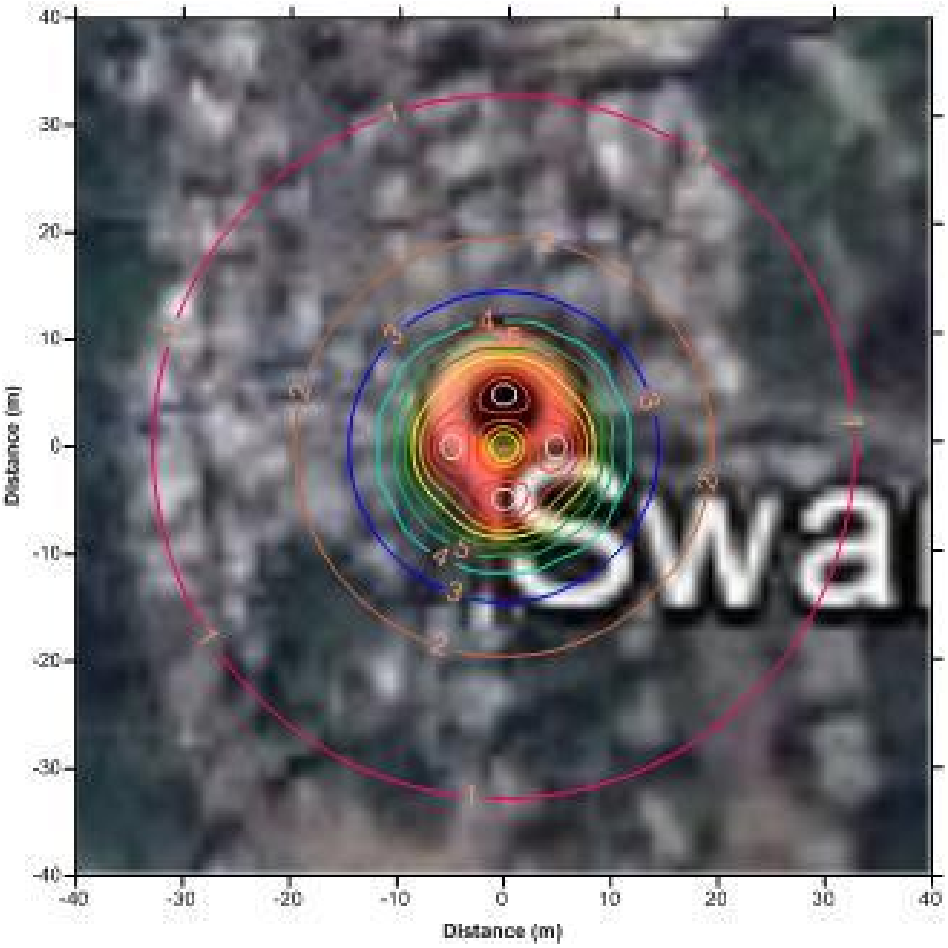
2. Civil Court: Controlled Blasting Construction Phase



3. Budhwar Peth: 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 5.11.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 5.12.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 7.50 lakh cum and fill of about 1.35 lakh cum with net quantity to be disposed of about 6.15 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 or chemical 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[3].
- Increased risk of fatal CHD associated with each 10 µg/m^3 increase in annual PM2.5 exposure[4].
- Significant association between exposure to PM2.5 and risk of incident CKD, eGFR decline, and ESRD[5].
- The mortality rate advancement attributable to traffic pollution was similar to that associated with chronic respiratory and pulmonary diseases and diabetes[6].
- Exposure to ambient PM2.5 air pollution is associated with a lower level of sperm normal morphology and a higher level of sperm concentration[7].
- In addition to noise induced hearing loss, stress hormone increases and increase in the risk of myocardial infarction are caused by noise[8].

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.

5.6.1. Noise Pollution

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

[4]*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*

[5]*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*

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

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

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

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

The information about Metro Rail operations considered to predict noise level at all stations of both the corridors as mentioned in DPR are given at Table 5.14. Predicted noise levels at all metro stations were modeled as per guidelines specified in "Transit Noise and Vibration Impact Assessment, May 2006 by Federal Transit Administration (FTA)". The data considered for the modeling are as follows:

- SELref: 82 dB (A) for fixed guide-way Rail cars @ 50mph at 50 feet distance
- Ground Factor G for ground attenuation is considered as 0.4
- Attenuation due to Shielding between source and receptor is considered as zero.

Table 5.13.Inputs to Noise Modeling

Corridor	**Train Type**	**Train Speed in KMPH**	**No. of Cars per Train**	**No. of trains per day each way (05.00 – 22.00)**	
				2021	**2031**
PCMC - Swargate	Electric	33	4	193	193
Vanaz - Ramwadi	Electric	31	4	89	135

Source: Pune Metro DPR, 2015

Predicted Noise levels at each station of both the corridors are given in Table 5.15, which shows that the predicted noise levels are less than the existing ambient noise levels measured at each station. Noise generated at each station for the respective corridors will be same because of number of trains and their speed is same for each corridor.

Table 5.14.Predicted Noise Levels at Stations due to Metro Operations

Corridor	Predicted Noise Levels Leqday in dB (A) at 15 m distance	
	Year 2021	Year 2031
PCMC - Swargate	62.24	62.24
Vanaz - Ramwadi	58.34	60.14

Based on the above modeling results, noise contours are generated up to a distance of 250 m along the proposed metro rail corridors for years 2021 and 2031. Noise contours due to proposed metro operations on both the corridors are shown in Figure 5.3 to 5.7.

The predicted noise levels estimated due to metro operations for year 2021 and 2031 reveals the following:

- The predicted noise levels at 15 m distance are less than the existing ambient noise levels measured at each station.
- The impact of noise generated by the metro in year 2021 and 2031 shall be categorized as low as per criteria mentioned in FTA guidelines.
- The noise levels generated due metro for year 2021 and 2031 will be within the permissible limits prescribed for commercial areas at a distance of 15 m.
- PCMC-Swargate corridor: These levels will be within the permissible limits prescribed for Residential areas at a distance of 48 m and for Silence areas at a distance of 108 m for year 2021 and 2031.
- Vanaz-Ramwadi: These levels will be within the permissible limits prescribed for Residential areas at a distance of 25 m (year 2021) and 34 m (year 2031); and for Silence areas at a distance of 57 m (year 2021) and 77 m (year 2031).

Cumulative future noise levels in the project area are modeled based on existing measured sound levels and future daily metro rail operations. Cumulative future noise levels at each station and at various distances up to 250 m around the stations are given in Table 5.16.

The cumulative noise is more than the Noise Standards for Commercial area at all elevated stations. Due to reduction of vehicular traffic, the road traffic noise is expected to come down, which ultimately reduces the noise at elevated stations.

Figure 5.3. Noise Contours up to 250 m for PCMC to Rangehill Corridor for Year 2021 & 2031

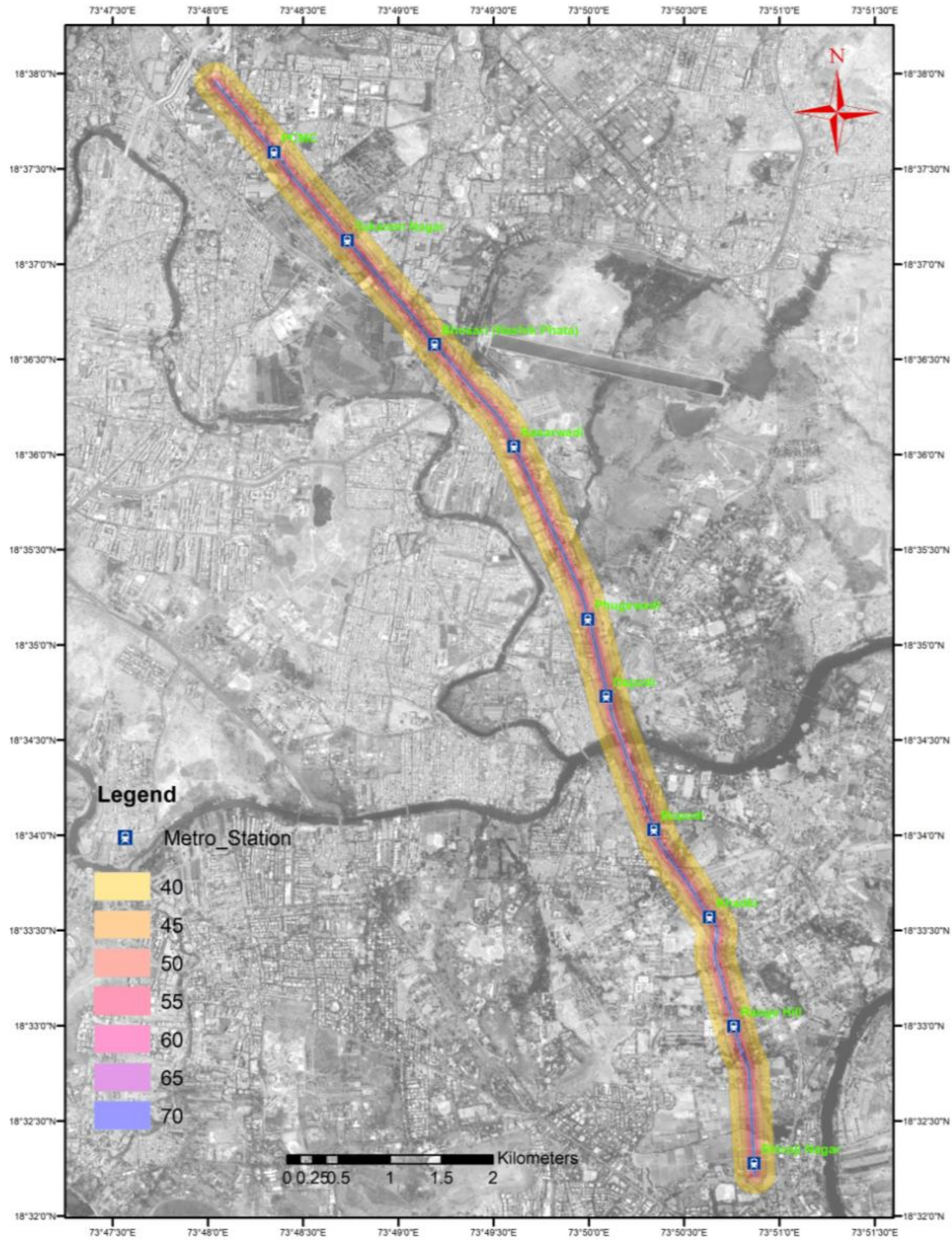


Figure 5.4. Noise Contours up to 250 m for Vanaz to Civil Court Corridor for Year 2021

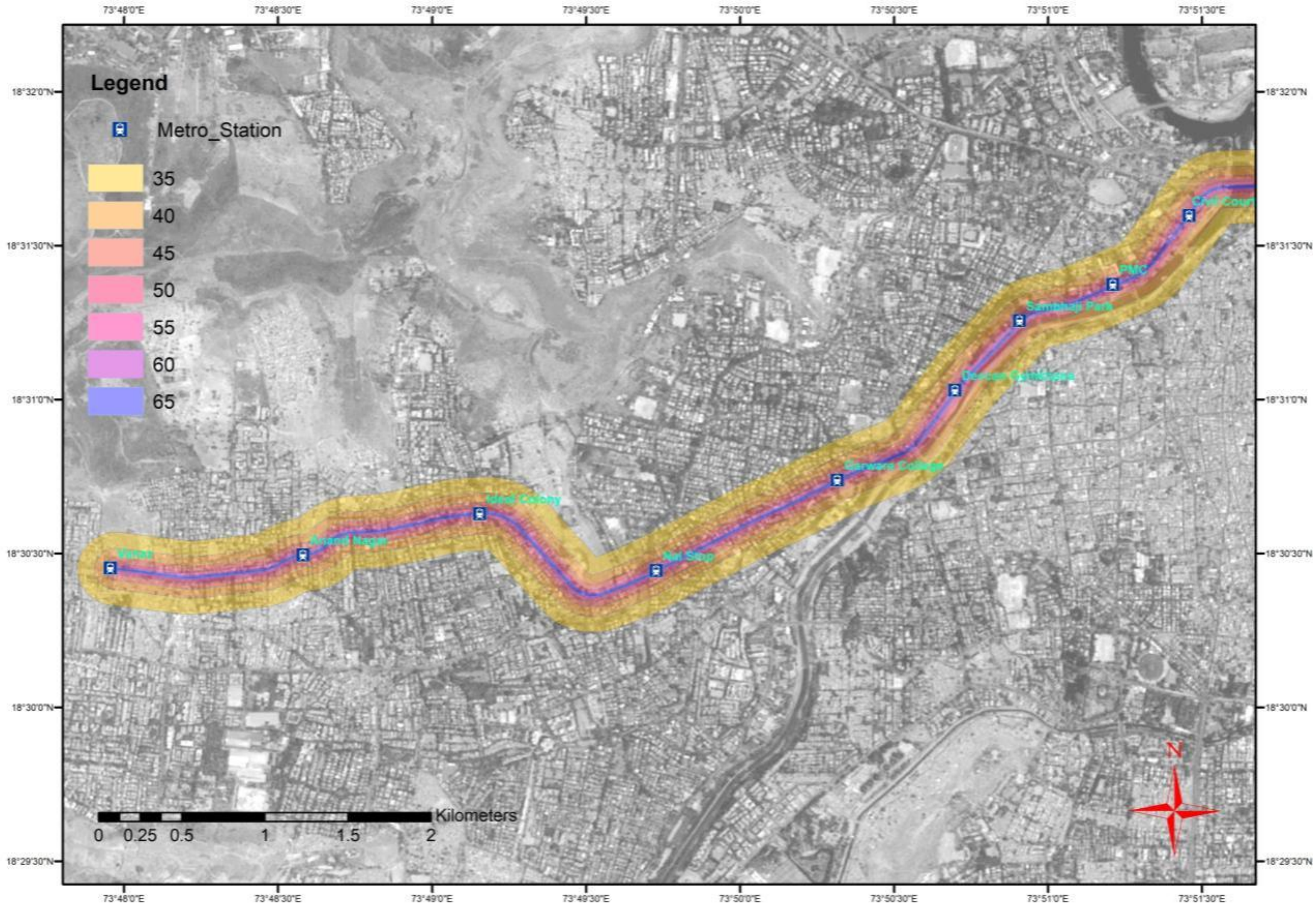


Figure 5.5. Noise Contours up to 250 m for Civil Court to Ramwadi Corridor for Year 2021

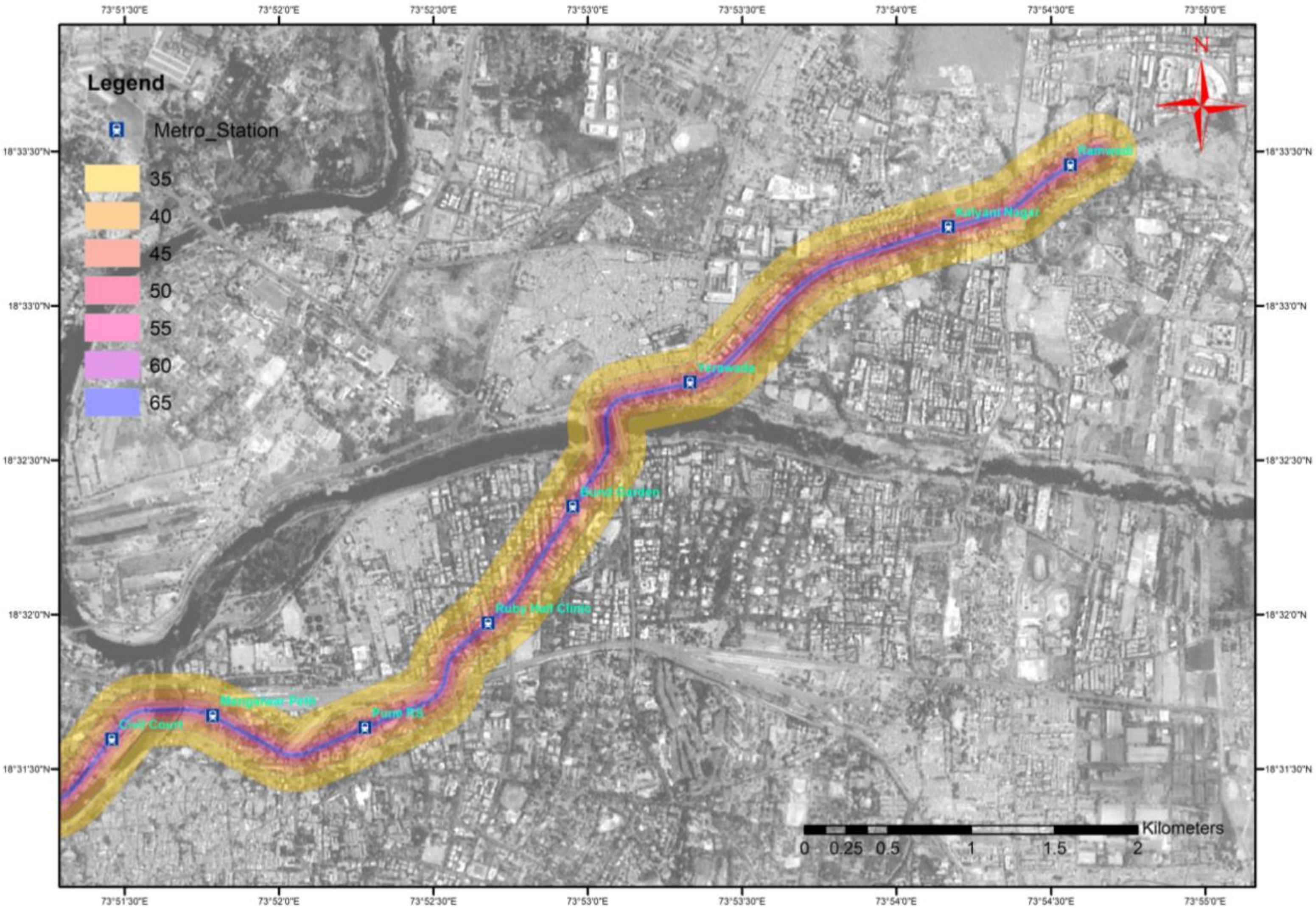


Figure 5.6. Noise Contours up to 250 m for Vanaz to Civil Court Corridor for Year 2031

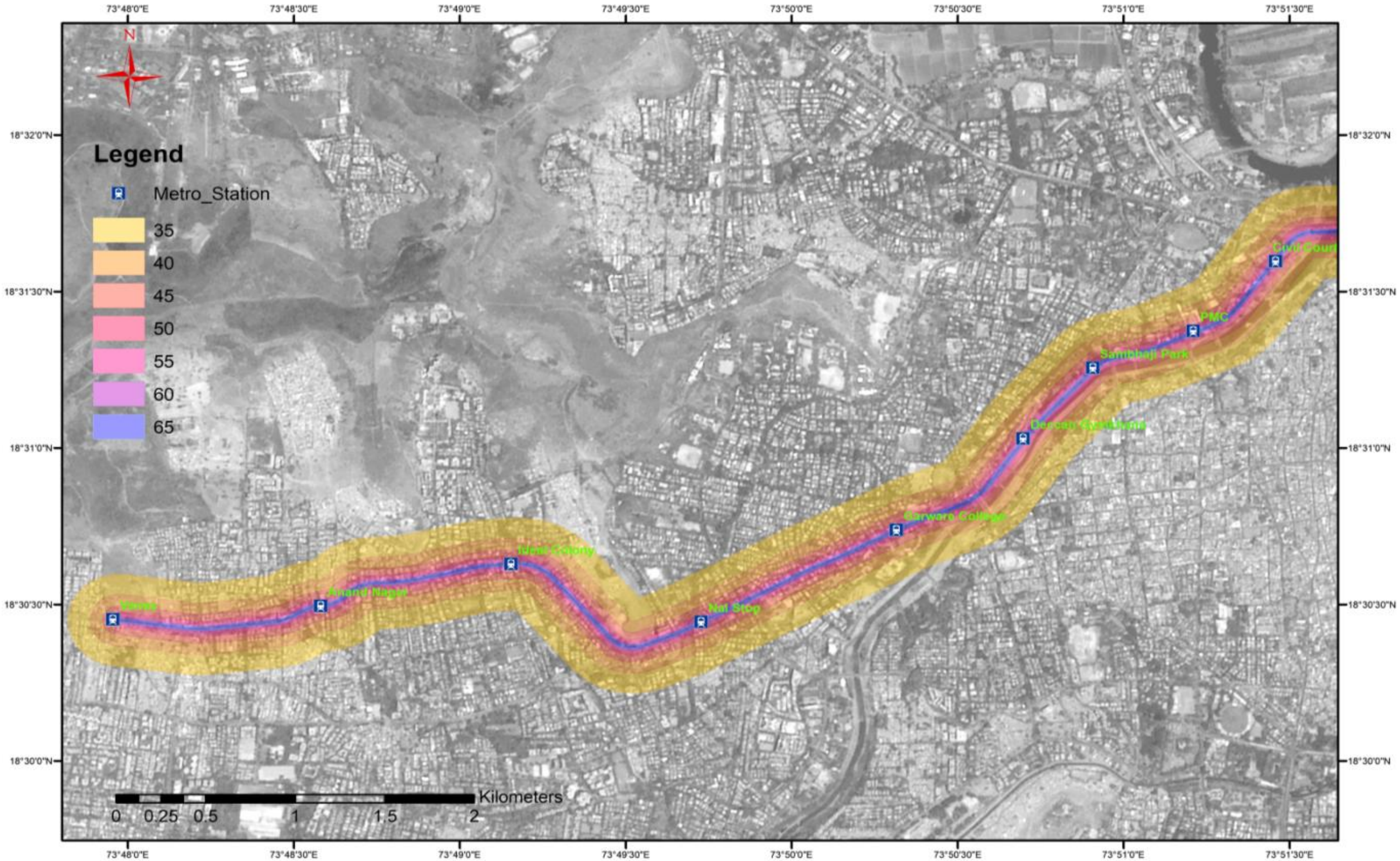


Figure 5.7. Noise Contours up to 250 m for Civil Court to Ramwadi Corridor for Year 2031

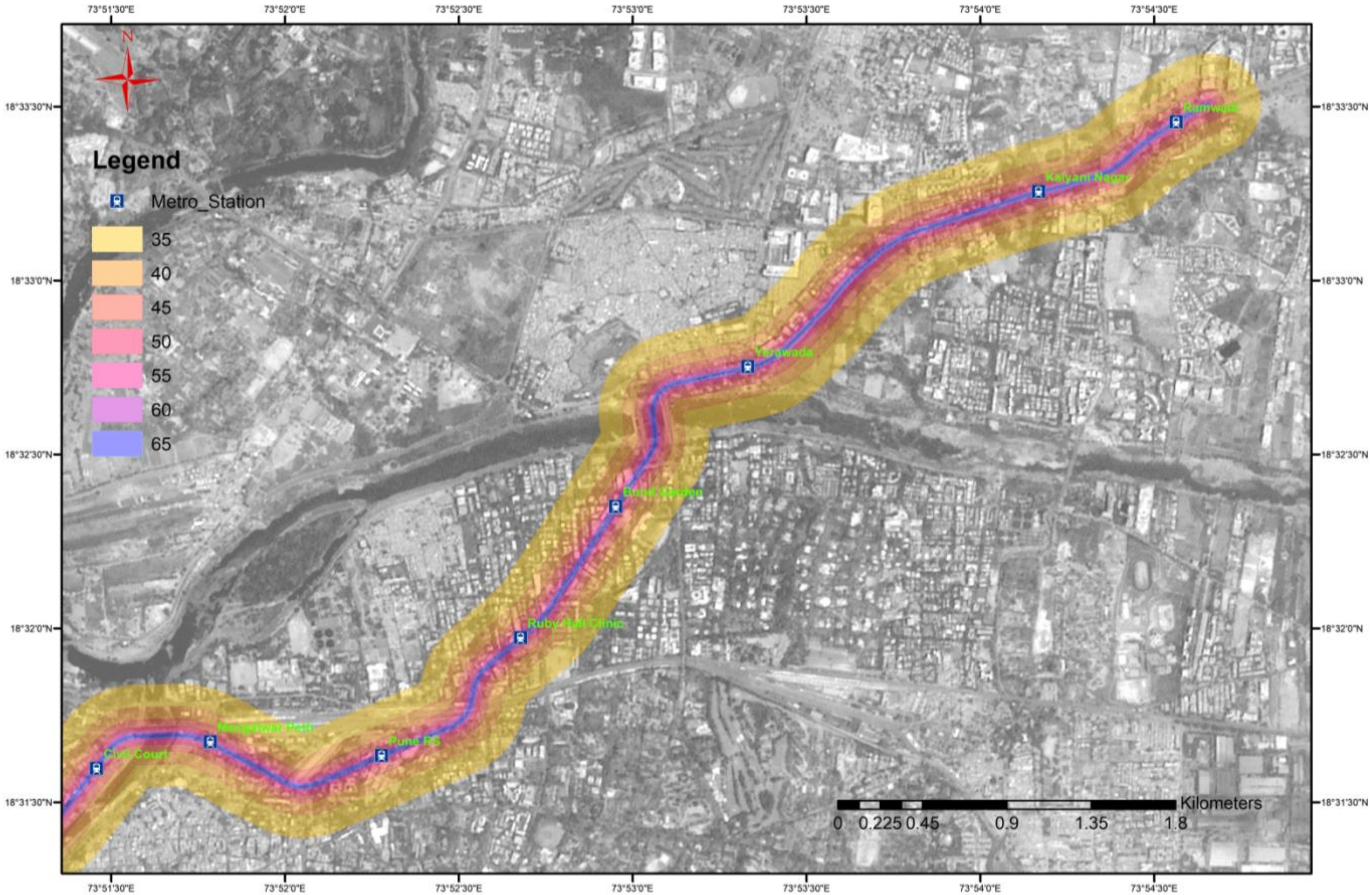


Table 5.15.Predicted cumulative future Noise Levels at each Station due to Metro Operations

Name of the Location	Ele/UG	Cumulative Noise in dB (A) for Year 2021							Cumulative Noise in dB (A) for Year 2031						
Distance in m		**15**	**25**	**50**	**100**	**150**	**200**	**250**	**15**	**25**	**50**	**100**	**150**	**200**	**250**
PCMC - Range Hill Corridor															
PCMC	Ele	75.15	71.8	67.6	63.4	60.9	59.2	57.8	75.15	71.8	67.6	63.4	60.9	59.2	57.8
Sant Tukaram Nagar	Ele	67.33	64.0	59.8	55.6	53.1	51.4	50.0	67.33	64.0	59.8	55.6	53.1	51.4	50.0
Bhosari (Nashik Phata)	Ele	75.40	72.1	67.9	63.7	61.2	59.4	58.1	75.40	72.1	67.9	63.7	61.2	59.4	58.1
Kasarwadi	Ele	75.09	71.8	67.6	63.4	60.9	59.1	57.8	75.09	71.8	67.6	63.4	60.9	59.1	57.8
Phugewadi	Ele	77.24	73.9	69.7	65.5	63.0	61.3	59.9	77.24	73.9	69.7	65.5	63.0	61.3	59.9
Dapodi	Ele	73.86	70.6	66.3	62.1	59.7	57.9	56.6	73.86	70.6	66.3	62.1	59.7	57.9	56.6
Bopodi	Ele	74.03	70.7	66.5	62.3	59.8	58.1	56.7	74.03	70.7	66.5	62.3	59.8	58.1	56.7
Khadki	Ele	73.83	70.5	66.3	62.1	59.6	57.9	56.5	73.83	70.5	66.3	62.1	59.6	57.9	56.5
Range Hill	Ele	63.15	59.8	55.6	51.4	48.9	47.2	45.8	63.15	59.8	55.6	51.4	48.9	47.2	45.8
Shivaji Nagar	UG	73.99	70.7	66.5	62.2	59.8	58.0	56.7	73.99	70.7	66.5	62.2	59.8	58.0	56.7
Civil Court - *Interchange Station*	UG	71.40	68.1	63.9	59.7	57.2	55.4	54.1	71.40	68.1	63.9	59.7	57.2	55.4	54.1
Budhwar Peth	UG	81.90	78.6	74.4	70.2	67.7	65.9	64.6	81.90	78.6	74.4	70.2	67.7	65.9	64.6
Mandai	UG	74.31	71.0	66.8	62.6	60.1	58.4	57.0	74.31	71.0	66.8	62.6	60.1	58.4	57.0
Swargate	UG	74.29	71.0	66.8	62.5	60.1	58.3	57.0	74.29	71.0	66.8	62.5	60.1	58.3	57.0

Name of the Location	Ele/UG	Cumulative Noise in dB (A) for Year 2021							Cumulative Noise in dB (A) for Year 2031						
Distance in m		**15**	**25**	**50**	**100**	**150**	**200**	**250**	**15**	**25**	**50**	**100**	**150**	**200**	**250**
Vanaz - Ramwadi Corridor															
Vanaz	Ele	73.77	70.5	66.2	62.0	59.6	57.8	56.5	73.84	70.5	66.3	62.1	59.6	57.9	56.5
Anand Nagar	Ele	72.85	69.5	65.3	61.1	58.6	56.9	55.5	72.93	69.6	65.4	61.2	58.7	57.0	55.6
Ideal Colony	Ele	71.77	68.5	64.2	60.0	57.6	55.8	54.5	71.88	68.6	64.3	60.1	57.7	55.9	54.6
Nal Stop	Ele	73.20	69.9	65.7	61.5	59.0	57.2	55.9	73.27	70.0	65.7	61.5	59.1	57.3	56.0
Garware College	Ele	74.13	70.8	66.6	62.4	59.9	58.2	56.8	74.19	70.9	66.7	62.4	60.0	58.2	56.9
Deccan Gymkhana	Ele	73.18	69.9	65.7	61.4	59.0	57.2	55.9	73.25	69.9	65.7	61.5	59.0	57.3	55.9
Sambhaji Park	Ele	73.25	69.9	65.7	61.5	59.0	57.3	55.9	73.33	70.0	65.8	61.6	59.1	57.4	56.0
PMC	Ele	73.83	70.5	66.3	62.1	59.6	57.9	56.5	73.90	70.6	66.4	62.2	59.7	57.9	56.6
Mangalwar Peth	Ele	70.40	67.1	62.9	58.7	56.2	54.4	53.1	70.54	67.2	63.0	58.8	56.3	54.6	53.2
Pune Rly. Stn	Ele	74.52	71.2	67.0	62.8	60.3	58.6	57.2	74.58	71.3	67.1	62.8	60.4	58.6	57.3
Ruby Hall Clinic	Ele	76.57	73.3	69.0	64.8	62.4	60.6	59.3	76.60	73.3	69.1	64.9	62.4	60.6	59.3
Bund Garden	Ele	69.08	65.8	61.6	57.3	54.9	53.1	51.8	69.27	66.0	61.7	57.5	55.1	53.3	52.0
Yerawada	Ele	72.14	68.8	64.6	60.4	57.9	56.2	54.8	72.23	68.9	64.7	60.5	58.0	56.3	54.9
Kalyani Nagar	Ele	74.71	71.4	67.2	63.0	60.5	58.8	57.4	74.76	71.5	67.2	63.0	60.6	58.8	57.5
Ramwadi	Ele	71.29	68.0	63.8	59.5	57.1	55.3	54.0	71.40	68.1	63.9	59.7	57.2	55.4	54.1

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 5.17 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 5.16.Predicted Vibration Level due to Rapid Transit Rail without 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)	Permissible*
PCMC – Swargate Corridor						
1.	Harris Bridge near Bapodi	4	0.138	0.129	0.267	0.25
2.	Pataleswar Cave Mandir (UG)	179	0.027	0.005	0.032	0.25
3.	District and sessions court(UG)	36	0.018	0.041	0.059	0.25
4.	Shaniwar Wada (UG)	168	0.031	0.005	0.036	0.25
5.	Kasba Ganapati Mandir (UG)	110	0.032	0.010	0.042	0.1
6.	Dagduseth Ganapathi Mandir (UG)	43	0.030	0.034	0.064	0.1
7.	City post (UG)	16	0.028	0.087	0.115	0.25
8.	Old wooden structure at Mandai (UG)	47	0.031	0.031	0.062	0.08
Vanaz – Ramwadi Corridor						
9.	St. Crispin Church	110	0.021	0.006	0.027	0.25
10.	Galaxy Care Hospital	35	0.035	0.024	0.059	0.08
11.	Sangam Bridge	27	0.024	0.031	0.055	0.25
12.	Ruby Hall (Hospital)	11	0.035	0.065	0.100	0.08
13.	Rajeev Gandhi Hospital	85	0.031	0.008	0.040	0.08
14.	Agha Khan Palace	120	0.021	0.005	0.026	0.25

* Standards as per Transportation and construction Vibration Guidance Manual, Caltrans, Secptember 2013

Predicted vibration without control measures as above reveals that most of the receptor locations fall within vibration damage threshold criteria listed in Table 5.6 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

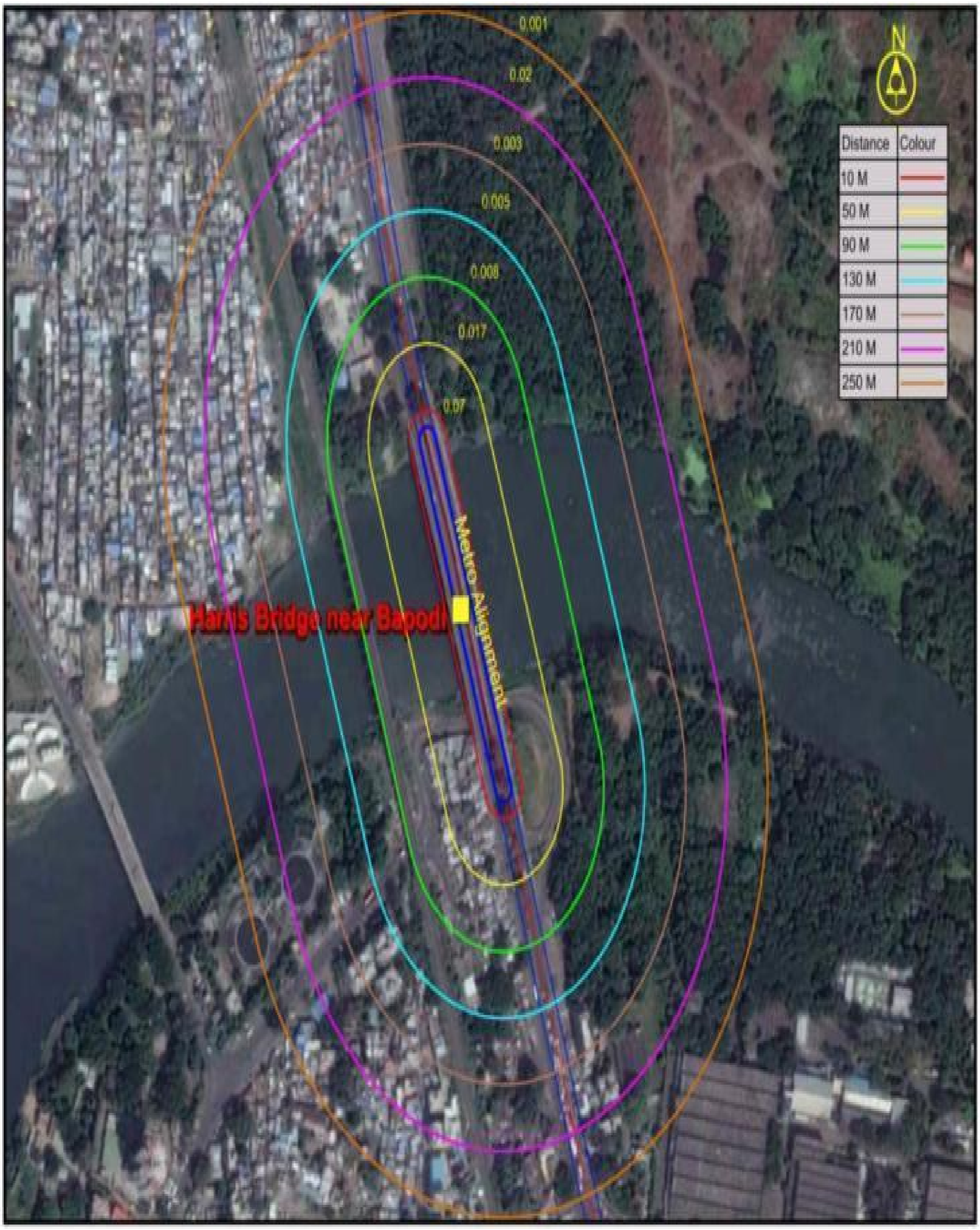
In the light of above non-conservative conditions modelling results are given in Table 5.18 and resultant magnitude of PPV at all receptors locations are predicted to be within vibration damage threshold criteria. Vibration contours during operation phase of the project are shown in Figure 5.8.

Table 5.17.Predicted Vibration Level due to Rapid Transit Rail with Control Measures

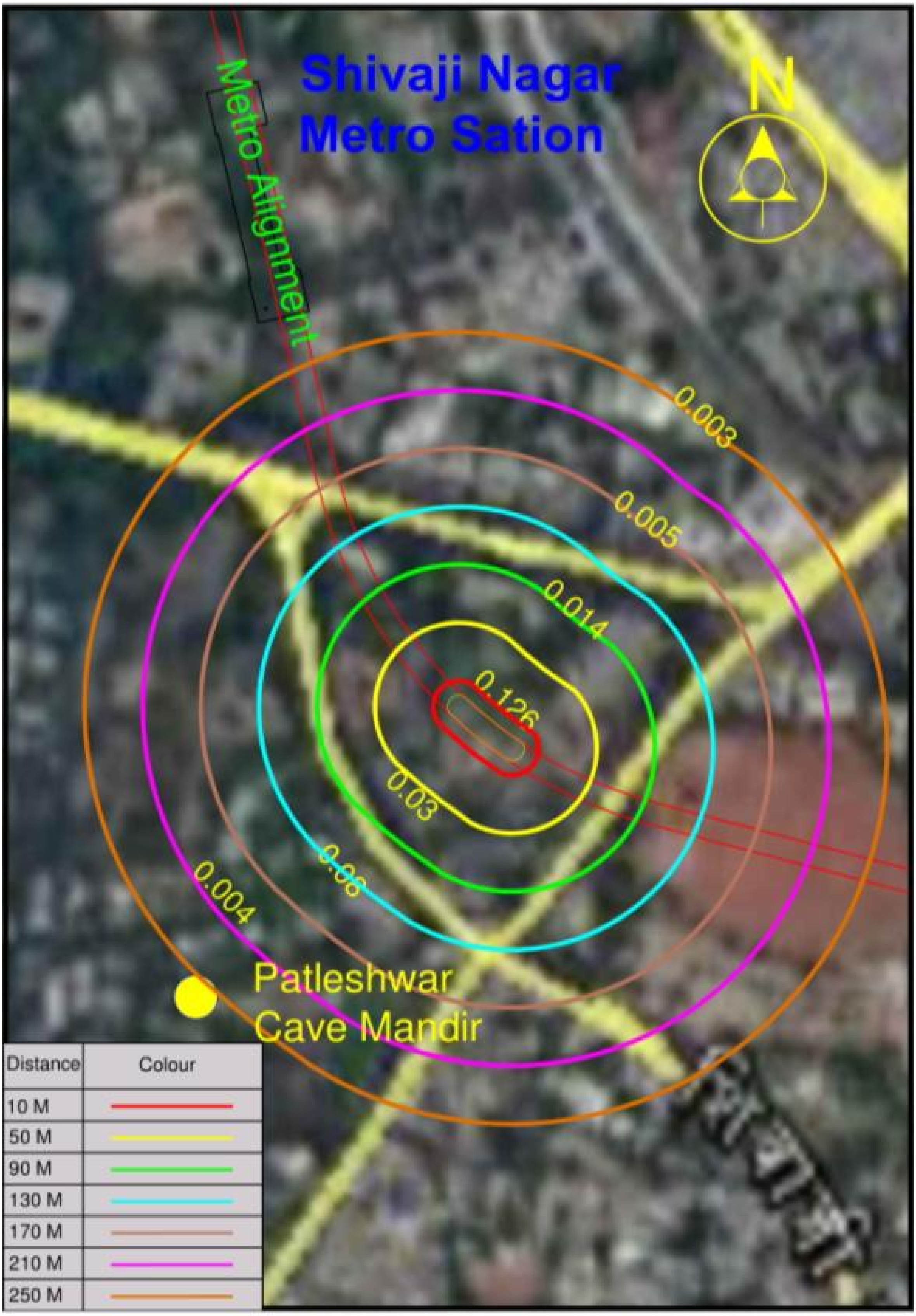
S No.	Location	Impact Distance (D) from source (m)/Metro alignment	Monitored Vibration Level (in/sec)	Predicted Vibration Level (in/sec) with Control measures	Resultant Vibration Level (in/sec)	Permissible*
PCMC - Swargate Corridor						
1.	Harris Bridge near Bapodi	4	0.138	0.003	0.141	0.25
2.	Pataleswar Cave Mandir (UG)	179	0.027	0.0001	0.0271	0.25
3.	District and sessions court (UG)	36	0.018	0.0007	0.0187	0.25
4.	Shaniwar Wada (UG)	168	0.031	0.0001	0.0311	0.25
5.	Kasba Ganapati Mandir (UG)	110	0.032	0.0002	0.0322	0.1
6.	Dagduseth Ganapathi Mandir (UG)	43	0.030	0.0006	0.0306	0.1
7.	City post (UG)	16	0.028	0.002	0.03	0.25
8.	Old wooden structure at Mandai (UG)	47	0.031	0.0006	0.0316	0.08
Vanaz - Ramwadi Corridor						
9.	St. Crispin Church	110	0.021	0.0004	0.021	0.25
10.	Galaxy Care Hospital	35	0.035	0.001	0.036	0.08
11.	Sangam Bridge	27	0.024	0.001	0.025	0.25
12.	Ruby Hall (Hospital)	11	0.035	0.001	0.036	0.08
13.	Rajeev Gandhi Hospital	85	0.031	0.0004	0.021	0.08
14.	Agha Khan Palace	120	0.021	0.001	0.033	0.25

* Standards as per Transportation and construction Vibration Guidance Manual, Caltrans, Secptember 2013

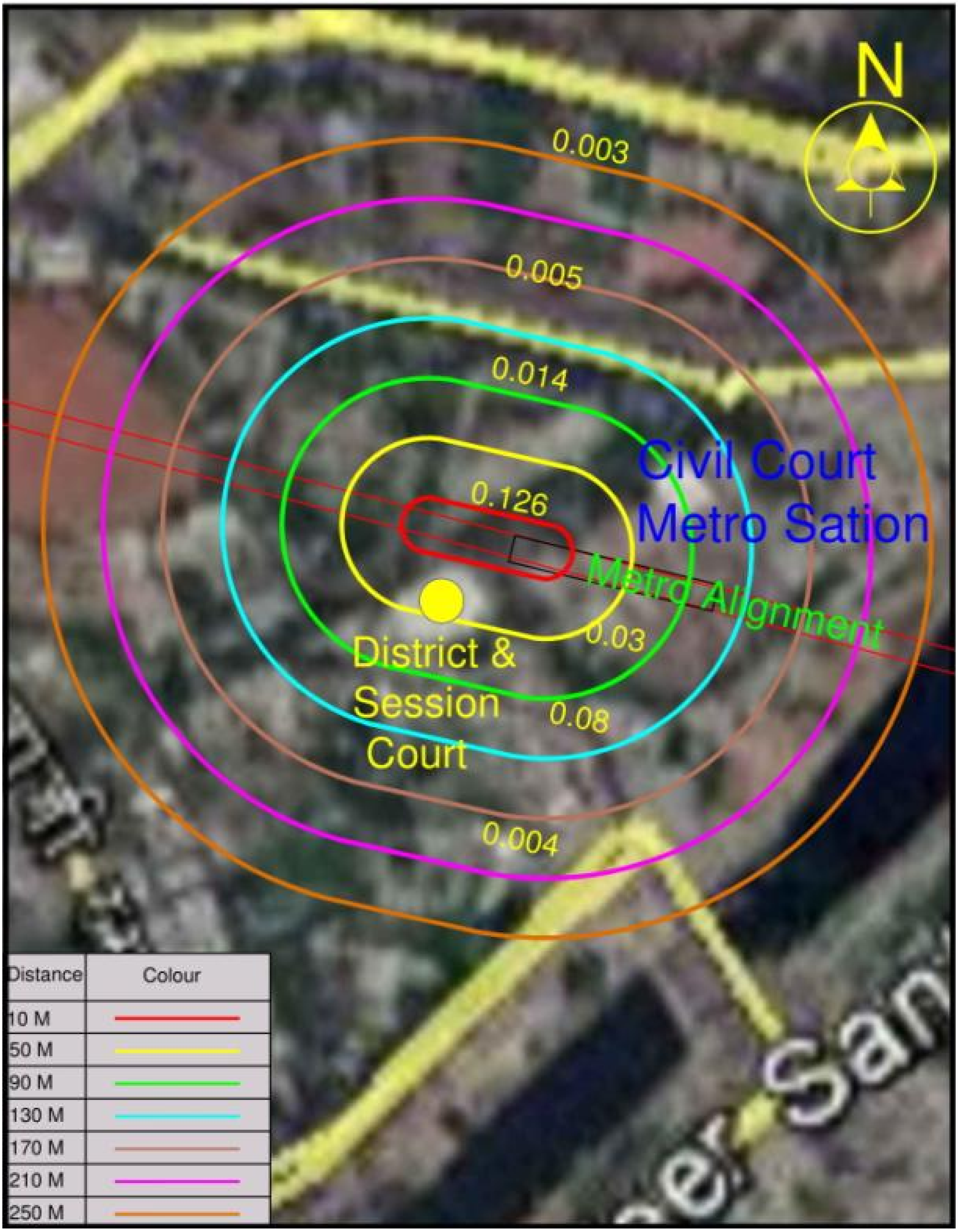
Figure 5.8. Vibration at Monitoring Locations during Operation Phase



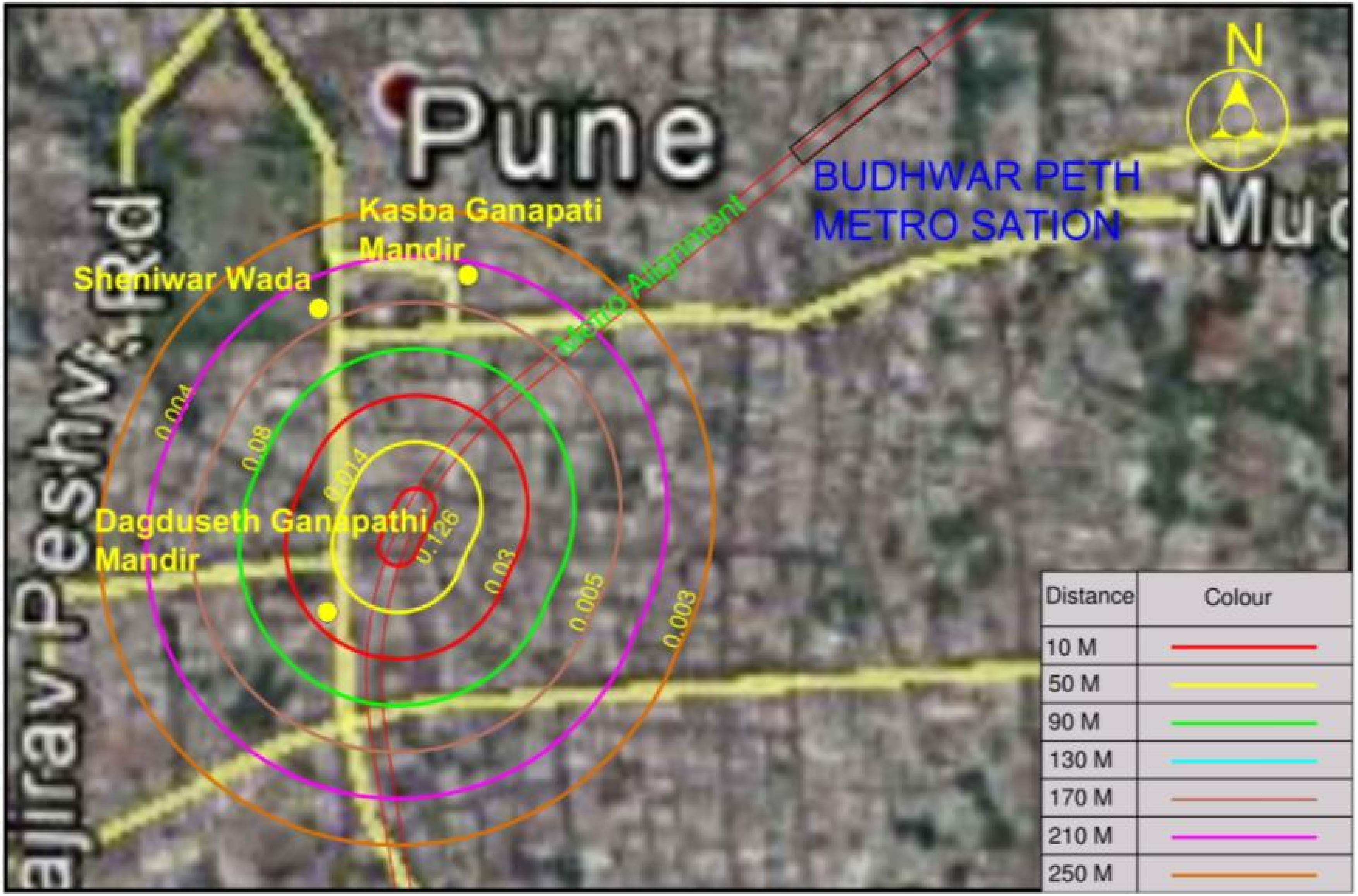
Harris Bridge near Bapodi



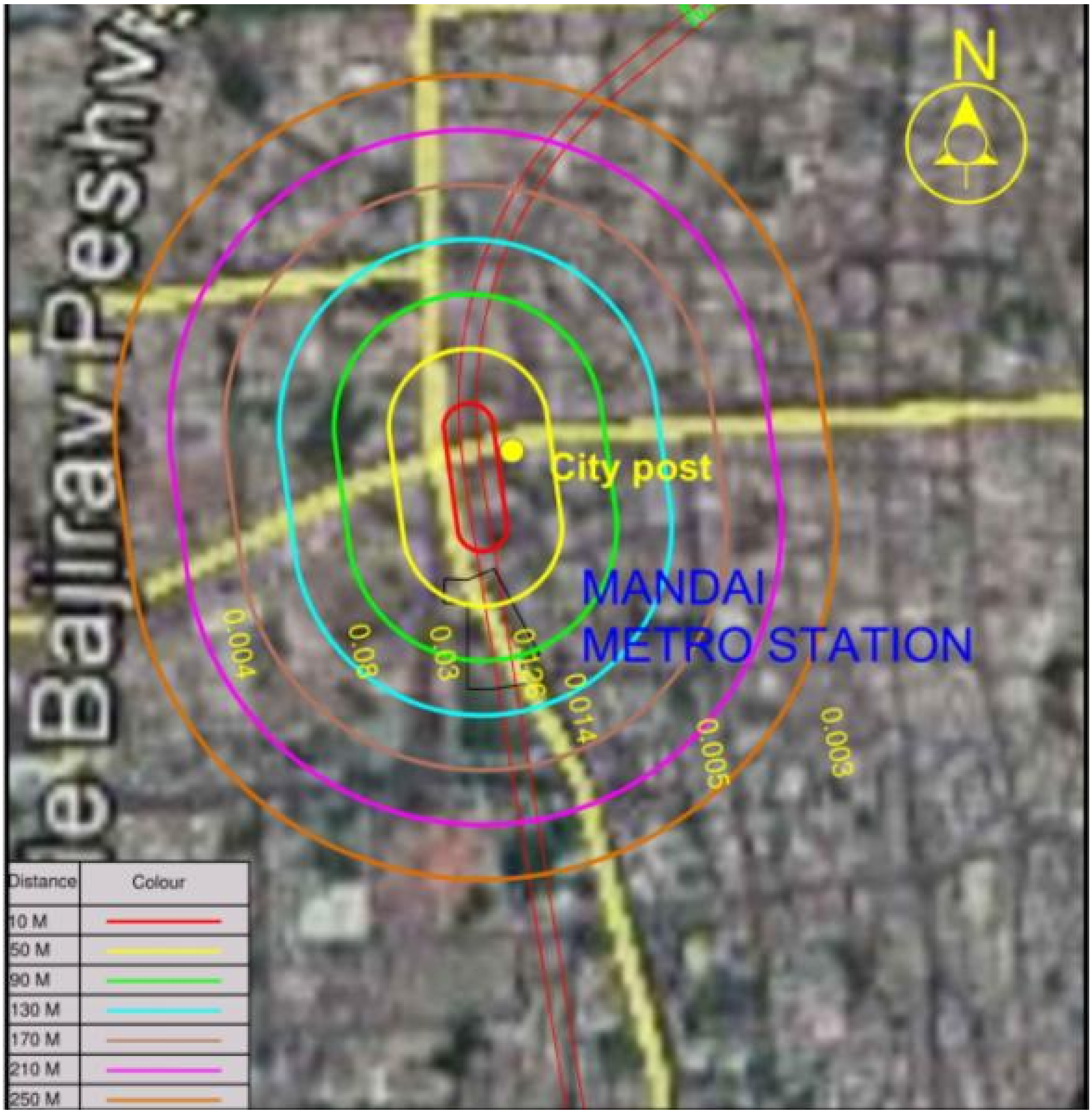
Pataleswar Cave Mandir



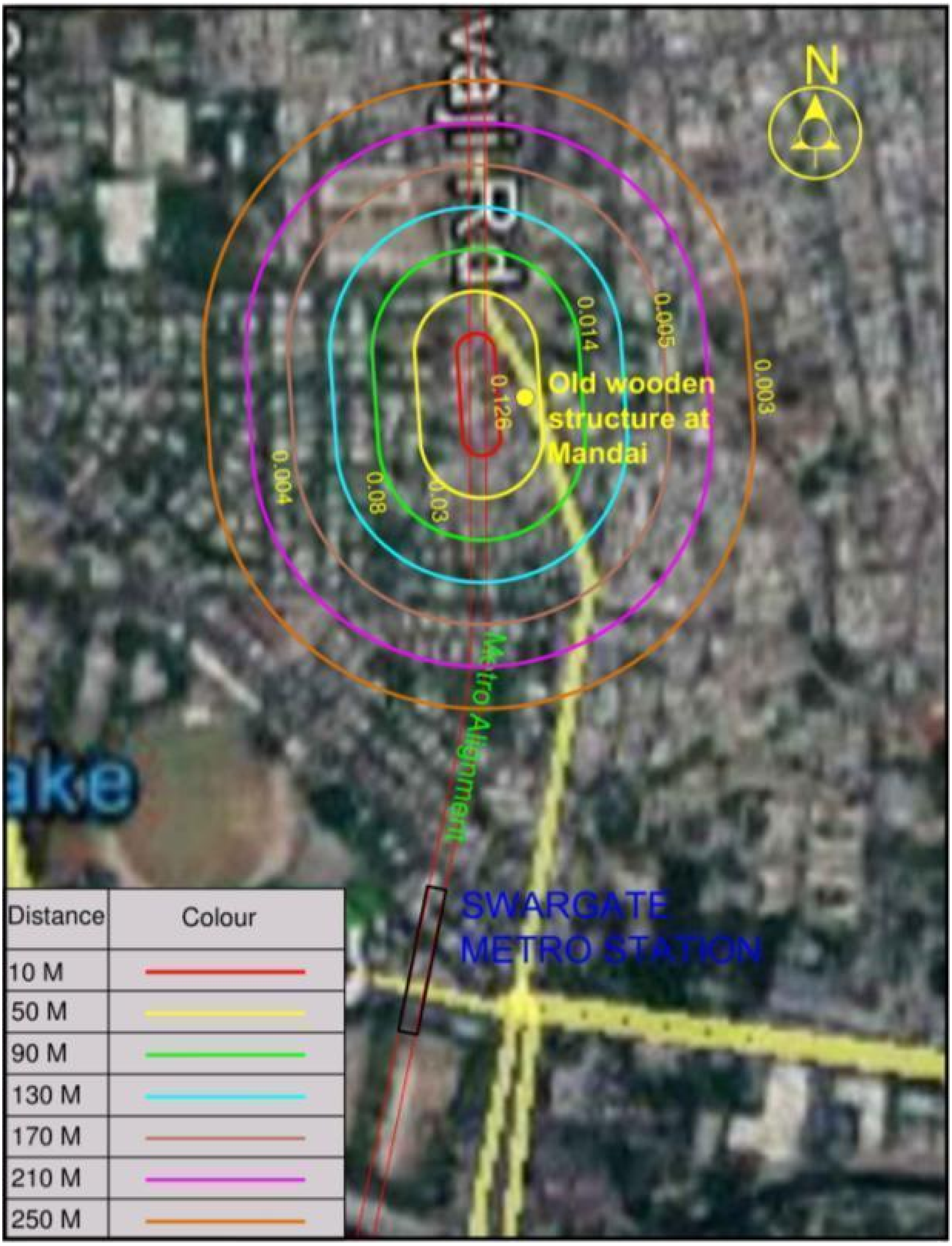
District and sessions court



Shaniwar Wada, Kasba Ganapati Mandir, Dagduseth Ganapathi Mandir and City Post



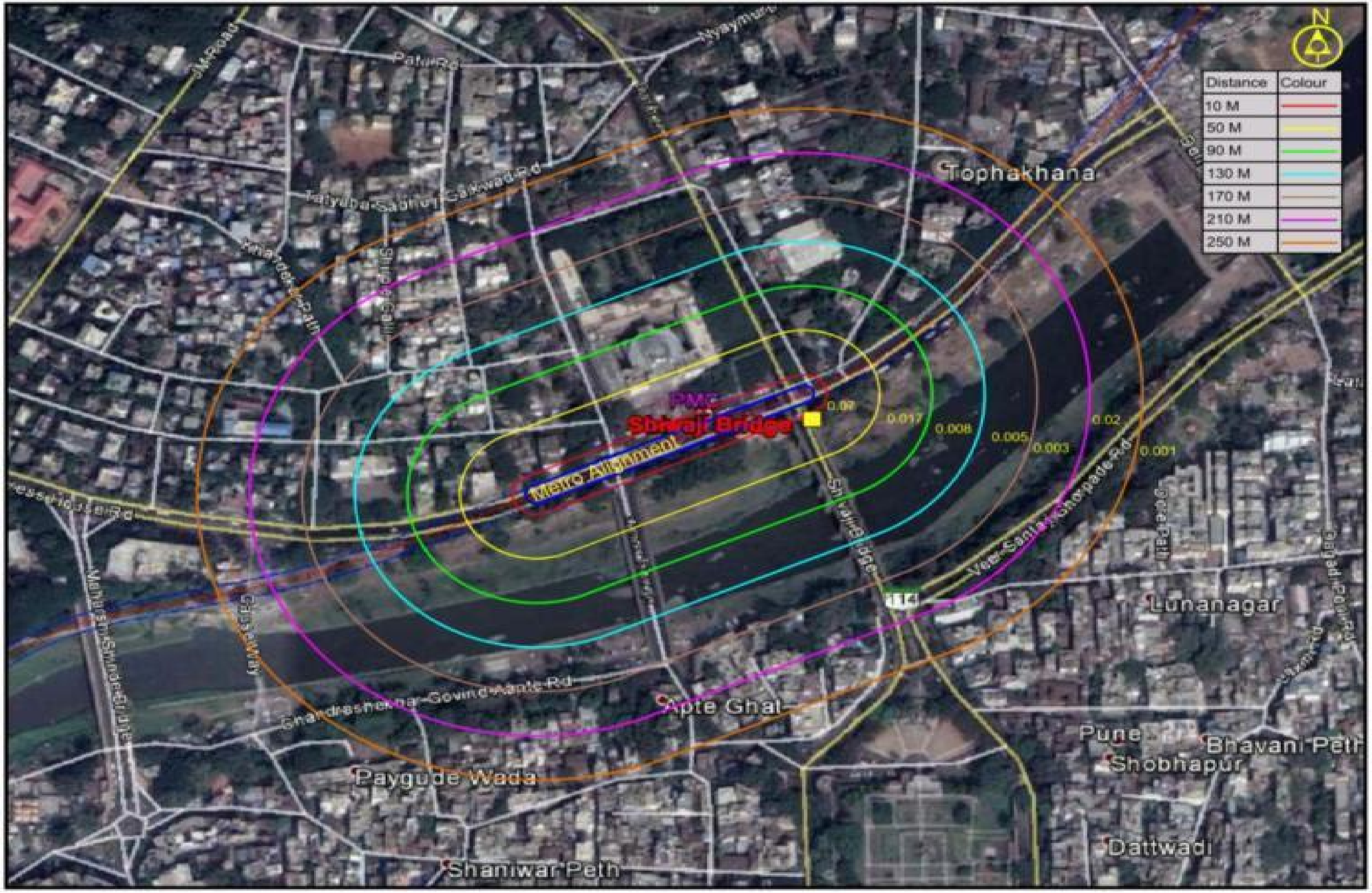
City Post structure at Mandai



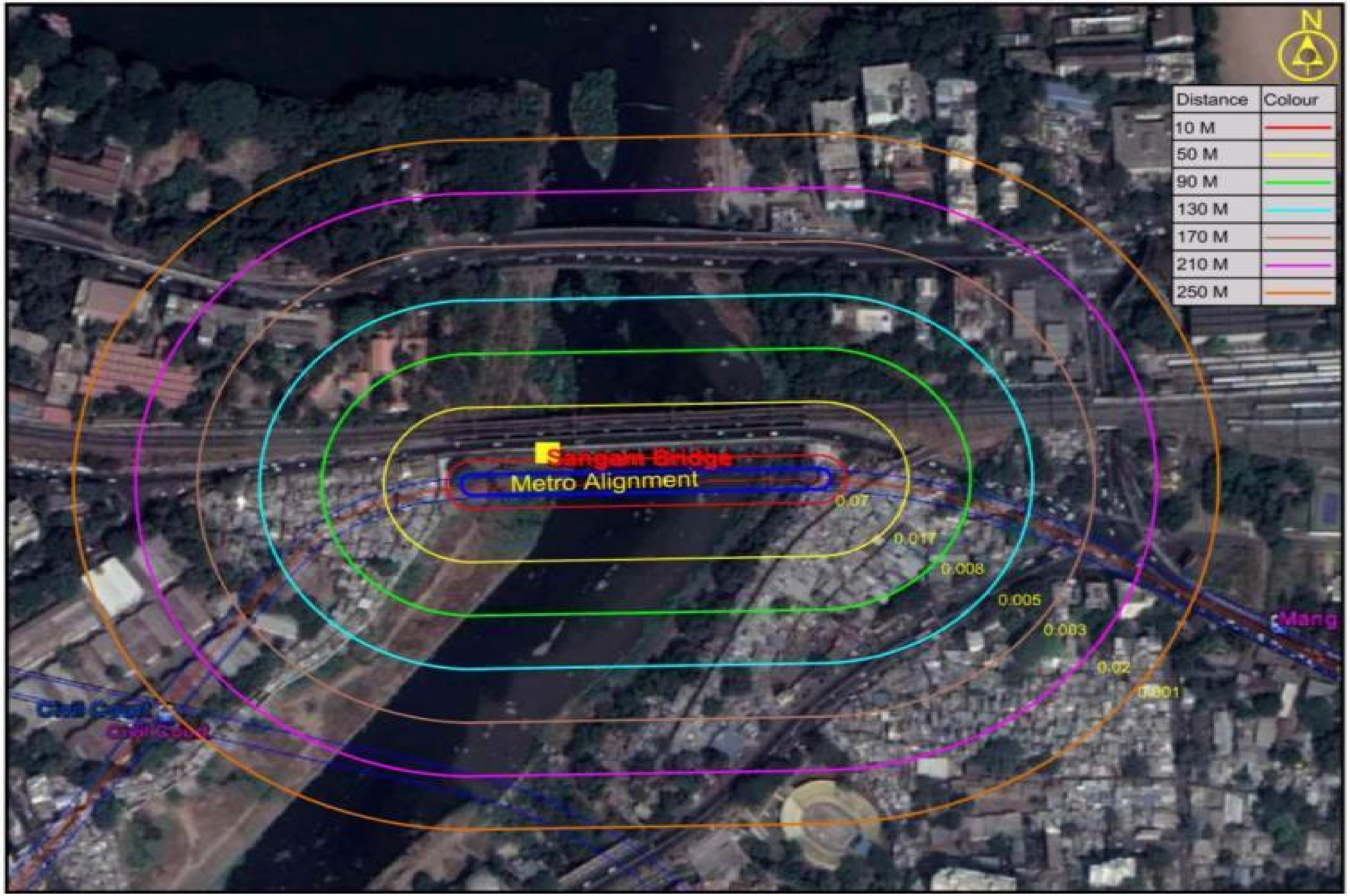
Old Wooden Structure near Swargate Station

St. Crispin Church

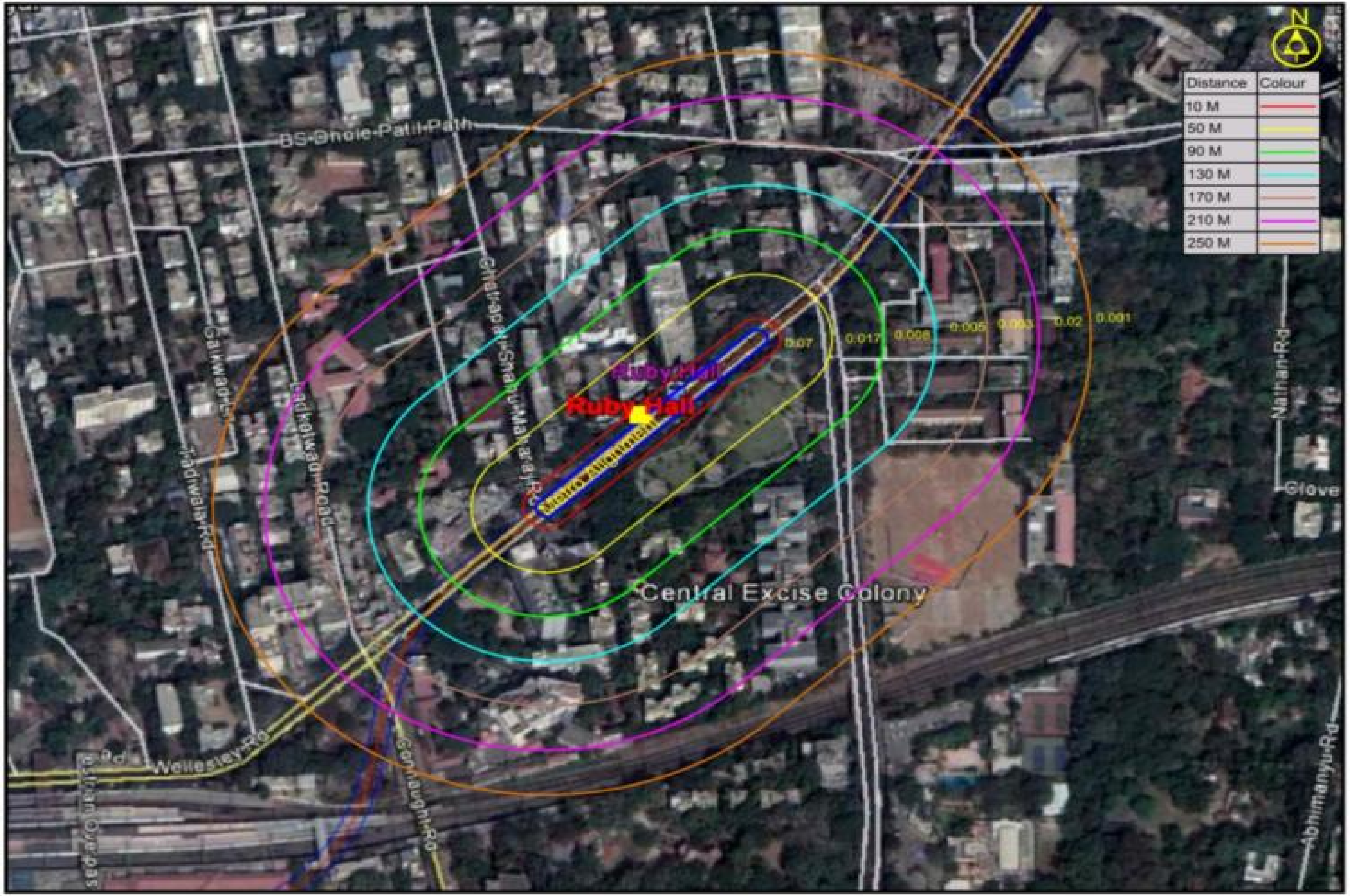
Galaxy Care Hospital



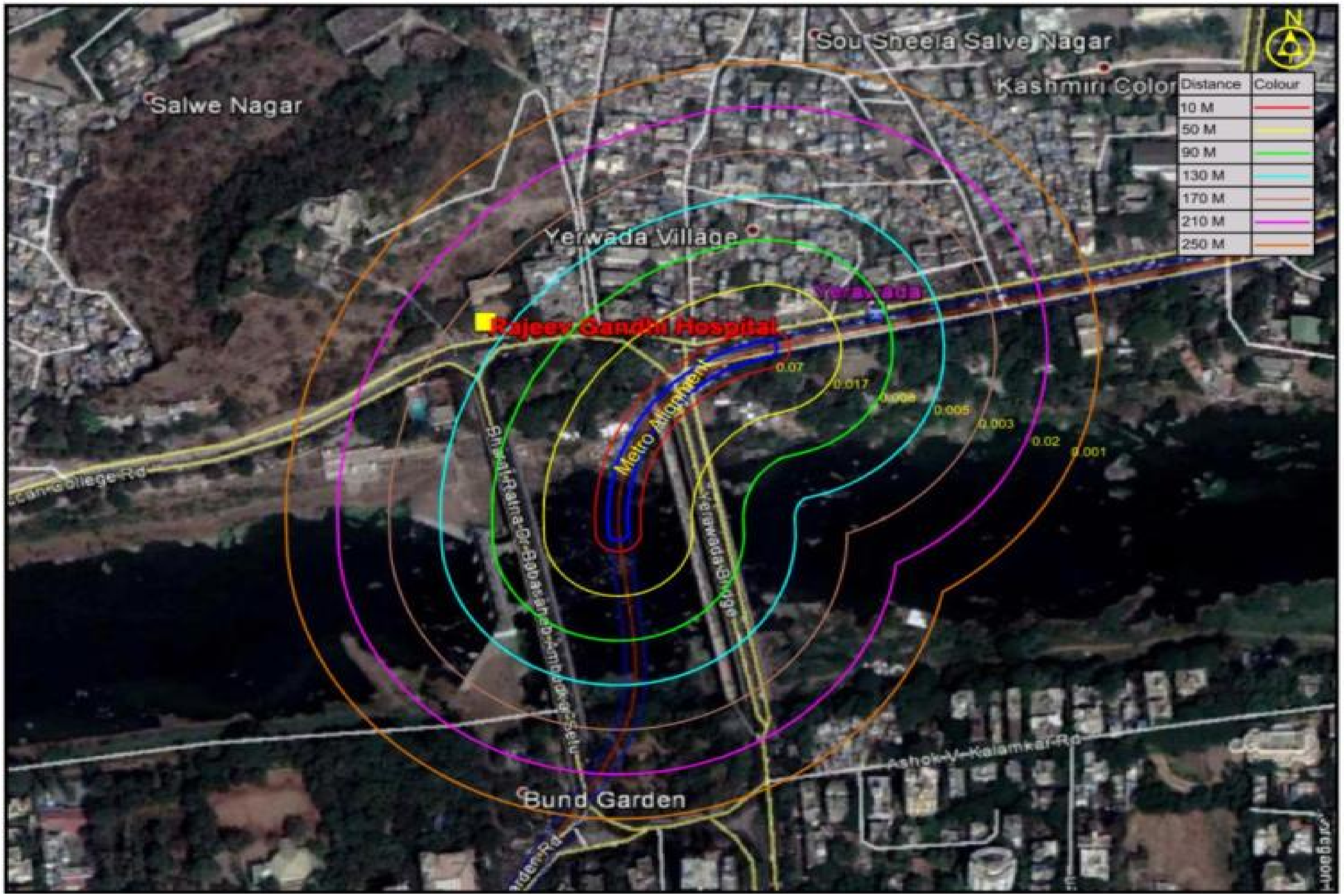
Shivaji Bridge



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 staff will be of the order of magnitude as indicated in Table 5.19. The demand is estimated on the following assumptions:

- Alighting passenger for Year 2031 as given in DPR are considered for the calculations
- 15% of Alighting passengers at each station will use the toilets
- Water requirement for each user will be 5 lit/passenger/day
- 10% of Alighting passenger at each station will generate Solid Waste
- 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 5.18.Water and Sewage Demand

S. No.	Station Name	Water requirement in KLD	Waste Water in KLD	Solid Waste in Kg
PCMC - Range Hill				
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
	Total	**224**	**202**	**2991**
Range Hill – Swargate				
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

S. No.	Station Name	Water requirement in KLD	Waste Water in KLD	Solid Waste in Kg
	Total	**109**	**98**	**1447**
Vanaz - Civil Court				
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
7	ASI	9.8	8.8	131
8	Civil Court	27.8	25.1	371
	Total	**132**	**119**	**1764**
Civil Court – Ramwadi				
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	**86**	**77**	**1141**

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 if inter modal integration with other modes is not done.

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

About 23.6 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 506 trees and at Vanaz Depot 161 trees have been impacted which will be transplanted at Range hill/Agricultural college and ARAI respectively.

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 camps during project construction. In operation phase of the project, about 35 persons per kilometre length of the corridor, ie about 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 study only 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[9].

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. Reduction in daily vehicle kilometres as given in Pune Metro DPR 2015 were too low, hence the same were estimated based on the available data in Pune CMP studies 2008 and Pune Metro DPR 2015. 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

Vehicle Type	2031
Car	32,94,509
2W	318,34,371
Auto (3W)	32,52,595
Bus	1,79,767

Note: Estimated based on Pune CMP 2008& Pune Metro DPR, DMRC 2015

6.6. LESS FUEL CONSUMPTION

Reduced fuel consumption from passenger vehicles during operation of Metro were estimated using the following:

a) based on mode-wise yearly number of vehicles from year 2005 to 2021
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
e) respective shares in vehicle, no impact of increased public transport or land use changes
f) Fuel efficiency factors from CMP Toolkit 2014 for sustainable transport scenario and

Based on number of daily vehicle kilometre reduction, daily reduction in fuel (diesel and petrol) consumption and corresponding expenditure as per October 2018 prices are reported in Table 6.2.

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

Table 6.2. Reduction in Fuel Consumption and Expenditure

Mode/Year	Reduction in Daily Fuel Consumption in Year 2031 (Thousand Lit/day)	Cost (Rs Lakh/day) as per Oct-2018 prices
Car (Diesel)	5.4	4.21
Car (Petrol)	62.2	52.92
2 Wheeler (Petrol)	153.6	130.62
Total reduction in Fuel Expenditure in Rs. Lakh/day		**187.74**

6.7. REDUCED AIR POLLUTION

Compared to other modes of transport, the metro is least polluting and can be classified as an environment friendly technology since no air emissions are involved in running and operating the metro trains. The reduction of air pollutants corresponding to the reduction of daily vehicle kilo meters are presented in Table 6.3 along with the treatment cost. For this purpose, emission co-effients as given in the Appraisal Guidelines for Metro Rail Project Proposals, MOHUA, Sept 2017 are used. Monetary rate of treatment benifits due to reduction in air pollution are also presented MOHUA guidelines for all aspects viz. Particulate matter, Nitrogen oxides, Carbon monoxide, Hydro Carbons and Carbon dioxide.

Table 6.3. Reduction in Air Pollutants due to Vehicle Reduction

Pollutant	Reduction in Air Pollutants in Kg/day for Year 2031				
	CO	HC	NOx	PM	CO_2
Car	4.58	0.49	0.40	0.07	459.65
2W	44.57	22.28	9.55	1.59	909.83
Auto (3W)	7.97	2.44	0.39	0.26	253.34
Bus	0.67	0.03	1.17	0.04	141.61
Total Pollutant Reduction in Kg/day	**53,206**	**24,752**	**11,114**	**1895**	**13,04,777**
Reduction in Treatment Cost in Lakh/day	**53.21**	**24.75**	**11.11**	**1.90**	**6.52**

6.8. CARBON CREDITS

The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets.This set legally binding targets for 37 industrialised countries to limit or reduce overall GHG emissions by at least 5% below 1990 levels during the period 2008-2012. In the Doha Amendment to the Kyoto Protocol December 2012 new commitments to reduce GHG emissions by at least 18 percent below 1990 levels in the eight-year period from 2013 to 2020 were committed from 1 January 2013 to 31 December 2020.

Under the Protocol, countries must meet their targets primarily through national measures. However, the Protocol also offers additional means to meet their targets by way of three market-based mechanisms. These are:

- **International Emissions Trading** - the international transfer of emission allocations between industrialized (Annex 1) countries. E.g. a country that stays within its target can sell the surplus allowances to another country that has exceeded its limit.
- **Clean Development Mechanism (CDM)** - creates Certified Emission Reductions (CERs) through emission reduction projects in developing countries, regulated by the United Nations. Each CER is equivalent to one tonne of CO_2. These CERs can be traded and sold, and used by industrialized countries to a meet a part of their emission reduction targets under the Kyoto Protocol.
- **Joint implementation (JI)** - any Annex I country can invest in emission reduction projects in any other Annex I country as an alternative to reducing emissions domestically.

The emission reductions generated by these mechanisms are collectively referred to as 'carbon credits'. A carbon credit is a financial instrument that represents a reduction or the avoidance of one tonne of carbon dioxide equivalent (tCO_2e) from the atmosphere.

CDM Benefits: The clean development mechanism was designed to meet a dual objective:
- to help developed countries fulfill their commitments to reduce emissions, and
- to assist developing countries in achieving sustainable development.

Benefits of CDM projects include investment in climate change mitigation projects in developing countries, transfer or diffusion of technology in the host countries, as well as improvement in the livelihood of communities through the creation of employment or increased economic activity.

General Eligibility requirements for CDM projects
- Submission of the "prior consideration of the CDM" form within 6 months of the project start date.
- Stakeholder consultation and addressing their observations
- Submission of documentation on environmental impacts of the project activity.
- The project activity is expected to result in a reduction in anthropogenic emissions by sources of greenhouse gases that are additional to any that would occur in the absence of the proposed project activity,
- Baseline and monitoring methodologies comply with requirements.
- All permissions/NOCs related to project obtained and project contribute to sustainable development criteria of Host country.

Transport projects that contribute to reductions in GHG emissions, and have potential for Carbon finance, include improved public transport (bus rapid transit, metros, light rail transit), electric and hybrid vehicles (e.g., electric scooters), inter-urban rail infrastructure (including double-tracking, new freight lines, new passenger lines, or rapid passenger trains), technologies like regenerating breaking system which generate electricity while breaking and electrification railways projects (depending on whether the country uses fossil fuels to generate power or not). The principles for reduction in GHG emission into transportation is as follows:

- Reduce emissions per km
  - Fuel switch e.g. bio-fuels
  - Behavioral management change e.g fleet management, driver training
  - Technology vehicle change. i.e. Energy efficiency improvements, regenerating breaking system & electric vehicles
- Reduce emission per unit transported
  - Passenger transport e.g. urban planning modal shift, use of large units, Improved occupation rate
  - Fright transport
- Reduce distance or number of units
  - Urban planning to induce behavior change via government policies/measures
- Use of renewable energy and energy efficiency in stations and offices
  - Solar roof tops, led lighting, natural lighting, use of glare glasses, VAM etc.

6.8.1. Carbon Credits for Pune Metro Rail Project

The measures used to calculate Carbon Credit for the projects are classified into following categories:

- Reduce emissions per km by use of regenerating breaking system & electric vehicles
- Reduce emission per unit transported modal shift from two, three and four wheelers

A. Reduce Emissions per km by use of Regenerating Breaking System & Electric Vehicles

The project activity operates low GHG emitting rolling stocks having regenerative braking system in Pune Metro. The project replaces the conventional electro-dynamic rheostatic braking technology, with regenerative braking technology fitted rolling stocks. The regenerated electrical energy reduces the consumption of equivalent grid electrical energy required by the powering trains, thereby conserving electrical energy and subsequently leading to GHG emission reduction.

Therefore the emission reductions are additional as the above project activity is expected to result in a reduction in anthropogenic emissions by sources of greenhouse gases(GHG) that are additional to any that would occur in the absence of the proposed project activity.

The net annual Energy requirement for Traction and auxillary power for both the corridors of Pune Metro is given in Table 6.4. Rolling stock proposed for the metro has regeneration features and it is expected that 30% of total traction energy. Hence the total regeneration energy for both the corridors in Year 2021 is 14.56 million units and in year 2031 is 16.73 million units.

Table 6.4. Traction Energy Requirement

S. No	Item	Unit	PCMC - Swargate Corridor		Vanaz – Ramwadi Corridor	
			2021	2031	2021	2031
Traction Power Requirment						
1.	Total Energy required per Year	Million Units	34.54	34.54	14.00	21.23
2.	**Regeneration Energy (30% of total Traction Energy) per Year**	Million Units	**10.36**	**10.36**	**4.20**	**6.37**
3.	Net Traction Energy Consumption per Year with 30% regeneration energy	Million Units	24.18	24.18	9.80	14.86
Auxillary Power Requirment						
4.	Yearly Auxillary Energy Consumption	Million Units	49.67	65.92	18.09	29.13
Gross Annual Energy Consumption (Traction & Auxillary)		Million Units	**84.21**	**100.46**	**32.09**	**50.36**

Source: DPR, November 2015

CO_2 emissions due Energy consumption (Traction and Auxillary) and reduction due to regeneration energy for year 2031 are estimated based on the CO_2 Intensity of Electricity from grid as given in CMP tool kit 2014 and results are given in Table 6.5.

Table 6.5. CO_2 Emissions from Energy Requirement of Metro Operations

Item	PCMC - Swargate Corridor	Vanaz – Ramwadi Corridor
CO_2 emissions due to Gross Energy Consumption (Traction & Auxillary) of Metro Operations for Year 2031 - Ton/day	93.58	46.91
Reduction in CO_2 Emissions due to Regeneration Energy (30% of total Traction Energy) for Year 2031 – Ton/day	9.65	5.93

B. Reduce Emission per unit Transported Modal Shift from Two, Three and Four wheelers

The traditional mode of transport including buses, taxis, private cars, rickshaws, motorcycles and bikes. The traditional mode (being run on high intensive carbon fuel) emit huge amount of GHG into the atmosphere. Metro complements other modes of transport and replaces partially, the trips made by conventional or traditional means of transit. Reduction of Traffic on Road in terms of Daily Vehicle Kilometers and corresponding reduction in daily fuel consumption are detailed in Section 6.5 and 6.6 respectively.

The emission reductions are additional as the above project activity is expected to result in a reduction in anthropogenic emissions by sources of greenhouse gases (GHG) that are additional to any that would occur in the absence of the proposed project activity. Reduction of CO_2 emissions due to modal shift are given in Section 6.7.

Details of carbon credits accruing from modal shift, gross energy consumption and regenerative breaking system for year 2031 are summarised in Table 6.6.

Table 6.6. Details of Carbon Credits due to Operation of Pune Metro in Year 2031

S. No	Item	Carbon Credits (tCO_2e/day)
a)	Reduction in CO_2 emissions due to Modal Shift	1304.78
b)	CO2 emissions due to Gross Energy Consumption (Traction & Auxillary) of Metro Operations	140.49
c)	Reduction in CO_2 Emissions due to Regeneration Energy (30% of total Traction Energy)	15.58
	Carbon Credits tCO_2e/day: (a)-(b)+(c)	1179.87

Chapter 7 : Additional EIA and Hydraulic Studies of Mula Mutha River

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 EIA and Hydraulic Studies of metro rail alignment passing through Mutha River. The work has been awarded to MITCON Consultancy & Engineering Services Ltd., Pune. EIA and EMP studies were carried out as per guidelines of MoEFCC, CPCB, World Bank and as per suggestions given by Biodiversity Management Committee, Pune Municipal Corporation.

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, effort was made to reduce the environmental impact by reducing the length to 1.45 Km. This was achieved by reducing the 250 meter 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.

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

1.45 Km stretch - It enters the river bed only once at the Panchaleshwar temple and exits at the Vridheshwar /Someshwar temple. In this stretech two metro stations i.e. Deccan Gymkhana Metro Station & Chatrapati Sambhaji Udyan Metro Station are proposed. Care has been taken to ensure that neither of these heritage structures is affected and the alignment stays on the landward side as near as feasible. This change also reduces number of affected trees from 60 to 13.

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 of river for 39+20 (viaduct + stations) will be 1475 sq.m. for actual construction on ground. The land belongs to Irrigation Department, Government of Maharashtra.

There is no acquisition of private land 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 Municipal Corporation land 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 the stretch passing through the left bank of the Mutha river. The studies were conducted for the period from 18th May 2017 to December 2017.

Water quality, soil quality, Noise & Vibration study were carried out in the month of May 2017; Air quality monitoring was conducted in the months of May to June 2017. Ecology and biodiversity studies were conducted during May to December 2017 (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 rocks permeability depends upon the vertical and horizontal joints, fractures, pores, vesicular condition, and their connection with each other, which permits the storage and movement of water. Most of the bore wells tap both semi confined and confined aquifers. In short, entire succession of the basaltic lava flow acts as a multi aquifer system including productive and less productive zones. They are permeable and impermeable in nature. Well inventory is a tool of hydro geological study. The following are the observations for the open well inventory in the study area.

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

Figure 7.1. Image showing 500 m Study Area

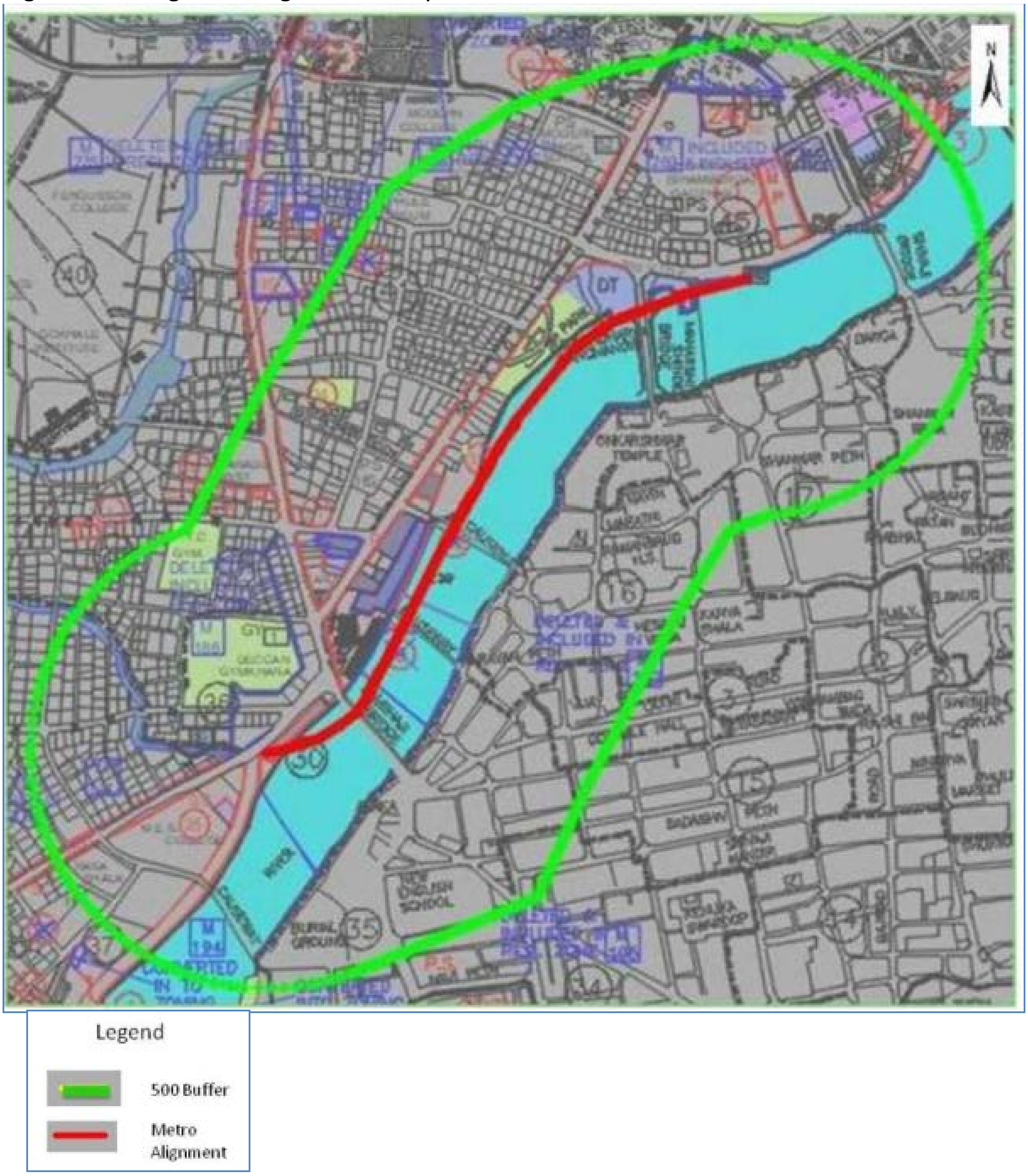


Table7.1.Environmental & Infrastructure Setting of the Study Area

S. No.	Particulars	Details	Distance from project site (km)
1.	Project Location	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

S. No.	Particulars	Details	Distance from project site (km)
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 that they receive their recharge from annual rainfall and their water table are at normal atmosphere pressures. Dug wells and bore wells in close proximity to such features have higher yields.

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

Table7.2.Well inventory of Dug Wells from the area in close proximity to the Metro Alignment

Well No	**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	Ayurved Rasashala, 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 pheratic aquifers are encountered in the area viz. shallow alluvial aquifer and vesicular basalt (compound pahoehoe) aquifer. The dug wells tapping these aquifers are large diameter wells with variable depths ranging from 5.9 to 20 meters below ground level (m bgl). The static water level ranges from ~ 2 m bgl in winter to ~ 9 m bgl in the summer. The depth to groundwater level (DTW) ranges from 0.50 to more than 8 m below ground level (bgl). Most of these wells are perennial but some like the dug well at Sambaji Park are augmented with bore well water. The groundwater is used mostly for domestic purposes, but waters from a few wells are used for gardening. Most wells yield potable, good quality water, but many wells like those from Sambhaji Park and Pataleshwar are not potable. Several bore wells have been sunk in the area. The shallow basaltic aquifers are tapped 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 bore wells per sq. km) in the Shivajinagar area is about 60.

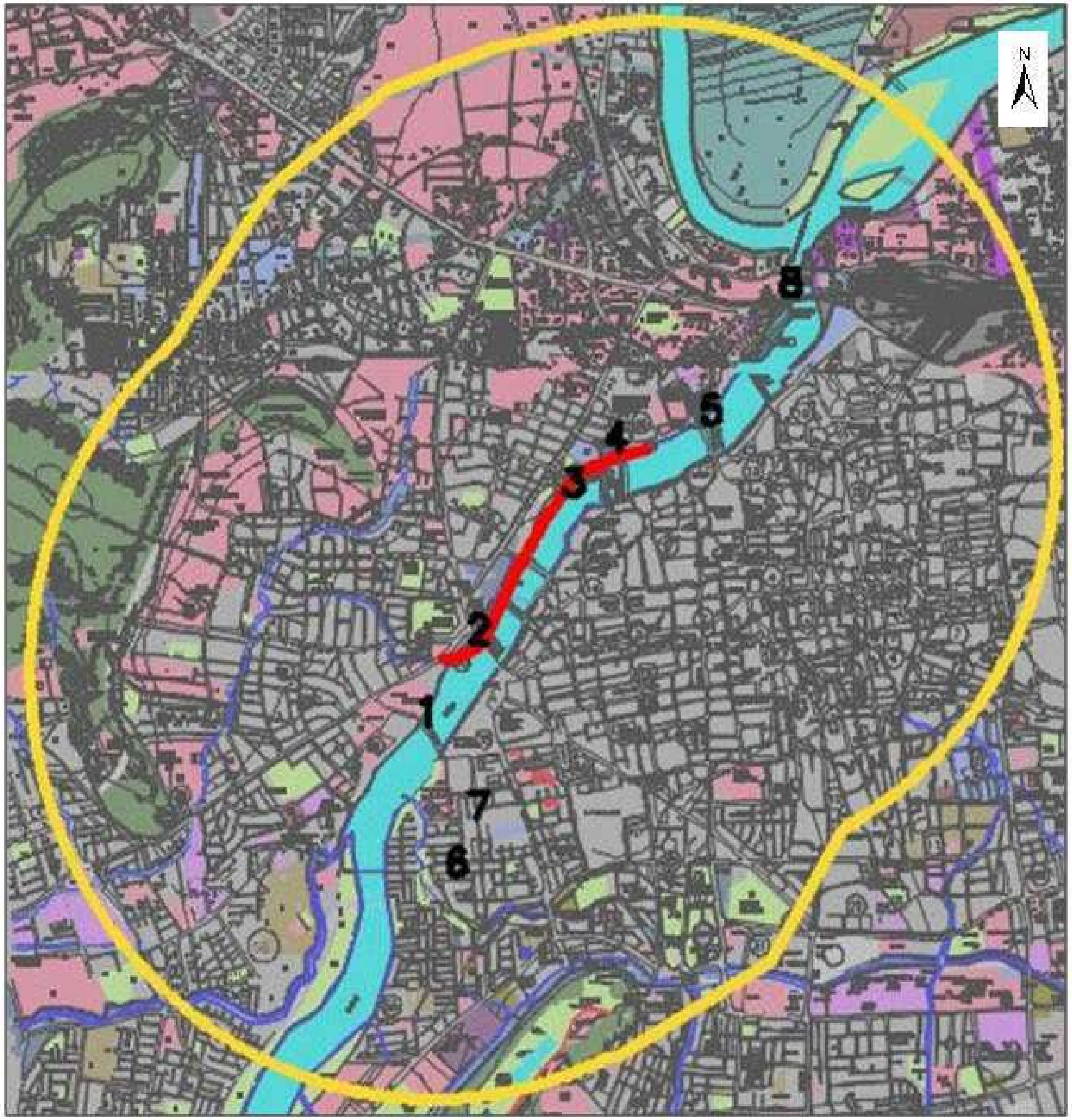
7.2.3. Soil Quality

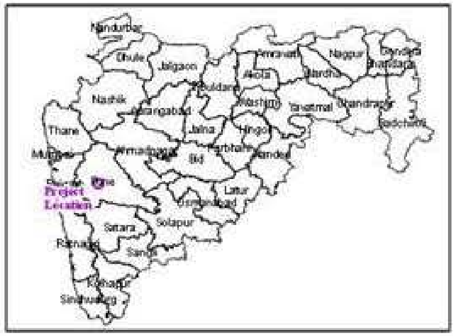
Selection of the sampling stations was based on the reconnaissance visit of the entire study area. Accordingly 8 samples were collected near the proposed corridor part passing through the Mutha River. Soil sampling locations are given in Table 7.3 and shown in Figure 7.2. Physico-chemical Characteristics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

Table7.3.Soil Sampling Locations along Mutha River

S. No.	Name of the Location	Latitude	Longitude
1	Garware Bridge U/S	18° 30.767'N	73° 50.487'E
2	Panchaleshwar Temple Ghat	18° 30.822'N	73° 50.556'E
3	Opposite Chhatrapati 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 Griha Niwara	18° 30.319'N	73° 50.450'E
8	Sangam Bridge	18°31'45.64"N	73°51'35.32"E

Figure 7.2. Soil Sampling Location Map





Soil Sampling Locations			
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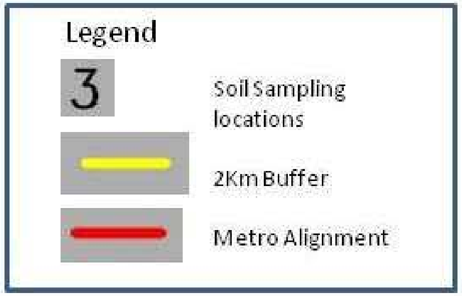


Table7.4.Physico-chemical Characteristics of Soils along Mutha River

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 Near Savarkar 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 at Sangam Bridge. Minimum Calcium 496 mg/kg was found at David Sasoon Anath Pangu Griha Niwara. Similarly, maximum Magnesium 154.92 mg/kg was found at Garware Bridge U/S and 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 Rajendra nagar and Garware Bridge U/S. Phosphorous ranges from 7.12 kg/ha to 8.52 kg/ha. Maximum concentration of Potassium (878.2 kg/ha) was found at David Sasoon Anath Pangu Griha Niwara 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 Griha Niwara 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 found to be fertile with predominantly clay-loam texture. These soils are favorable to nurture herbaceous flora in the project area. It is proposed to use excavated top soil for plantation and landscaping purpose. Fertility of the soils is due to higher organic content.

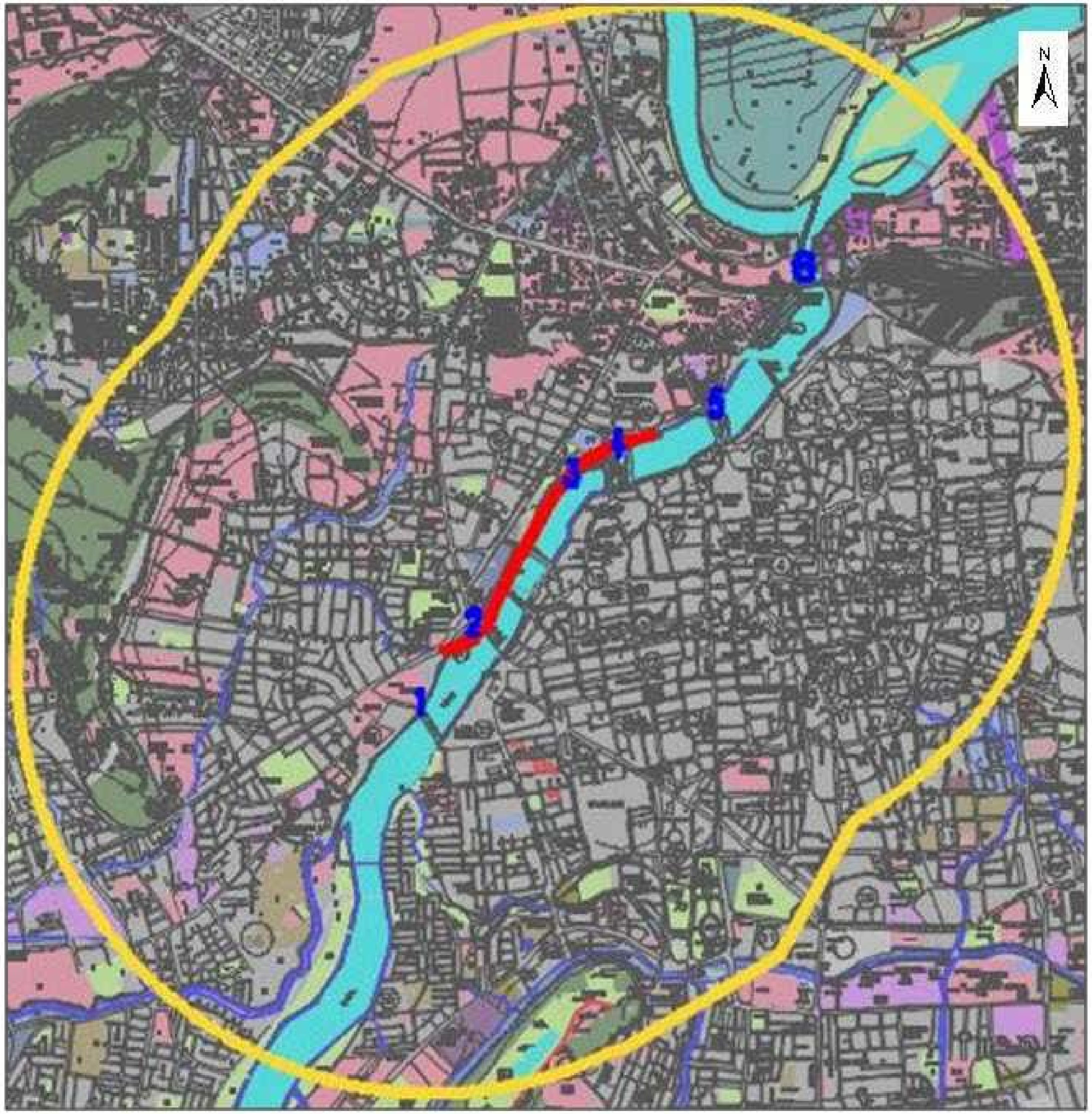
7.2.4. Water Quality Study

River water sampling locations were selected based on sewage release point, Ghat and other anthropogenic activities at the upstream, along the stretch and downstream side of the alignment. Representative ground water samples were collected within the study area and the 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.

Table7.5.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 Chhatrapati 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	Confluence of Mula 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 Pangu Griha 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 D/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

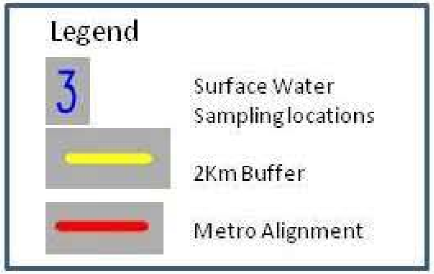
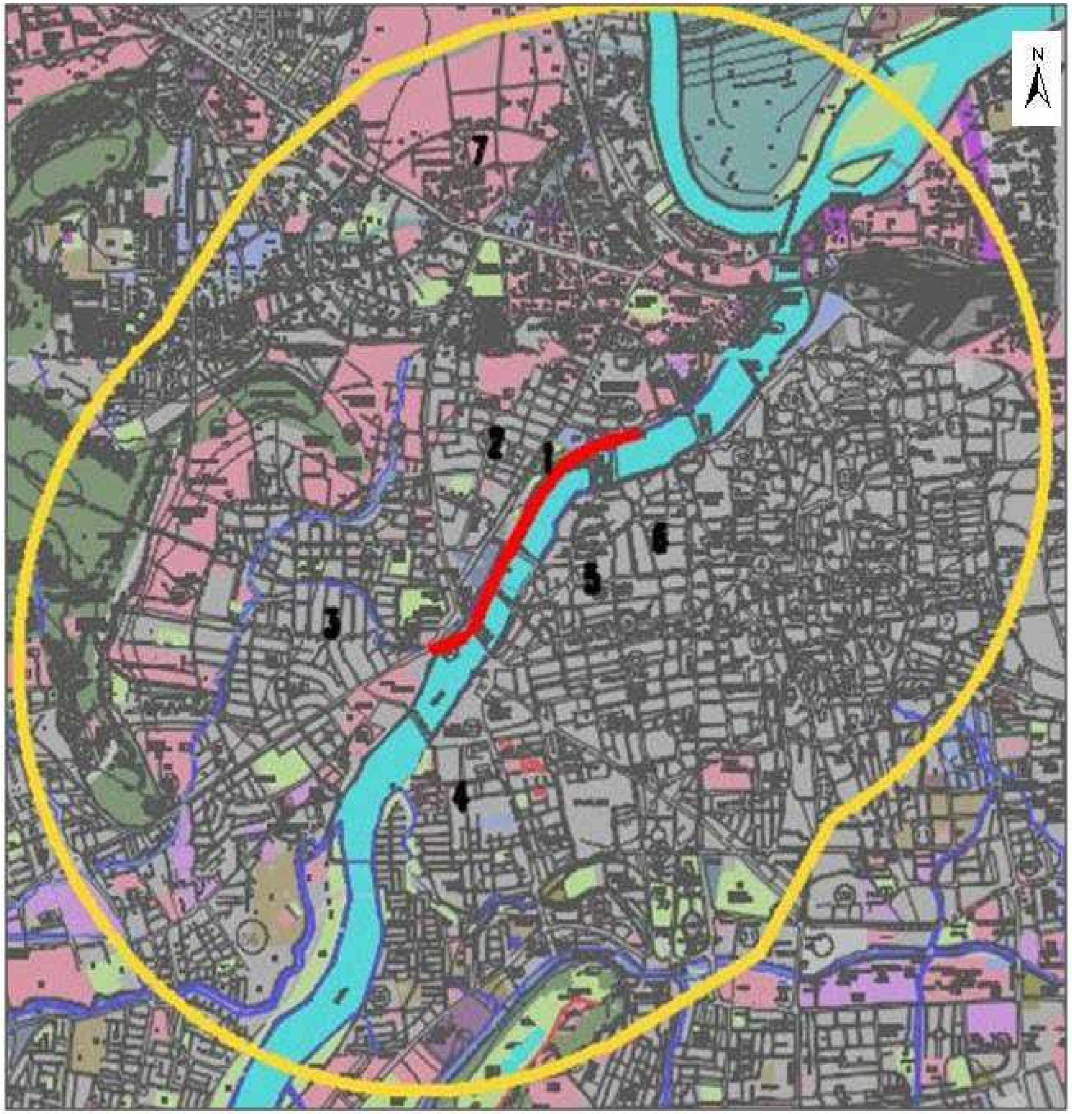
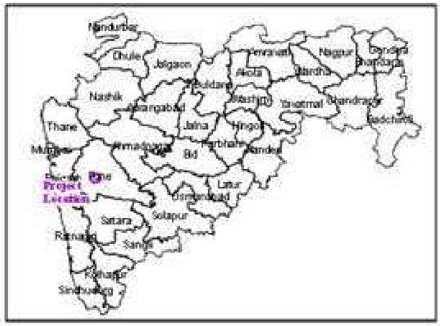


Figure 7.4. Ground Water Sampling Location Map





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° 30.850'N	73° 50.240'E
4	David Sasoon Anath Pangu Griha Niwas	Open Well	18° 30.815'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° 31.996'N	73° 50.719'E

Legend

7 Ground Water Sampling locations

2Km Buffer

Metro Alignment

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.

Table7.6.Physico-chemical Characteristics Surface Water Monitoring

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)
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

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)
22.	Nitrate as NO3	mg/l	5.50	5.6	7.5	6.5	8.15	7.45	50
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
29.	Sodium as Na	mg/l	12.00	8.00	10.00	8.00	7.00	22.00	N.S
30.	Potassium as K	mg/l	6.00	5.00	5.00	1.20	1.30	8.00	N.S
31.	Hexavalent Chromium (as Cr6+)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	N.S
32.	Iron (as Fe)	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	50
33.	Copper (as Cu)	mg/l	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	1.5
34.	Zinc as Zn	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	15
35.	Nickel as Ni	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	3
36.	Boron as B	mg/l	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	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 of river Mutha are presence of dissolved salts and carbonates of the surrounding soil & disposal of sewerage 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 COD concentration.

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 Pune Municipal Corporation (PMC) in the last five years (2011-2016). Information towards the data from secondary sources was collected from Environment Status Report (2016-2017) published by Pune 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.

Table7.7.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)							
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 and four locations for Open wells. The interpretation of the test results were given below.

Table7.8.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

S. No	Parameter	Units	Chhatrapati Sambhaji Udyan –	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
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	
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	

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
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 ml	110	12	11	90	140	26	14	Absent
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 was maximum 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 IS 10500:2012. However, presence of Total Coliforms and E coli indicate that the ground water in 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 average by drawing air at the rate of 1.0 -1.5 m^3/min through glass fiber filter paper and analyzing by the gravimetric method. Pre-calibrated fine dust particulate samplers were used for monitoring of PM10 & PM2.5. Concentrations of SO_2 and NO_X were analyzed by Modified West and Gaeke & Jacob and Hochheiser method respectively.

Table7.9.Ambient Air and Noise Quality Monitoring Locations

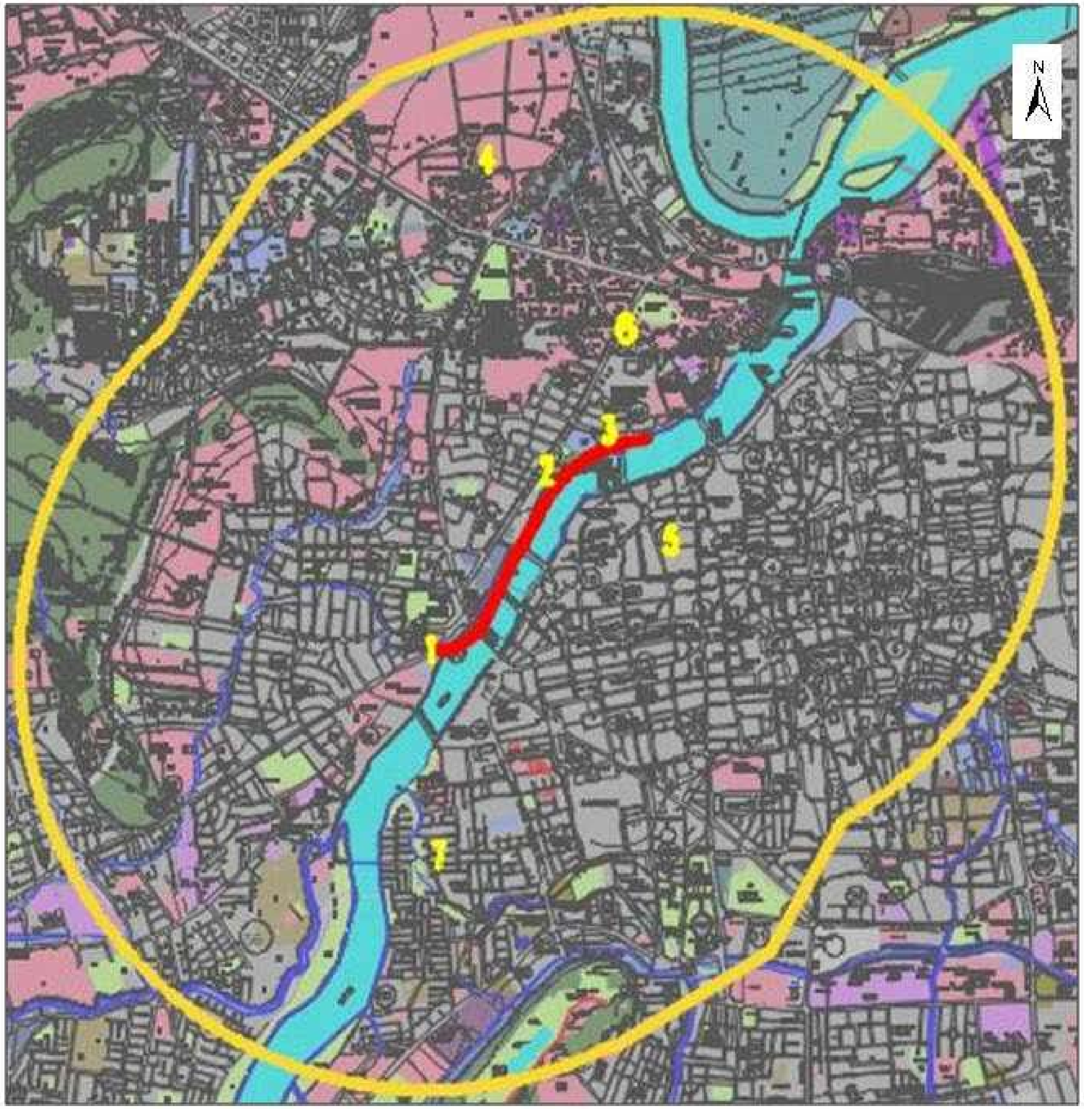
S. No.	Name of the Location	Latitude	Longitude
1.	Karve Road Kshetriya Karyalaya	18° 30.767'N	73° 50.415'E
2.	Chhatrapati Sambhaji Udyan	18° 31.143'N	73° 50.781'E
3.	Savarkar Bhavan	18° 31.314'N	73° 50.992'E
4.	DIC, Pune	18° 31.986'N	73° 50.719'E
5.	Parchure Wada	18° 31.045'N	73° 51.189'E
6.	Kalaniketan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

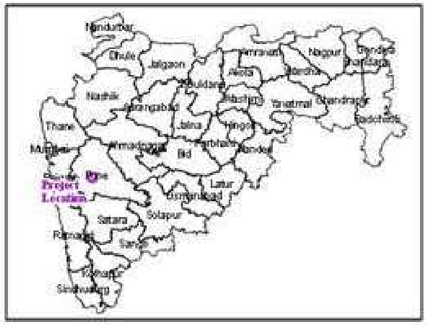
Results of the ambient air quality are given in Table 7.10. From the results, it was observed that concentration of PM10 minimum at DIC Pune (42.1 µg/m^3) & Maximum at Kalaniketan (89 µg/m^3). Higher values recorded due to heavy traffic at Kalaniketan during the study. The drop down in the concentration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

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

Similarly CO concentration was minimum at Rajendranagar (0.4 µg/m^3) and maximum at Kalaniketan (2.1 µg/m^3).

Figure 7.5. Ambient Air and Noise Quality Monitoring Location Map





Ambient Air Quality Monitoing Locations			
Sr.No.	Name of the Location	Lattitude	Longitude
1	Karve Road Kshetriya Karyalaya	18° 30.767'N	73° 50.413'E
2	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

Legend

2	Ambient Air Quality Monitoring locations
	2Km Buffer
	Metro Alignment

Table7.10. Results of Analysis of Ambient Air Parameter (µg/m3)

S. No	Monitoring Locations	Date of Monitoring	22/05/2017	26/05/2017	29/05/2017	2/6/2017
1.	Karve Road, 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.	Chhatrapati Sambhaji 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.	Savarkar Bhavan	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.	Rajendra nagar	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

It is concluded that concentrations of PM10 and PM2.5 was found beyond permissible limits of National Ambient Air Quality Standards of CPCB at Karve Road Kshetriya Karyalaya, Savarkar Bhavan 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 24 hours. 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.

Table7.11. 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.	Savarkar Bhavan	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 during Ganapati festivals.

B. Ambient Vibration Levels

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

Table7.12. 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
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

S. No.	Name of the Location	Latitude	Longitude
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

Table7.13. 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 Temple and Vridheshwar temple and at Baba Bhide bridge vibration levels measured were from 0.1 to 0.2 mm/sec. Vibration level significantly within the permissible limits of Director General of Mine Safety (DGMS) at all locations.

7.3. HYDROLOGY OF MUTHA RIVER

7.3.1. Site Description

Mutha River has undergone several man-made modifications over the years. The major impact on the river was breach of the Khadakwasla Dam on 12 July 1961. Residential houses and businesses on both the banks of river were completely washed away. New flood zones had to be defined to avoid any new construction within the flood zone. The width of critical part of river, which flows through the city was divided in two parts. The central part was confined to small width by constructing walls on both sides. Tall retaining walls were built on both sides for 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 for pedestrian 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.

Table7.14. 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

S. No.	Name of the Bridge	Levels	
		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 & Obstructions to River Flow in the Project Area

(a)

(b)

(a) Low level causeway on Mutha River

(b) Floating vegetation and debris causing obstruction to flow at the bridge piers. Also shows the highly polluted quality of river water.

(c)

(d)

(c) Steps providing easy access to use river water for multiple uses
(d) Low level concrete wall for restricting river width during low flow and a tall retaining wall on the extreme right side for restricting high river flow over full width

(e)

(f)

(e) View of another low level causeway on river near a temple
(f) Photo showing full width of river during low flow, bounded by low height concrete walls on both sides

(g)

(h)

(g) Full river width and several structures on right side built for discharging storm water in the river
(h) Steps for access to river water and guiding wall & Floating vegetation

(i)

(j)

(i) Another access ramp and steps, large diameter concrete pipe, Storm water flow structure, Concrete pipe outlet of effluent drainage into river water
(j) Busy road on the left bank of river underneath a bridge


(k) (l)

(k) Obstructions in river water flow in the form of rock outcrop, large concrete pipeline, dense vegetation and grass directly in the river under one of the bridge spans. Bridge pier and floguide stone wall are seen.
(l) Physiography of left bank of Mutha River


(m) (n)

(m) Pedestrian road in the river basin
(n) Large diameter concrete pipeline above ground level along 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, (refer Table 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.

Table7.15. 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		

Table7.16. 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 for determining the effect of bridge pier on waterways constriction. He concluded that if the water ways become constricted, bank erosion and scour may happen much more than expected values. To avoid this drastic situation, river training work from 1 km upstream to 1 km downstream 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 depending on the shapes. Considering the aesthetical point of view, pier may occupy more waterways and it is the engineers challenge to suggest suitable and substantial remedial measures for making the construction possible with nominal adverse effect on river morphology. Bridge pier construction was already completed before the present study and some severe morphological response has been observed. At the bridge location both for the upstream and downstream it is affected 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 and domestic consumption for large towns and cities. It may be noted that more than seventy percent of water stored in dams is needed for agriculture. The remaining is used for the domestic use and industrial use. Khadakwasla Dam was the oldest dam built on the Mutha River to meet the needs of Pune City. Three more large dams were built during the subsequent years to store more water for the increasing needs of irrigation, population and industry. As of today, four dams exist upstream of the city of Pune, namely Khadakwasla, Panshet, Varasgaon and Temghar.

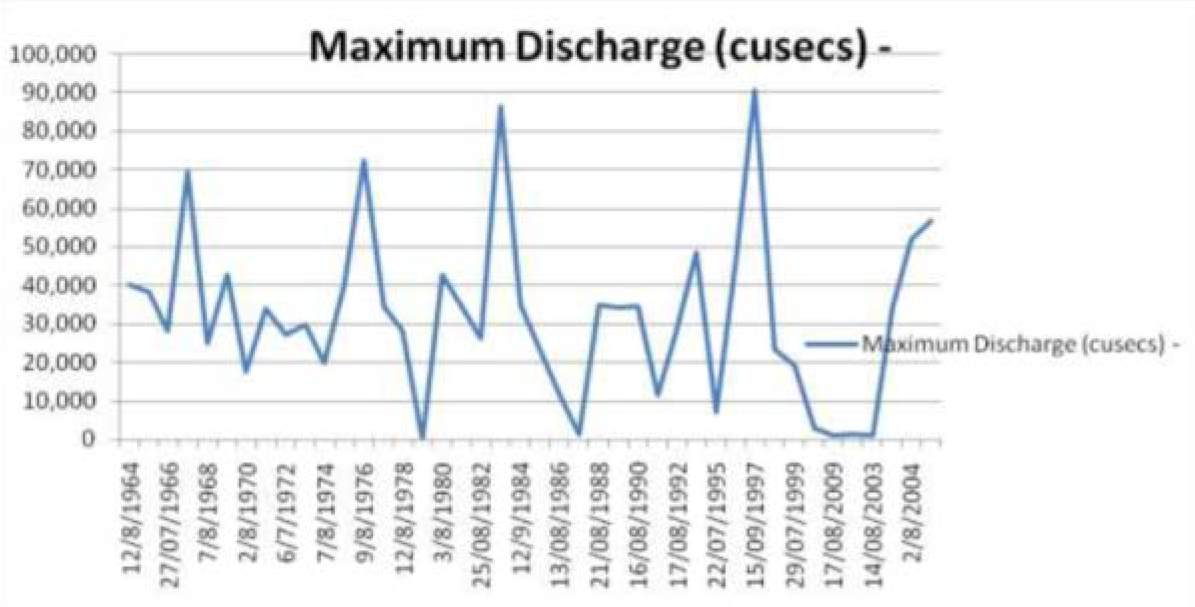
Water from the three dams is released into Khadakwasla Dam as and when needed and it is supplied to Pune city through closed pipes for drinking and through open canal for irrigation throughout the years. Under these conditions hydrological calculations for the river discharge become meaningless because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

Since the discharge in Mutha River is not a function of natural parameters, there is no need to get any data on rainfall, infiltration etc. Data on actual volume of water released into Mutha River daily through Khadakwasla Dam is available from the Irrigation Department. It is believed 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 available and presented in Annexure 7.1 and maximum discharge to Mutha River is shown in Figure 7.7.

7.3.5. Environmental Aspects Related to Hydrology

Metro Rail would be a major addition to the existing infrastructures in Pune City. However it will not be like an addition of a new factory or sewage treatment plant, which will generate pollutants over its entire life span. Periodic Monitoring of the structure will be needed to ensure safety in spite of continued use and to ensure that it does not develop any signs of deterioration such as cracks, component failures, exposed reinforcement, rusting of components etc. The air pollution will be limited to that of a locomotive railway engine. No significant impact on air, water, noise and soil etc. are predicted during operational phase of the project.

Figure 7.7. Maximum Discharge (Cusecs)



7.3.6. Khadakwasla Dam Discharge Data

The flow in Mutha River has two sources. The first and the major source is water released from the Khadakwasla Dam during high rainfall days. Additional flow joins the river through small tributaries on the downstream side of Khadakwasla Dam. However, their contribution is quite small, of the order of less than 10 percent up to project location.

Blue line and Red line of Mutha River are decided by Irrigation Department on discharge of 60000 cusecs and 100000 cusecs respectively. (Source: Flood Control and Disaster Management Action Plan, 2017-18, Pune Municipal Corporation)

7.3.7. Estimation of Maximum Flood Frequency

While discussing river floods, the word Return Period is often used. The amount of water flowing through each year often has large variation. It depends predominantly on the quantity of rain during monsoon season, which has a large spatial and temporal 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 water for determining the storage capacity of dam in order to meet the annual requirement of water.

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

Table7.17. 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

7.3.8. Estimation of Afflux

The maximum water surface change just upstream of a bridge is termed the afflux in hydraulic engineering. If the Afflux is large, its magnitude needs to be taken into account for calculation of 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 and eccentricity, are investigated in the LBM method. Afflux calculations are important for bridges with multiple spans and large sizes of piers. In the case of present project, there will be a single pier 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 such as a bridge pier, measured at a location unaffected by high local flow velocities caused by the constriction 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 mainly results from the obstruction to river flow caused by the series of bridge piers, particularly when they have large width in the direction of river flow. Afflux also results from other obstructions such 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.

B. Afflux Calculations Using Empirical formula

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

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

Where

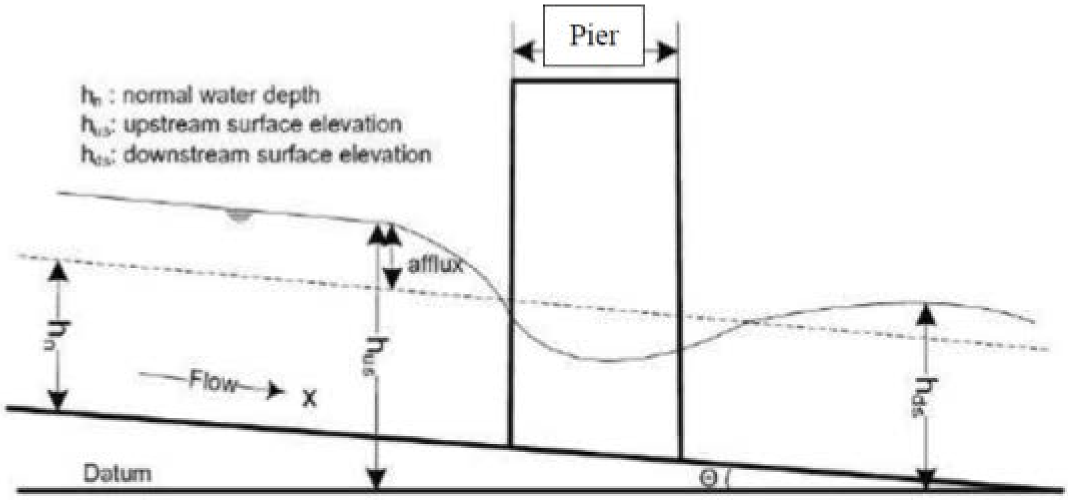
h = afflux in m,

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.

Figure 7.8. Afflux Definition Sketch



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

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 along the alignment of Pune Metro are presented in Figure 7.9 and Annexure 7.2.

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 several structural limitations, the span of arches for the stone bridges had to be kept small and the size of 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 of spans for a bridge and the size of bridge piers also became smaller. This resulted in a reduction in the area obstructed by a bridge on rivers. However, several bridges have slender piers but the foundations submerged below water surface have very large diameter. Such bridges also cause large obstruction to flow.

Figure 7.9. Plot Showing Afflux along the Metro Pier Alignment

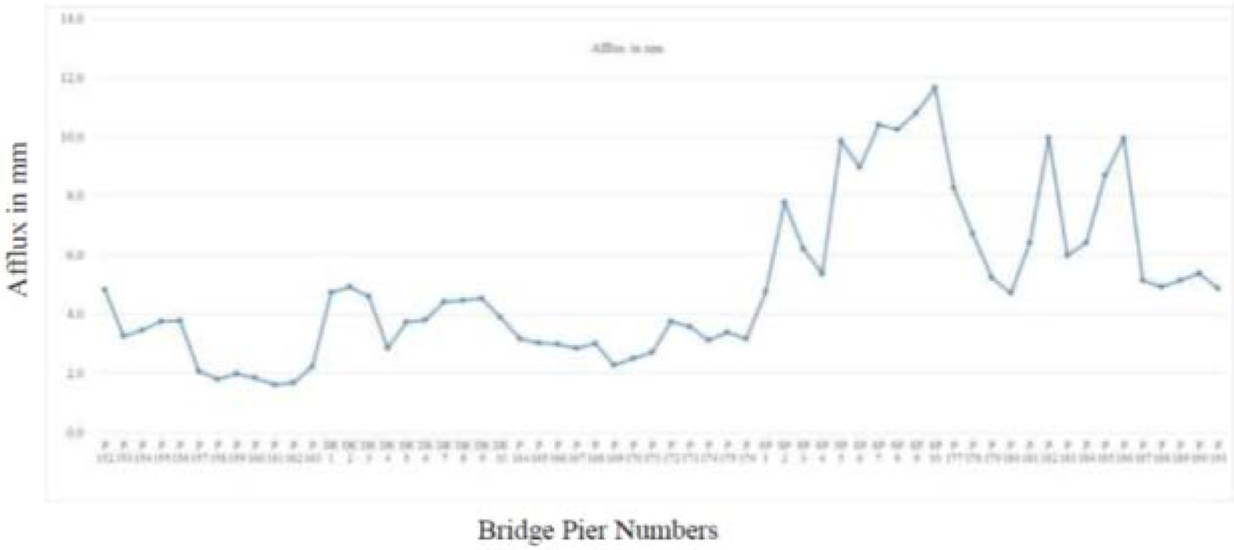


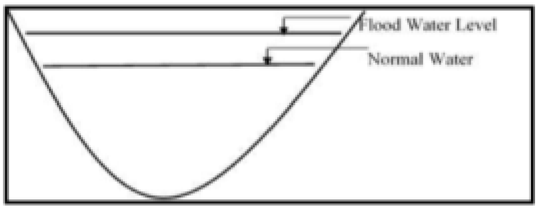
Figure 7.10. Photograph of a Stone Bridge with Arches

Introduction of Reinforced Concrete was the next step in bridge construction. The spans became much larger and arches were on longer necessary. They got replaced by beams (refer Figure 7.11). The bridge piers are slender and fewer in number. Such bridges cause very little obstruction to river flow and have a very small Afflux.

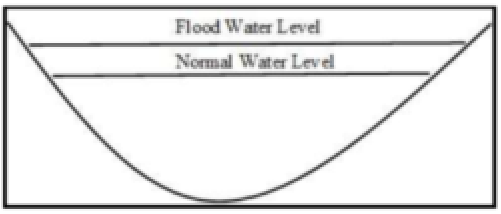
Figure 7.11. Photograph of a Reinforced Concrete Bridge

River Section and Bank Inundation: As the water level in a river rises, area on both banks of the river gets submerged. This can have 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 land submergence. Different types of river cross-sections are shown in Figure 7.12.

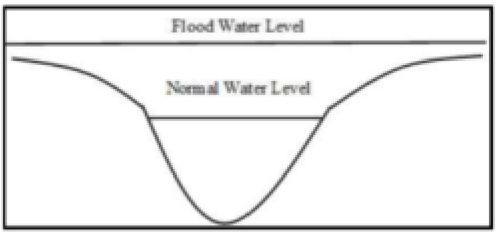
Figure 7.12. Typical Types of River Cross Sections



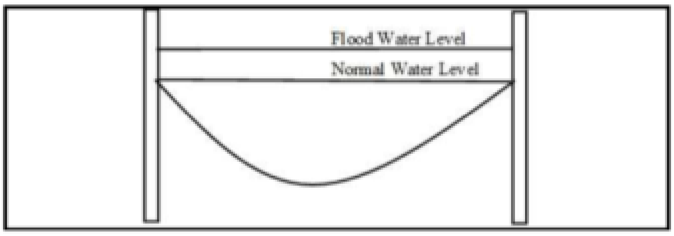
Type 1: Deep Gorge River



Type 2: Commonly Existing River Section



Type 3: River with Flat Banks on both sides

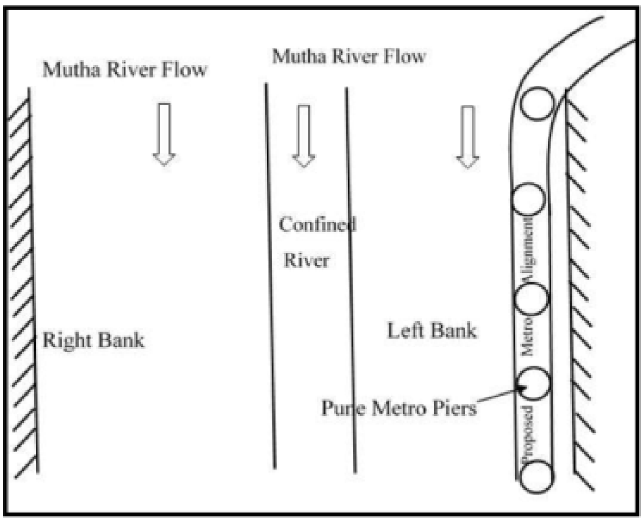


Type 4: River with Retaining Walls or Flood Embankments

Under Type 1 the flood water does not have any scope to spread on the banks. Under Type 2 only a strip of land parallel to the river flow gets inundated. Type 3 has a regular river channel within which the normal flow is restricted. However, there is a large flat area above a certain elevation. Hence a large area over both the banks gets inundated under floods. Type 4 has retaining walls or flood embankments on both banks of river. Hence the water spread remains constrained. 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 Flood Embankments are applicable to present study. An important feature of Pune Metro is its alignment with respect to the river. 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 as shown schematically in Figure 7.13. The obstruction caused to the flow is only one percent of the river section, which is insignificant.

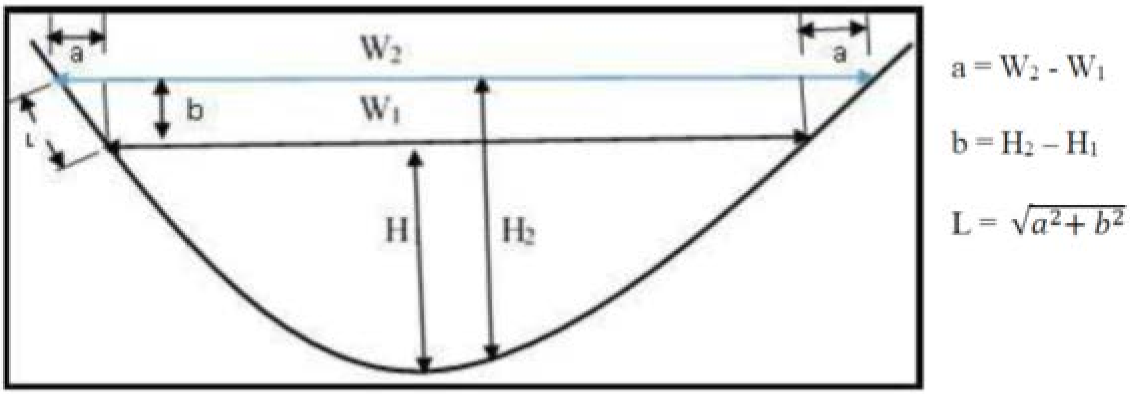
Figure 7.13. Plan View of Circular Bridge Piers for Pune Metro Project



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

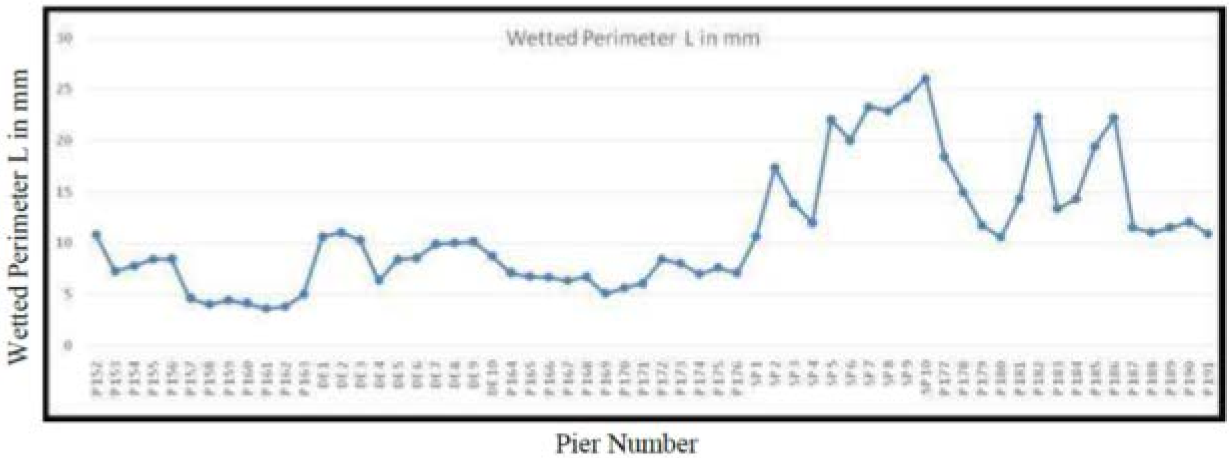
Effect of Afflux on River Width at Water Surface (submergence): Regarding the effect of Afflux on water level between the two banks of the river, the flow pattern generated at the pier needs to be considered. This is shown schematically in Figure 7.14. It is assumed that the afflux will be spread uniformly 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 the wetted perimeter (increased submergence), which is shown by L in above figure. Values of L are plotted in Figure 7.15.

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



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 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 3.24 mm to 23.32 mm at Pier No. 161 and Chatrapati Sambhaji Udyan Metro Station Pier No. 10 respectively.

7.3.9. 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 Bridge) 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.

7.3.10. Estimated Erosion at Viaduct Pillar Foundation

Biswas S. K. (2010) reported that at downstream of the bridge, bed scouring ranges from 1 to 5 meter associated with the thalweg movement from middle to left bank. Such changes i.e. bed scouring along the left bank extends approximately 1 km downstream from the bridge. At immediate 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 gets eroded at a very small bed shear stress and gets in suspension. The suspended sediment moves with 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 the river bed, exposing the foundation of piers.

7.3.11. Flow Pattern at Viaduct Piers

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

7.3.12. 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 weathered basalt. Hydro geologically, the area is underlain by an unconfined aquifer consisting of shallow alluvium-weathered vesicular basalt. Most of the dug wells are used for domestic purposes and as 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 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.
  - The submergence would be possible only during flood situation.

7.3.13. 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 natural communities and are sensitive to any change in their surroundings. Ecological system shows complex inter-relationships between biotic and abiotic components including inter-dependence, competition and mutualism. Biological communities, being dependent on the condition 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 environmental impact assessment studies, in view of the need for conservation of environmental quality and biodiversity. The biological environment includes mainly terrestrial and aquatic ecosystems. Information on the impact of environmental stress on the community structure serves as an inexpensive and efficient early warning system to check the damage to a particular ecosystem.

Biological Communities exhibit a strong relationship with their surroundings and climatic variables like temperature, humidity, rainfall, soil characteristics and topography. Diversity and richness of biological communities depend on the environmental conditions and available resources of the location. The animal and plant community exist in their natural habitat in a well-organized manner and their natural settings can be disturbed by any external factors, including anthropogenic activities. So, once natural setting is disturbed it becomes practically impossible or takes longer time to come back to its original status. Plants and animals communities are reflected by changes in distribution pattern, density, diversity, frequency, dominance and abundance of natural species of flora and fauna existing in a particular ecosystem. These changes over a span of time can be quantified and related to the existing environmental factors. The sensitivity of animals and plants species to the changes occurring in their existing ecosystem can therefore, be used for carrying out Environmental Impact

Keeping this in view, Environmental Assessment Studies of any given area require information on the present status of flora and fauna. This information was collected within the study area and the relevant details on aquatic life were also collected. Ecology and biodiversity studies were 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 the herbaceous flora, detailed phytosociological studies were undertaken. Sampling stations was spread along the proposed alignment passing through Mutha River. For the herbaceous study, stratified quadrat sampling method was applied. The vegetation sampling was carried out at 10 different locations. For each location 7 to 9 quadrats of size 1 X 1 m were taken. The Qualitative and Quantitative information such 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.

Table7.18. 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 C Next are *Phyla nudiflora* (L.) Greene, *Amaranthus polygamus* L., *Amaranthus cruentus* L., Cyperus *compressus* L., *Senna occidentalis* (L.) Link., *Alternanthera triandra* Lam. having 55.56 & 50 % frequency respectively under the class B.

Density: The density of the species Cynodon dactylon (L.) Pers. is 8.47, which is the highest among all other species. Alternanthera triandra Lam. is the next dense species with a density value 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., Eleusine coracana (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 and fertile land along the Mutha River.

Diversity Indices

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

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

Simpson's Index (D): Simpson's Index (D) basically measures the probability that two individual 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- Index with value ranging from 0 to 1. Values near zero correspond to highly diverse or heterogeneous ecosystems and values near one correspond to more homogeneous ecosystems. As per study Simpson'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 – Weaver diversity index, takes into account both number and evenness of categories considered and can be increased either by greater evenness or more unique species. Normally, the Shannon's index ranges between 1.5 to 3.5 and rarely goes to 4.5. Shannon Diversity Index (H) in the study area is 3.49.

Species Richness: Species Richness is a measure of species found in a sample. Since, the larger the sample, more the species we would expect to find, the number of species is divided by the square root of the number of individuals in the sample. This particular measure of species richness 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), Pistia stratiotes 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 these weeds 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 species randomly from the study area. The species encountered during transect survey were also noted separately.

Primary data were generated by preparing a general checklist of the trees around 500m study area. Total 15128 tree individuals were recorded. The area shows overall 309 species which included 196 Tree species, 80 Herbs and 33 Shrubs species. No flora was enlisted under the

Indian 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.

In 1.45 KM Riverbed alignment, initial assessment envisages that total 32 no. of trees to be impacted, while execution of the works it was observed that 19 trees can be preserved at site and balance 13 trees need transplantation. Since the area has no rare or endangered species of trees and maximum number of trees has been preserved at the site and additional 104 new saplings has been planted hence this would not cause any significant loss to the biodiversity and riverine system

Table7.19. List of Trees likely to be Affected (Actual Impact on 13 trees)

S. No	Local Name	Scientific Name	Lattitude and Longitude	Grith M	Height M	Canopy Dia M
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"N 73°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

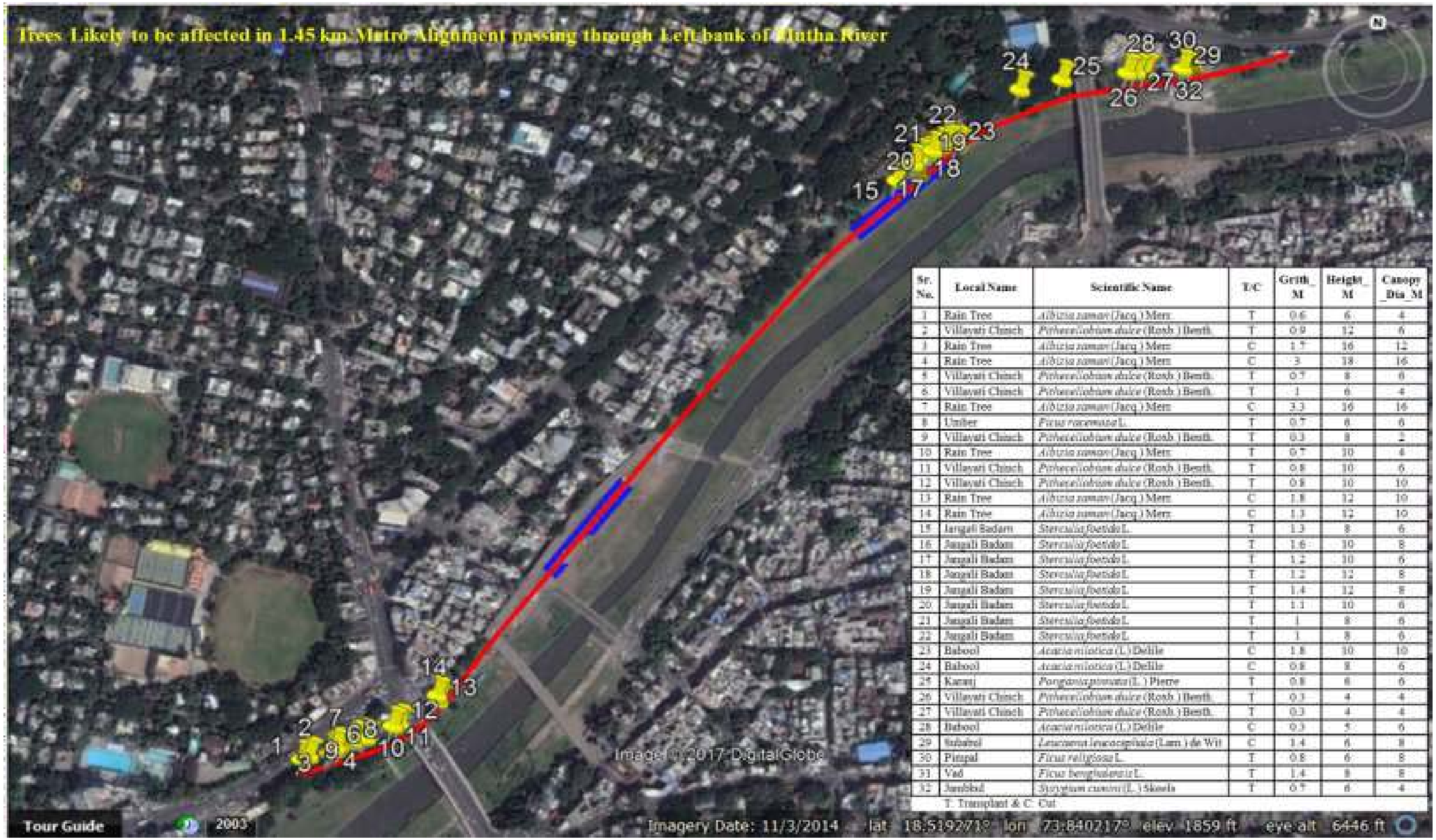
14.	Rain Tree	Albizia saman (Jacq.) Merr.	18°30'51.32"N 73°50'34.24"E	1.3	12	10
15.	Jangali Badam	Sterculia foetida L.	18°31'12.52"N 73°50'50.62"E	1.3	8	6
16.	Jangali Badam	Sterculia foetida L.	18°31'12.81"N 73°50'51.48"E	1.6	10	8
17.	Jangali Badam	Sterculia foetida L.	18°31'13.23"N 73°50'51.23"E	1.2	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

Table7.20. 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 Metro along the Left bank of Mutha River



Sr. No.	Local Name	Scientific Name	T/C	Grith_ 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	12
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	8	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	6
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 Mammal which are present in the study area, are discussed as below.

A. Butterfly Diversity

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

Table7.21. 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 commonly seen throughout the project area while damselfly Ischnura aurora was common in the periphery of the project site. Please refer Table 7.22 and Figure 7.19.

Table7.22. 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 Common Indian Toad and Skipper Frog (refer Table 7.23).

Table7.23. 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.

Table7.24. 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
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 wild mammal was observed in this area. Goat, buffalo, cow and squirrel were commonly seen. Please refer Table 7.25 and Figure 7.20.

Table7.25. 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 Palm Squirrel	Sch-V	Least Concern
12.	Funambulus pennantii	Five Striped Palm Squirrel	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, house sparrow, blue rock pigeon, red wattled lapwing, pond heron, white breasted kingfisher etc., were dominant in the study area (refer Figure 7.21).

Table7.26. 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	-

S. No.	Scientific Name	Common Name	IUCN Status	IWPA Status
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				
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

S. No.	Scientific Name	Common Name	IUCN Status	IWPA Status
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 Wildlife Protection Act

IUCN: International Union for Conservation of Nature and Natural Resources

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 water saturated for a sufficient length of time such that excess water and resulting low soil oxygen levels are principal determinants of vegetation and soil development. Wetlands will have a relative abundance of obligate hydrophytes in the vegetation community and soils featuring “hydric” characteristics. From an ecological perspective, either an abundance of hydrophytes or 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 of hydrophytes, and wetland soil characteristics. Figure 7.22 showing anthropogenic activities in the Mutha River.

A. Phytoplankton

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

Figure 7.21. View of Mutha River & Anthropogenic Activities

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

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

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

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 and prepare 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 values between 15 and 20 are believed to indicate semi & poor productivity and below 15 is an indicator of absence of organic pollution respectively. Pollution tolerant genera and species of four groups of algae from five sites were encountered. Palmer’s (1969) has shown that the genera like Oscillatoria, Euglena, Anabaena, Scenedesmus and Navicula are the species found in organically polluted waters supported by Gunale and Balakrishnan (1981). Similar genera are recorded in the present investigation. List of pollution tolerant is represented in Table 7.27.

Table7.27. 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

S. No	Genus	Pollution Index
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 22 indicating presence of organic pollution. Dominance of Cyanophyceae clearly indicates tendency towards organic pollution. Also, emergence of Euglenophyceae denotes enrichment of organic pollutants. In Mutha River, occurrence of high pollution indicator species is more. The algae like Anabena, Microcystis, Aphanocapsa and Oscillatoria that were recorded primarily in Mutha River, are prone to form dense surface water blooms and excreting organic compounds creating serious problems in the river.

Count: Phytoplankton counts recorded at different sampling stations are presented in Table 7.28 & 7.29 and Figure 7.23 to 7.27. Total algal population varied between 3360 and 5530 algal cells ml^{-1}. Garware Bridge U/S showed highest count of phytoplankton. The phytoplankton population comprised 4 major groups, namely Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae with thirteen genera. Cyanophyceae dominated all the samples. The SWI values varied between 0.98 and 1.62 that suggest low to medium impact of pollution or adverse factor.

Table7.28. 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 Bridge U/S	5530	50	30	10	10	1.19	20
2.	Panchaleshwar Temple Ghat	4320	65	25	10	0	1.62	22
3.	Opposite Chhatrapati Sambhaji Udyan	5100	55	30	15	-	1.40	15
4.	Near Savarkar Bhavan	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

Table7.29. Phytoplankton Genera Recorded in Mutha River

S. No	Phytoplankton Genera	Garware Bridge U/S	Panchaleshwar Temple Ghat	Opposite Chhatrapati 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 7.22.Phytoplankton counts observed in Mutha River

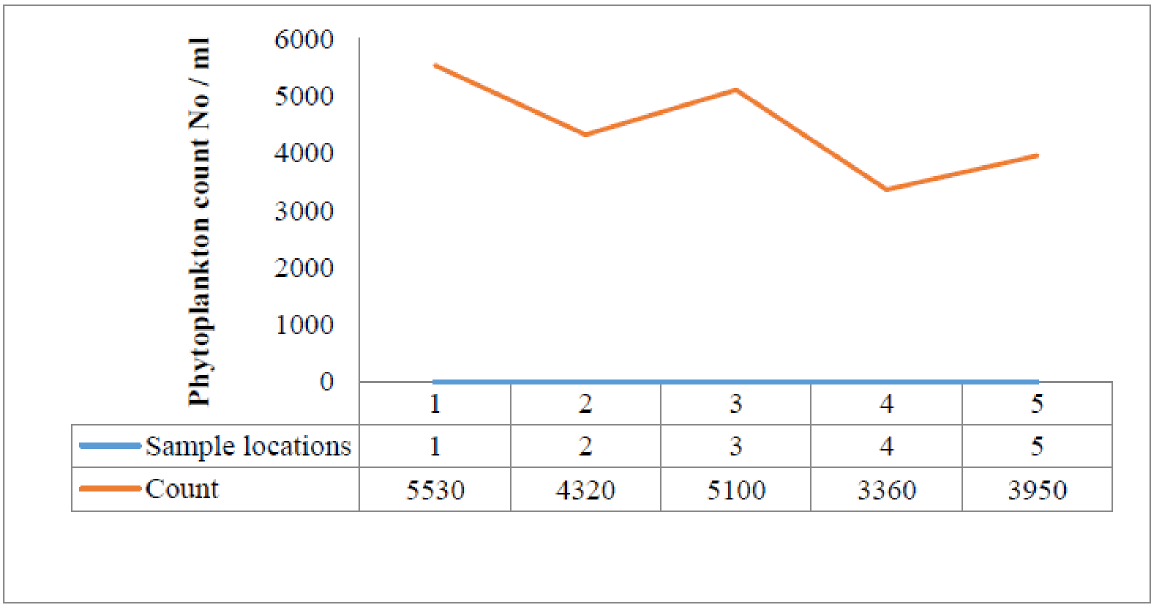


Figure 7.23.SWI counts observed in Mutha River

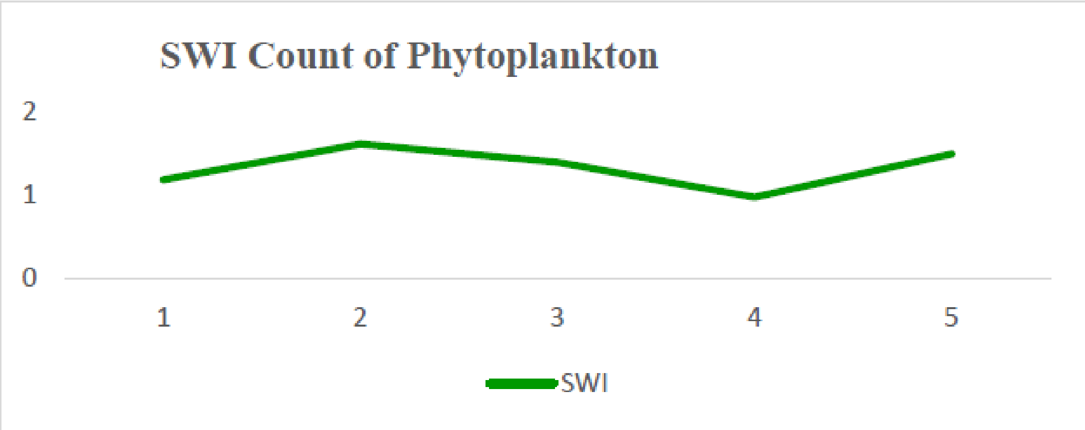


Figure 7.24. PPI counts observed in Mutha River

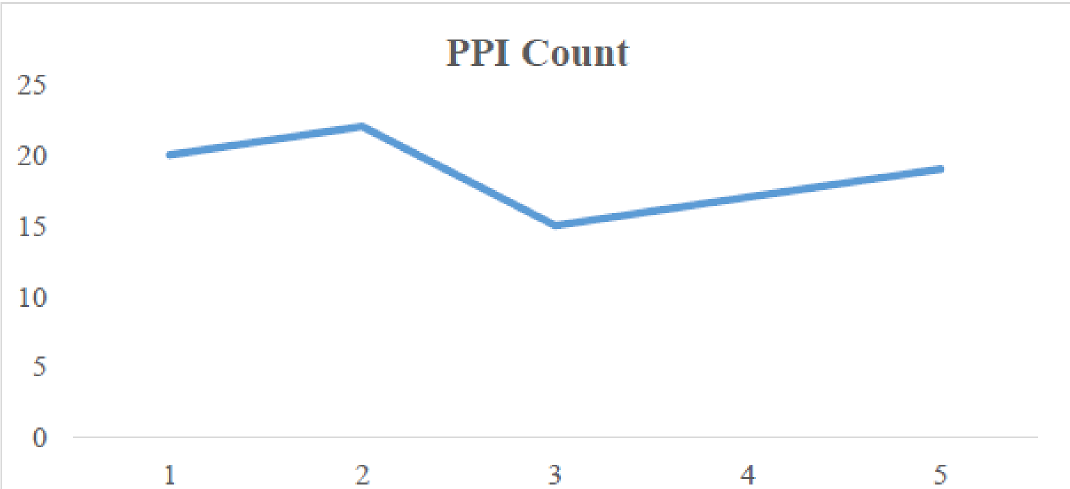


Figure 7.25. Percent composition of algal groups of Phytoplankton observed in Mutha River

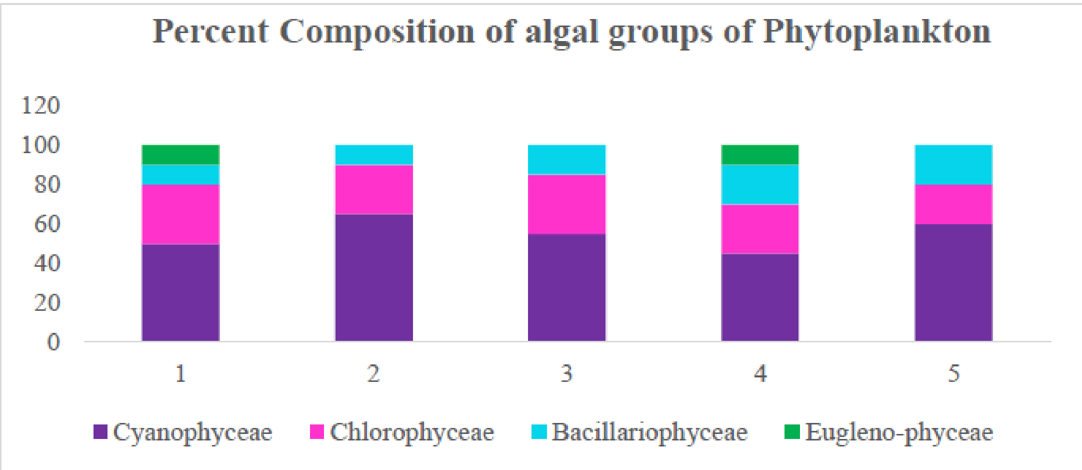
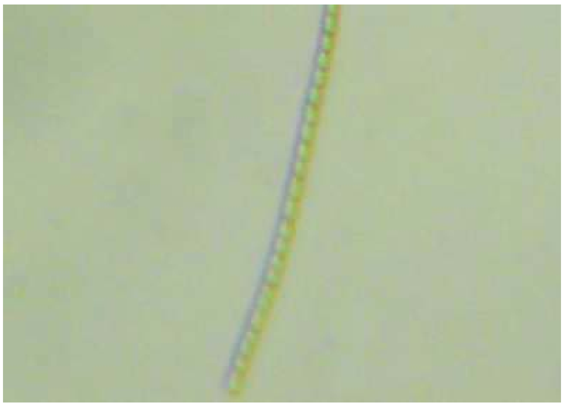


Figure 7.26. Photographs of Phytoplankton

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 Mutha River in Pune City. Several researchers have proposed temperature as a vital factor responsible for the growth of algae.

The growth and photosynthesis of algae are influenced by the pH and alkalinity of water. In the present study the pH values of Mutha River varied between 6.5 and 7.3. Similar results were also observed by Pali Sahu et al. (2015).She reported that the pH values ranged from 6.71 to 8.40 in Mula- Mutha River. According to Pali Sahu et al. (2015), the major sources of pollution of river Mula -Mutha are presence of dissolved salts and carbonates of the surrounding soil, waste from temples, additional flow of domestic waste and agricultural waste which 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 and decay of macrophytes.

B. Zooplankton

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

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 and 2610 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 could be due to the presence of ample amount of phytoplankton in the respective station. Rotifera dominated all the samples. The SWI, observed to vary from 1.20 to 1.82 indicated low to medium load of organic pollution or adverse factors. High pollution indicator genera, like Brachionus, Cyclops and Daphnia were observed in the river.

Table7.30. Enumeration of Zooplankton in Mutha River

Sample No.	**Sampling Locations**	**Zooplankton Count No/m^3**	**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

Table7.31. 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 7.27.Zooplankton count observed in the Mutha River

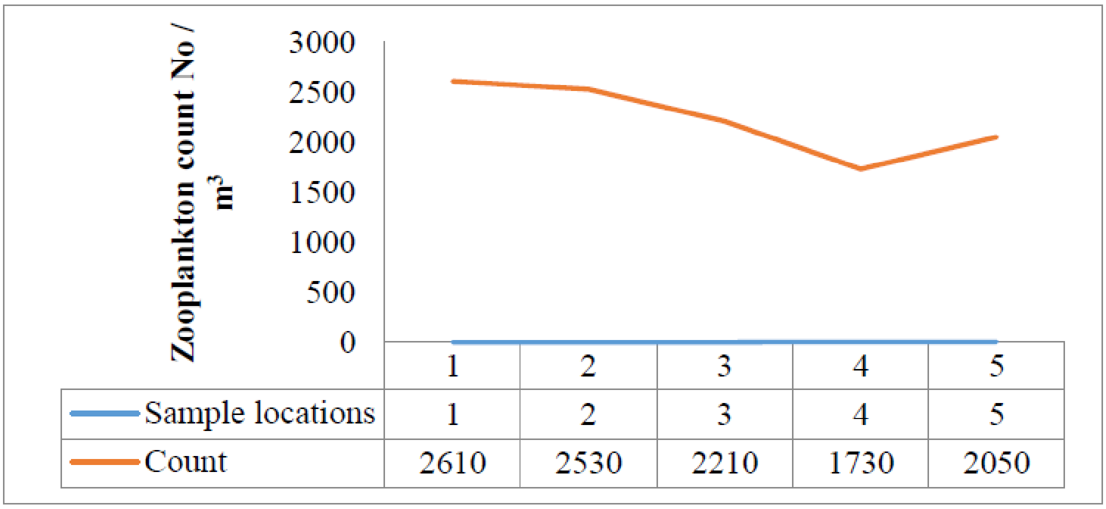


Figure 7.28.SWI Count observed in the Mutha River

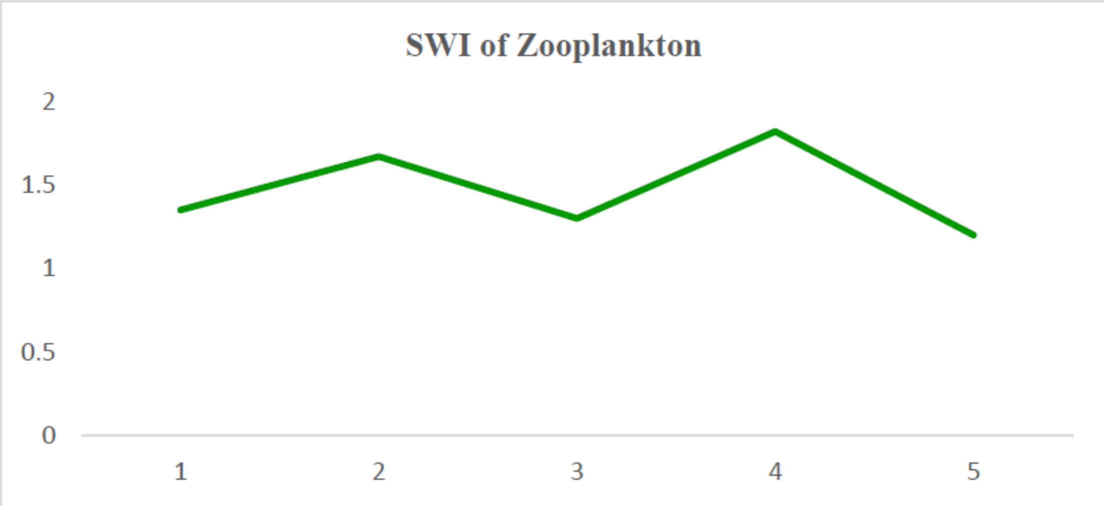


Figure 7.29. Zooplankton Count observed in the Mutha River

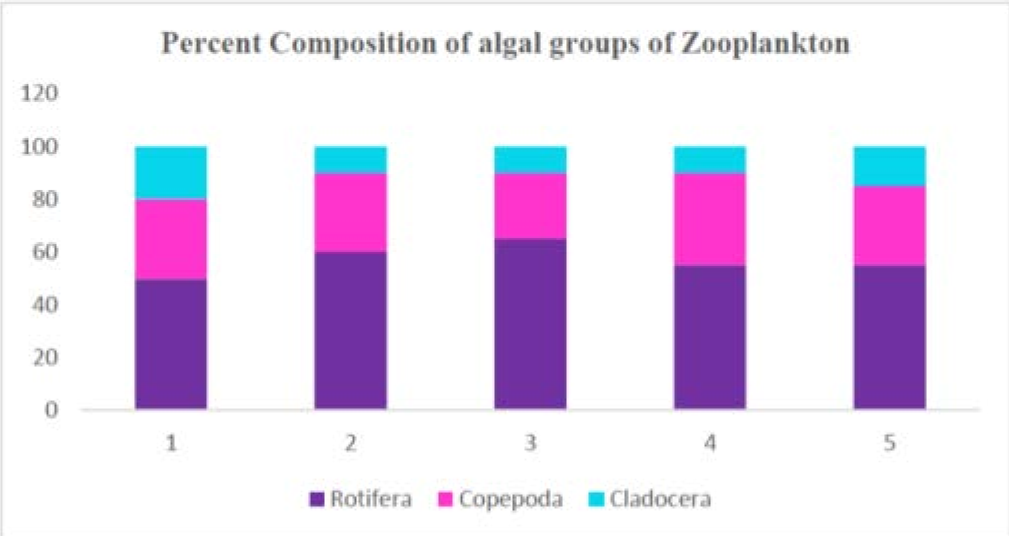


Figure 7.30. Photographs of Zooplankton



Moina	Cyclops	Brachionus

C. Benthos

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

Meio and micro fauna are present in and on muddy / coastal / shores water. Therefore, in the present study only macro benthos were studied. Quantitative estimations of benthic fauna require effective sampling procedures, separation of organisms from the substratum, identification and evaluation of biomass of species and of their life history stages.

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

Figure 7.31. Benthic Sampling

Sieving of collected sediment for Benthos Isolation Insertion

Insertion of Vanveen grab for sediment collection Chironomous larva

A large homogenous sediment sample, collected by the grab sampler, was sieved with a screen mesh 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. Chironomous larvae are abundant all over the river. The chironomid larvae are known as blood worms, due to the presence of hemoglobin in their bodies. They represent an abundant group of benthos insects in freshwater ecosystem. The size of the larva typically ranges from 4 mm to 5mm. The highest count was 350 m^2 near Chhatrapati Sambhaji Udyan. Please refer Table 7.32.

Table7.32. 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 as indicators of environmental change. The mobility and sensory perception of many species allow them to avoid environmental perturbations, and thus they can show a rapid response to environmental changes. Different types of nets having definite meshes, made of nylon twines are commonly used as gears for fish harvesting.

Preliminary investigation with local fishermen revealed that there are different varieties of fishes, viz. Oreochromis mossambicus (Tilapia), Gambusia affinis (Western mosquito fish) Heteropneustes fossilis (Asian stinging catfish), Cyprinus carpio (Common carp) and Ompak bimaculatus (Pabda) normally harvested in the river. It may be mentioned that Tilapia is an exotic 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 sections like 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 various sections of the society along the project alignment, shopkeepers, pilgrims and influential persons of the project area (refer Figure 7.33) Land belong to 1.45 Km of left bank of Mutha river belongs to Irrigation Department. Though, no private land is being acquired for the Pune Metro alignment, public consultations with pilgrims at various temples, local business community and Chaupati stall holders were conducted to understand any direct and indirect impacts on them resulting from the proposed project.

It was observed that most of the stakeholders are aware of the project. Various concerns raised by the stakeholders along with their valuable suggestions are recorded and presented in Table 7.33.

Figure 7.32. Photographs of Public Consultation

Table7.33. Suggestions of Stakeholders and Mitigation Measures

S. No	Concerns raised	Suggestion of Stakeholders	Mitigation Measures
1	Tree Cutting	Not to cut the two identical trees Couropita guianensis Abul., located at Panchaleshwar Temple. (Pilgrim called Jule, (Twins) Kailaspati, Shivaparvati, Shivalingam)	Alignment is shifted slightly hence these two likely to be affected trees are saved.
2	Access to the temple	Access to Panchaleshwar temple should not be hampered during construction activities.	Existing access to Panchaleshwar & Vridheshwar temple shall be maintained. During construction phase access to temples and Ghats will be given by providing proper barricades.
3	Traffic Manageme nt	Considering heavy traffic load of two wheelers on river side road Traffic should not be affected during Construction phase	Traffic management shall be done effectively by providing barricades, signage's, signs and all the safety measures during construction phase.
4	Labor Camps	Labor camp with all the sanitary facilities should be provided in construction phase	No labor camp shall be provided in 1.45 Km riverside Metro alignment. All the skilled and unskilled labors during construction phase will have to use the existing facilities and designated labor camp from outside of the project site.
5	Water, Air And noise pollution	Air pollution and noise pollution should be minimized and regular monitoring should be done	Sedimentation of storm water will be minimized 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 dust suppression. Monitoring

S. No	Concerns raised	Suggestion of Stakeholders	Mitigation Measures
			schedule shall be prepared for monitoring of water, air and noise quality.
6	Socio economic Consideratio ns	Local business community and Chaupati stall holders raised their concerns about displacements and timeline of completion of the Metro rail project.	No local business community/Chaupati stall 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 project passing 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 Mutha River from Panchaleshwar temple to Vridheshwar Temple. Land required on left bank of river for 39+20 (viaduct + stations) will be 1475 sq.m. for actual construction on ground. The land is belong 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 Municipal Corporation land shall be utilized for parking of Chhatrapati Sambhaji Metro Station. Total 4425 cubic meter excavated material will be generated. Out of 4,425 cubic meter excavated material about 295 cubic meter top soil will be generated. Thirty two (32) tress will be affected due to the proposed alignment.

Herbaceous vegetation and Top soil will also disturbed due excavation and allied activities. Negative impacts are envisaged due to cutting, leveling and allied construction activities. Overall herbaceous vegetation predominated with 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 during study period.

B. Impact on Air Environment

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

The overall scenario with predicted concentrations superimposed over the maximum baseline concentrations is shown in the isopleths (refer Figure 7.34 to Figure 7.36).

Maximum ground level concentrations of dust particles were predicted considering micro meteorological data of the study area obtained during the study period to estimate the construction phase project scenario. It is predicted from the modeling studies that around 50 to 500 m area on eastern and north east direction of the proposed metro rail alignment will be impacted with additional concentration 39.39 $\mu g/m^3$ of particulate matter to the baseline concentrations.

Figure 7.33. Predicted GLC Model for Impact of Particulate Matter (Pier No. 1 to 10)

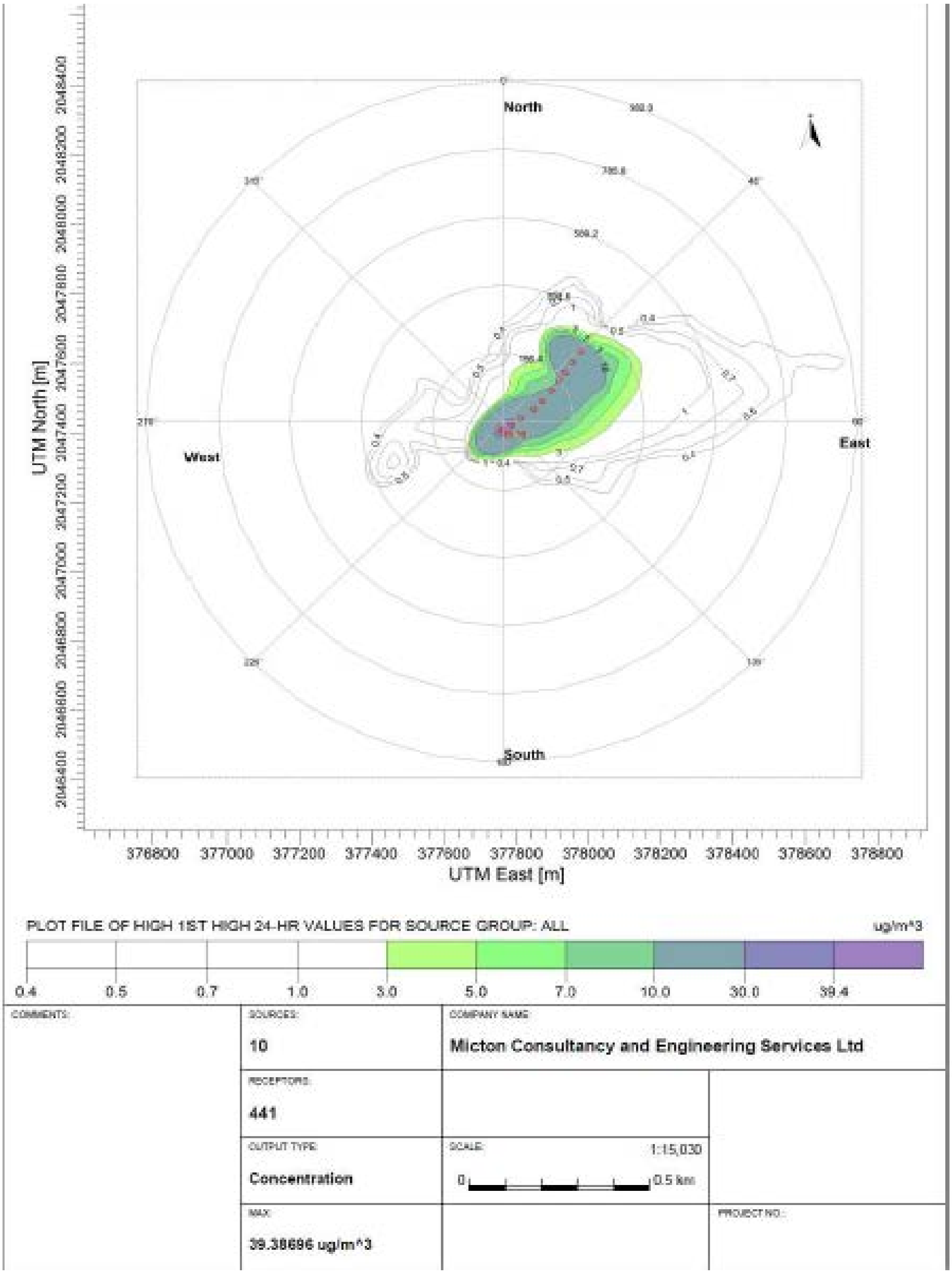


Figure 7.34. Predicted GLC Model for Impact of Particulate Matter (Pier No. 29 to 39)

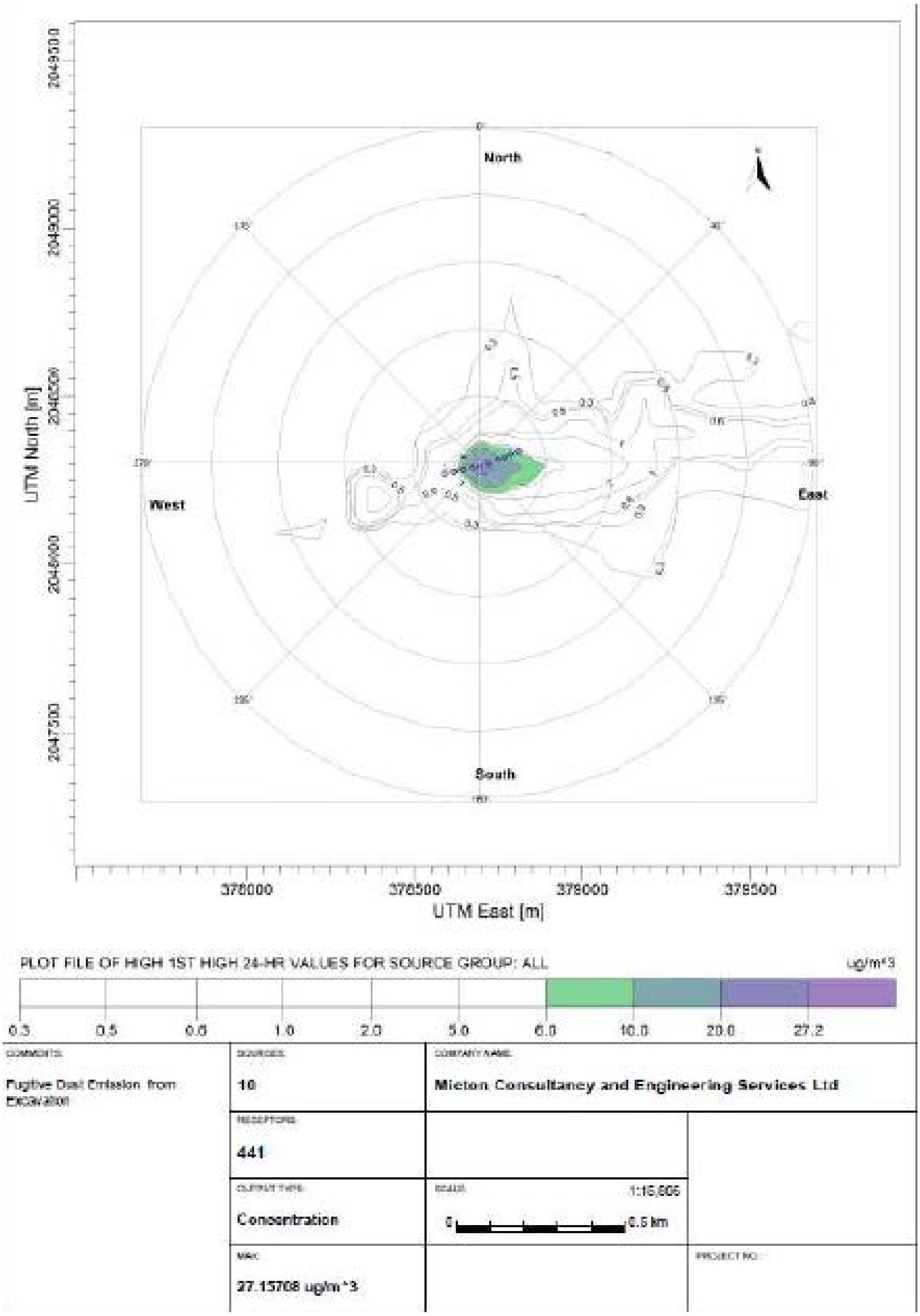
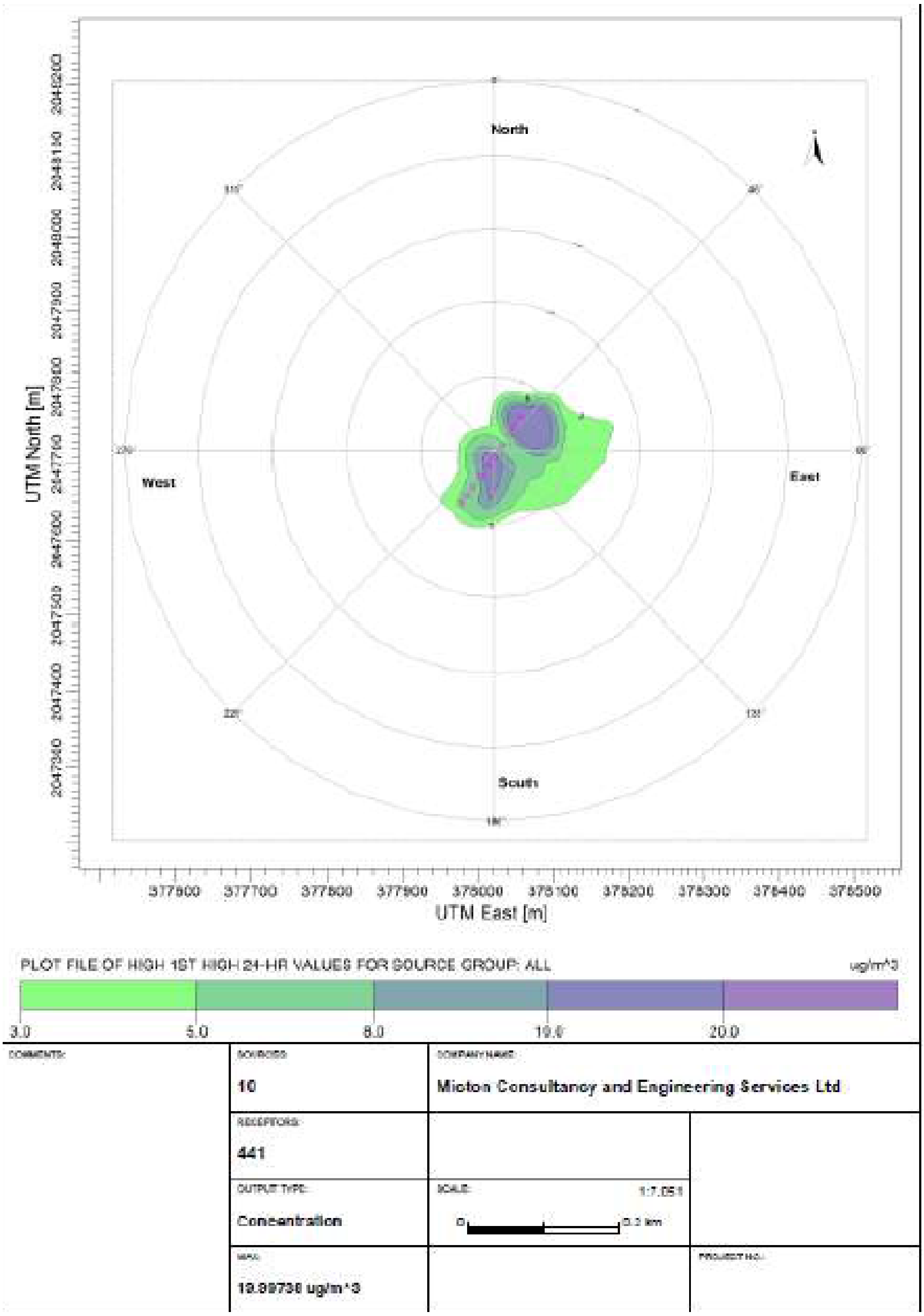


Figure 7.35. Predicted GLC Model for Impact of Particulate Matter (Deccan Metro Station)



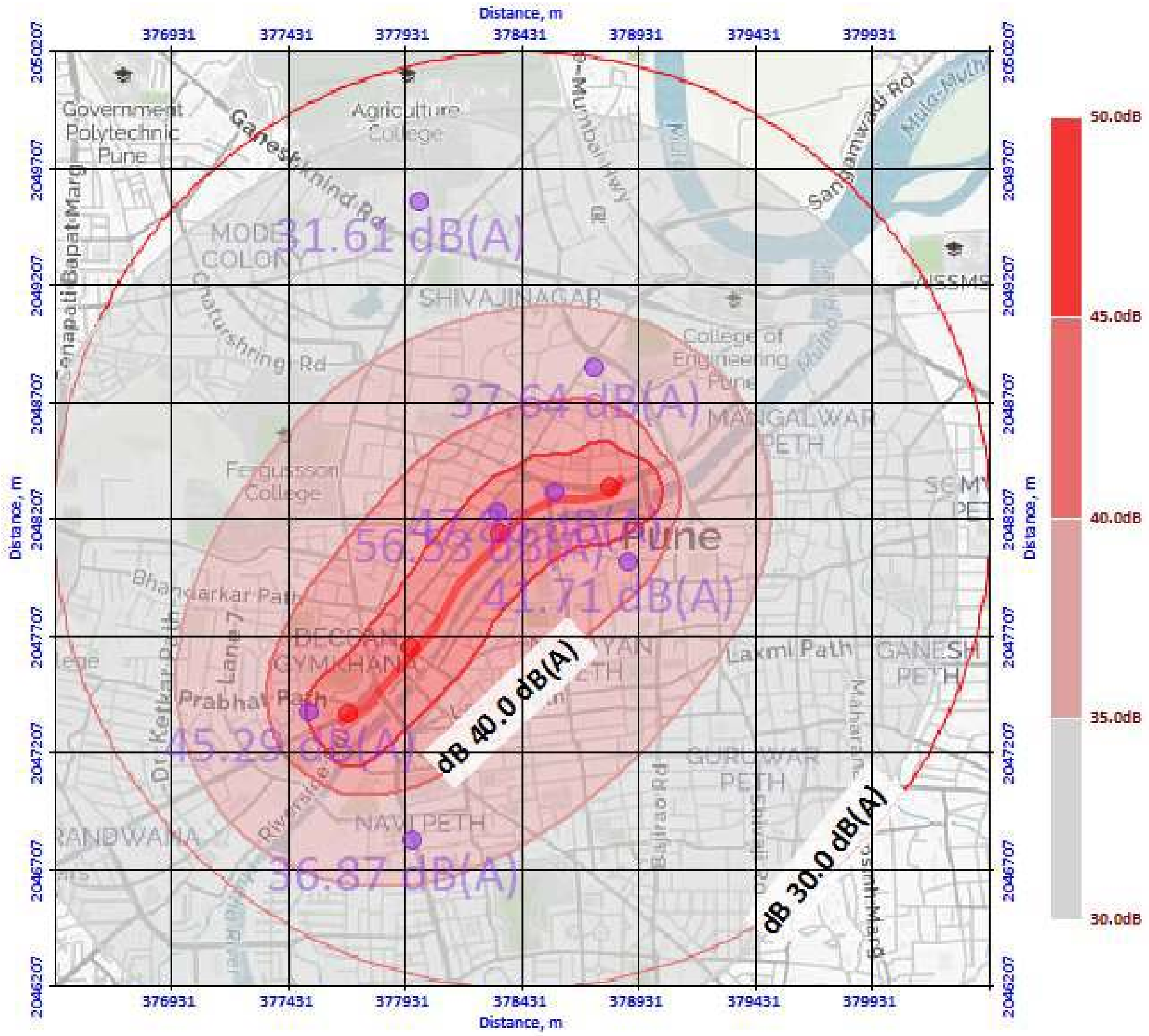
C. Impact on Noise Level and Vibration

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

From the dhwaniPRO® sound propagation modelling it is depicted that maximum noise level due to construction activity at receptor Chhatrapati Sambhaji Udyan will be 56.87 dB (A), at Commercial 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. Predicted Noise Level during construction phase has been shown in Figure 7.37.

Figure 7.36. 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 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 weathered basalt. Hydro geologically, the area is underlain by a unconfined aquifer consisting of shallow alluvium-weathered vesicular basalt. Most of the dug wells are used for domestic purposes and as 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 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 northern bank during floods/peak discharge.

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

In addition water will be required during construction phase at about 100 kld for site activities such 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 predominated with commonly found weed species. This herbaceous vegetation attract butterfly, dragonfly/damselflies etc. Indirect impacts on butterfly, dragonfly/damselflies etc. envisaged due to impact on herbaceous flora. Natural vegetation is much disturbed by anthropogenic pressure. No Rare, Endangered, and Threatened (RET) species of herbaceous flora were observed during study period. No adverse impacts envisaged on aquatic biota.

Initial assessment envisages that total 32 no. of trees to be impacted, while execution of the works it was observed that 19 trees can be preserved at site and balance 13 trees need transplantation. Since the area has no rare or endangered species of trees and maximum number of trees has been preserved at the site and additional 104 new saplings has been planted hence this would not cause any significant impact to the biodiversity and riverine system

F. Impact on Socio Economic Environment

The land will be acquired from Irrigation Department, Government of Maharashtra. There is very minor acquisition of private land for the alignment. No direct impacts are envisaged on socio economic condition from the project area. Beneficial impacts are predicted on local business community and Chaupati stall holders. No direct impacts envisaged on historical & Cultural monuments by proposed metro rail alignment.

G. Impact on Traffic

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

7.6.2. Impact during Operational Phase

A. Land Environment

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

B. Air Environment

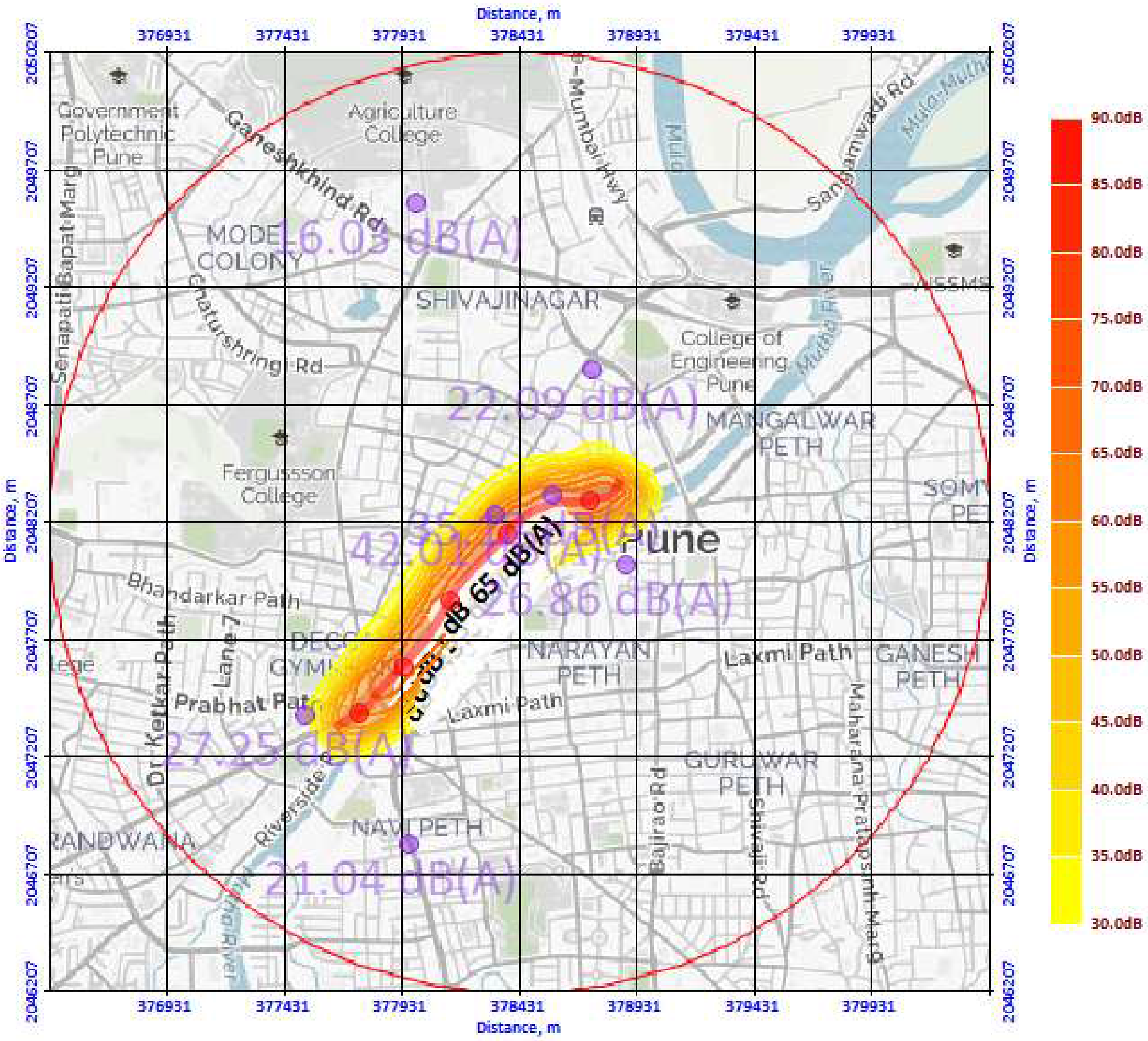
Metro operation will cause no air pollution in the project area because of electric engines. However, DG set provided for power back at metro station may cause short term air pollution.

C. Noise Environment and Vibration

The maximum noise level has been estimated as 64 dB (A) including background noise level as 20 dB (A) inside the Metro. Noise level at a distance of 12.5m, 25m, and 50m from the alignment have 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) noise generated 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 level due to operational phase of the Metro Rail Project at receptor Chhatrapati Sambhaji Udyan will be 42.01 dB (A), at Commercial zone 27.25 dB (A) and at Residential zone 26.86 dB (A) (refer Figure 7.38). Impact due to vibration are envisaged due to rail-wheel interaction during operation of metro rail.

Figure 7.37. Predicted Noise Level during Operational Phase of the Project



D. Hydrogeology and Hydrology

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.

Water flowing through the Mutha River is 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. Higher river water flows are released through the Khadakwasla Dam on very few sporadic 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 so-called Flood situation in Mutha River is very different from other rivers, which have 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 flow velocity at other locations. If the flow velocity increases beyond the permissible bed shear strength, it will reduce in scour of river bed. 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.

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 aquatic weeds on the landfill exists, which affects flow as well as water quality.

Hydrogeological and hydrological survey conducted concluded that no natural riverine system exist 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 is proposed beyond majority of these structures along blue line. No irreversible impact of the proposed 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. However due to orientation of piers, locations and shape only the minimum impacts are predicted beyond discharge 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 60,000 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 3.24 mm to 23.32 mm at Pier No. 161 and Chatrapati Sambhaji Udyan Metro Station Pier No. 10 respectively.

E. Water Environment

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

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

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 requirement for the reported fauna is general at can be fulfill from adjoining area. However, impacts due to construction activity are reversible and cause no further major adverse impact due to operational phase.

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

G. Impact of Solid Waste

Floating population for each the station will be around 15000 thousand per day. Considering 60gm solid waste generation per capita per day, 900 kg solid waste will be generated due floating 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 sections of the society along the project alignment, shopkeepers, pilgrims and influential persons of the project area were made. Land belong to 1.45 Km of left bank of Mutha river is of Irrigation Department.

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 land belongs 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 Municipal Corporation land shall be utilized for parking of Chhatrapati Sambhaji Udyan Metro Station.

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

- Out of 4425 cubic meter excavated material about 295 cubic meter top soil will be preserved and same shall be used for plantation.

- Excavated murum and hard rock shall be used for backfilling and remaining quantity will be used and disposed at identified designated 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 network is 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 will be used for landscaping
- Non degradable waste will be handed over to authorized agency for further treatment and disposal.
- Total 13 trees to be affected and all will be transplanted at project site. Scientific methodology for transplantation shall be adapted to minimize mortality.
- Fertile top soil (Top 20 cm of soil i.e. 295 cubic meter) shall be used for plantation.
- Contractor is responsible for identifying, collecting, transporting and disposal of all the waste 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. Hence land area required in the river basin will be minimum
- No area other than underground foundation and for erection of piers will be used for this project.
- Elevated Metro station are proposed at Deccan and Chtrapati Smbhaji Udyan. No structures on 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 will be made from outside source of Ready Mix Plant. The debris and unutilized construction material and earth from the construction site shall be removed immediately to recycle within the project so that no nuisance dust is generated due to wind. Construction Activities shall not be allowed at Night.
The site being influenced by winds would result in quick dispersal of the pollutants and thereby the impacts due to emissions during the construction will be negligible. Therefore, considering all the air pollutants, it is not expected that air emissions due to construction will exceed air quality standards (NAAQS).

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

Following measures would greatly reduce the impacts during the construction and operational phase:

- 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 monitored with 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 hence insignificant 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 precautions to control noise pollution as mentioned under:

During Construction:

- Use of equipment generating noise of not greater than 90 dB (A).
- The noise control measures during the construction phase include provision of acoustics hoods wherever possible on the construction equipment and regular maintenance of the equipment.
- Movement of vehicles should be strictly restricted to existing roads and tracks, and creation of new roads and tracks or off-roading shall be prohibited on the river banks.
- Recommend light and sound barriers to proposed activities/working areas.
- The construction workers will be provided with the personal protective equipment like ear muffler, hand gloves etc. to reduce the impact of noise pollution.
- Noise generating activities shall be restricted during day time only.

During Operation: 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 and piping 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 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 and noise levels, the complete track is proposed to be joint-less and for this purpose even the turnouts 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 the strata below soil are not favorable to form aquifer. However unconfined aquifer reported from project area has poor potential. It is envisaged that construction of Piers on the bank are not likely to cause significant impact on any aquifers. Natural springs are not observed in the area during the study period. Hence no adverse impacts during construction phase are envisaged on existing hydro geological condition.

Water flowing through the Mutha River is 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. Higher river water flows are released through the Khadakwasla Dam on very few sporadic 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. 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 no adverse impact envisaged. Following management measures are suggested to protect the water quality.

During Construction Phase:

- 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 at construction 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 have to take all precautions to minimize the wastage of water in the construction process.

- 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
- Water and air pollution devices control will be installed

During Construction Phase:

- 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 stations. 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.
- 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.
- Elevated metro rail alignment and stations are proposed, insignificant impacts envisaged on ecology.

7.7.5. Solid Waste Management Plan

During Construction Phase:

- Waste management practices shall be as per Solid Waste Management Rules, 2016
- Degradable waste will be composted and used for landscaping

During Operational Phase

- 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 waste composter and used for landscaping
- Non degradable waste of approx. 540 kg will be handed over to Pune Municipal Corporation for further treatment and disposal.

Organic Waste Converter (OWC):

The OWC processes wet organic waste by employing aerobic microbial decomposition. The machine works in two stages, in the first stage it first crushes the waste and then mixes it homogeneously with the bio decomposition culture. In the second stage this homogeneous mixture is further mixed & churn with saw dust, to soak the excess water content from the biomass which ultimately deodorizes it. The critical components of the machine should be manufactured in SS304, HSD2& WPS for longer life and better results.

Curing: The pre-composted mass is kept for curing and stabilization in the curing bays/drums/Pits for about 12 days. After the 12th day the container is ready with compost and can be used as fertilizer for onsite 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 traffic during construction phase:

- Install, maintain and work within temporary traffic management (using traffic lights, 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.

During Operational Phase:

- Adequate parking will be provided with traffic arrangement at metro station

- Entry exit points to be planned effectively to avoid congestion
- Setting up of sign boards and display boards at metro stations to give information regarding traffic movement.

7.7.7. Management of Ecology and Biodiversity

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 will consider 115 trees and current final route passing through Mutha River would affect only 13 trees.

During Construction & Operation Phase:

- Total 13 trees to be affected and all will be transplanted at project site. Scientific methodology for transplantation shall be adapted to minimize mortality.Apart from 13 trees no. transplantation, 104 new saplings has been planted to compensate the loss.
- Nine trees will be cut and compensatory afforestation for all the affected trees (Ratio 1:3) 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, off-road 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.

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 tier root system and a new system is then gradually encapsulated in a root ball. The entire method is 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 plant adapt itself gradually into a new routine whereby after cutting the roots treat the cut parts and feed it with alternative methods. It is a gradual process and it takes about 3-4 months to actually adjust a tree into a new system of living. Before initiating root cutting process, make sure that the tree is not infected and if it is we treat accordingly. Certain growth promoter may use for root 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 like insecticides, pesticides during the course for general treatment. Simultaneously expert staff is needed to sew packing material properly and tightly according to the root requirement. Plant has to pack in the same environment as before. It needs external support to remain in the same position without falling down because of wind pressure. Scaffolding is required for about one and a half to three months depending upon the condition of the tree for each transplanted tree to 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 the tree depending upon its size, from its original location to the place where it is to be transplanted. JCB will be used for digging pits. Pruning may be required depending upon the size of the root ball, the plant canopy, health of the plant, species transplanted or because of overhead wires and 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 & heavily foliaged. Scaffolding is required for about one and a half month for each transplanted tree to give it external support. The support provided to a tree should be removed as soon as the tree can stand alone. It takes about 30 to 45 days in the growing period for the transplanted tree to grow new branches & foliage. The sooner the support will be removed, the faster the tree will become stronger.

F. Afforestation and Compensatory Plantation

Criteria for Selection of Species: The choice of vegetative species for planting should be based 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 climatic extremes after initial establishment

Table7.34. 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
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

S. No.	Botanical Name	Vernacular Name	Family
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 is no acquisition of private land for the proposed alignment.
- No displacement of local shopkeepers, Chaupati stall holders.
- No direct impact are envisaged on socio economic condition from the project area.
- Existing access to Panchaleshwar and Vridheshwar shall be maintained.
- During construction phase access to temples and Ghats will be given by providing proper 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 to be following provisions for an effective system which can timely detect the threats and help suppress 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 site conditions 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 to improve and stabilize with time, intensive mock drills for the staff concerned is very essential to train them to become fully conversant with the action required to be taken while handling emergencies.

They also need to be trained in appropriate communication skills while addressing passengers during incident management to assure them about their well-being seeking their cooperation. Since learning can only be perfected by 'doing' the following Mock Drills are considered essential:

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 of employees to occupational safety and health hazards.

During Construction:

- 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, where there is possibility of dust generation.
- In high noise generation areas ear mufflers will be provided for the workmen.
- Contractor should organize weekly health and safety meeting with the working personnel on risk associated with the day's tasks and activities ad means of prevention and protection to be implemented.

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 measures in the system design itself. The auxiliary power consumption of metros is generally more than the traction energy consumed by train movement during initial years of operation. Subsequently, traction power consumption increases with increase in train frequency/composition in order to cater more traffic. The proposed system of Pune Metro includes 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.) have 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 structures shall 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 by way of environmental protection function efficiently during the entire period of operation. Capital cost of Rain water harvesting structures at metro stations is part of Civil Contract. Summary of Budgetary Provision for EMP of Metro Stretch Passing through Mutha River is given in Table 7.35.

Table7.35. Budgetary Provision for EMP of Metro Stretch Passing through Mutha River

S. No.	Pollution Control & Other Environment Infrastructure	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	-
8.	Training & awareness	2.00	-
B.	During Operation Phase:		

S. No.	Pollution Control & Other Environment Infrastructure	Capital Cost In Rs. Lakhs	Annual O & M Cost in Rs. Lakhs
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 be monitored during construction and operational phase are presented in Table 7.36 and 7.37.

Table7.36. Monitoring Program during Construction Phase

Component	Parameters	Location	Frequency
Ambient Air Quality	PM10, PM 2.5, SO2, Nox,	1. Construction site 2. upstream of site 3. downstream of site	Half Monthly
DG Sets	Particulates, SO2, NOx, CO, HC	DG stacks at construction sites	Monthly
Noise Level	Leq day, Leq night, dB(A)	1. Construction site 2. upstream of site 3. downstream of site	Half Monthly
Surface and Ground Water Quality	Physical, Chemical & biological Parameters	1. Construction site 2. upstream of site 3. downstream of site	Monthly
Drinking Water	IS 10500:2012	At construction site	Quarterly
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/Hazardous wastes	Depending on type of wastes	At the construction area	Quarterly
Ecology & Biodiversity	Plantation / Green belt development, Periodical monitoring of aquatic ecology	Project site and periphery	Quarterly
Waste Water (Sewage)	As per SPCB guidelines	Mobile Toilet & STP at Construction site	Monthly

Table7.37. Monitoring Program during 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
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 7A: Mathematical Model Studies Of River Mutha

SUMMARY OF THE CWPRS REPORT

In addition to Hydraulic studies conducted by M/s MITCON and in order to compliance of NGT Expert committee recommendation new mathematical model study was conducted by Central Water and Power Research Station, Pune and report (Technical Report no. 5886) was submitted to Maha-Metro vide letter no. HAPT/Maha-Metro/2021-46/23 dated 22 January,2021. This study was intended to estimate the afflux for two river discharges of 60,000 ft3/s and 1,00,000 ft3/s and inundation of riverbanks caused by afflux in Mutha river due to the construction of metro pier and allied structures.

The Mathematical model of river Mutha covers a reach of about 15.0 km from Khadakwasla dam to Sangam near confluence of Mutha river with Mula river was developed using HEC-RAS 5.0.7. Simulations were carried out for the discharges of 60,000 ft3/s and 1,00,000 ft3/s to compute the water surface profiles under existing conditions (without Metro Piers) and also by incorporating the Metro piers to estimate the afflux and inundation. The summary of the CWPRS report are as below:

1. *"The maximum afflux (rise in water level) for the 100,000 ft3/s and 60,000 ft3/s due to introduction of Metro piers have been estimated as 216 mm at Metro pier no. P152 and 241 mm at pier no. DE 1 respectively.*
2. *This increase in water level results in incremental increase in inundation. Inundation is the spread of the water along both banks (i.e. left bank + right Bank).*
3. *For the discharge of 100, 000 ft3/s the incremental increase in inundation would be insignificant (0.02 m) in the reach between Shivaji Bridge and Shinde Bridge. In the reach between Shinde Bridge and Metro pier DE 8 incremental increase inundation varies between 0.02 to 10 m. Further from DE 8 to Baba Bhide bridge the incremental inundation varies from 2.6 to 10.94 m. (i.e. about 5m on either bank.)*
4. *At three locations i.e. P159, P160 and Z Bridge the inundation is 22.2 m 20.6 and 29. 8 m respectively. The incremental inundation extent 55.76 m at pier no P167 due to specific topography at this location. There is a low level cross road connecting the river front road and Kelkar road at this location. Water is spreading along this road and hence the higher inundation extent at this particular location was observed.*
5. *The incremental increase in inundation extent for 60,000 ft3/s in the reach between Shivaji Bridge and Shinde Bridge is insignificant (0 to 0.01 m). In the reach between Shinde Bridge and Metro pier DE 8 varies between 0 to 2.27 m. From DE 8 to upstream*

of Baba Bhide bridge is 2.27 to 11.44 m. At two locations i.e. P162 and P 163 is 10 to 11.4 m. (i.e. 5 to 5.6 m on either bank.)

6. *The Irrigation Department has demarcated the redline for a discharge of 100,000 ft3/s and blue line for discharge of 60,000 ft3/s in year 2011.The expert committee is of the opinion that the Red line and Blue line to be redefined by the competent authority taking into account the recent developments along the river reach.*
7. *The CWPRS has also highlighted that the contribution of discharge from the local catchment downstream of the Khadakwasla dam to Sangam Bridge will only yield about 8,500 cusecs corresponding to the discharge of 90,000 cusecs. Therefore, in the worst-case scenario the total discharge will not breach 100,000 cusecs. Also, the spillway design capacity of Khadakwasla dam is 97,000 cusecs only.*
8. *The CWPRS scientist has also pointed out that in the last 56 years the discharge of 60,000 cusecs has only been breached four times and the 100,000 cusecs has not been breached even once, so scenario for breaching the 100,000 cusec discharge would be a rare.*
9. *It was referred that the Irrigation Department and the Smart City project both have robust flood alarm and evacuation system to avoid loss of life and property. The Smart City Project has already identified the flood prone locations and areas to where people will be moved in case of floods. This has been tested during the floods of 2019."*

The above mentioned report was presented to NGT Expert committee meeting held on 8th March, 2021 under the ageis of Divisional Commissoner, Pune. Minutes of the meeting and complete CWPRS Mathematical Model studies of River Mutha and add on reports has been enclosed as **Annexure-1**

CHAPTER 8: Additional EIA and EMP Study For Revised Reach -3 Alignment Passing Adjacent to Dr. Salim Ali Bird Sanctuary

8.1. PREAMBLE

Pune Metro project has been undertaken by Maha Metro, a SPV (Special Purpose Vehicle) of Government of India and Government of Maharashtra. A population of approximately 50 lakhs, from Pune's metropolitan area, will be benefited by proposed metro corridors. The approved alignments, are expected to provide much-needed connectivity to commuters and would traverse through some of the densest and traffic-congested routes in the Pune Metropolitan Area. Since a few decades, the city witnessed substantial rise in population due to migration of people from different parts of the country for job and educational opportunities. However, the sustainable infrastructure to facilitate easy commute to the citizens was missing. Average travel time for citizens using public transport in Pune is over ~100 mins a day. This makes more and more citizens use their personal vehicle, which causes traffic chaos and congestion issues.

Maha Metro has proposed following two corridors considering immediate need of rapid transport within the Pune city:

Corridor - 1 Pimpri Chinchwad (PCMC) to Swargate via Shivaji Nagar, Pune Municipal Corporation having length of 17.534 km with 9 elevated & 6 underground Stations.

Corridor - 2 : East-West corridor (Vanaz, Kothrud – Ramvadi) covering a length of corridor 2 is 15.749 km. Total 16 number of elevated stations have been planned along this corridor. Since the permission was rejected by National Monument Authority for the alignment in consort with the centre line of BRTS median and passing by the Aga Khan Palace (Ch:12575 to Ch:12675), alignment has been shifted adjacent to Dr. Salim Ali Bird Sanctuary as an alternative alignment with following justifications (Figure 8.1).

- ❖ According to the 2016 order issued by the Bombay High Court in response to a petition filed by the city-based NGO Parisar that construction of the Metro project should not proceed without getting permissions from the NMA.
- ❖ As Aga Khan Palace was declared as a nationally protected monument in 2003, hence application for seeking NOC/permission for construction of viaduct was submitted to RD & CA on 13 April 2018 and the proposal was forwarded to National Monuments Authority (NMA) on 31 August 2018.
- ❖ The National Monument Authority (NMA) has rejected the permission sought by Maharashtra Metro Rail Corporation Limited (Maha-Metro) to undertake Pune Metro alignment from Civic Court to Ramwadi near Aga Khan Palace as it falls within the prohibited area of the monument.

- The NMA took the decision in a meeting on September 10 as this section lies within the prohibited area of the Aga Khan palace.

- Subsequently General Consultants (GC) undertook feasibility studies and identified the following alternate alignments
  - Starts at Ch: 11015 (Gunjan Chowk), turns RHS near Garbage collection center, runs along DP road and re-joins the main alignment at Ch: 13454. A small segment of this alignment runs on the median of DP road adjacent to Dr. Salim Ali Bird Sanctuary.
  - This has resulted in an increase of 920 m to the original alignment and relocation of Kalyani Nagar station

SN	Route	Length and Type	Stations
1	North–South Corridor: PCMC to Swargate Alignment from (-) 450 m to 16589 m	5.019 km/Underground + 11.570 km. Elevated	6 nos. (Underground) 9 nos. (Elevated)
2	East–West Corridor: Vanaz to Ramwadi	15.585 km / Elevated	16 nos. (Elevated)
	New Proposed alternative Alignment passing adjacent Dr. Salim Ali Bird Sanctuary has resulted in an increase of 920 m to the original alignment and relocation of Kalyani Nagar station		
	Total	**32.174 km**	**31 Nos.**

8.2. PURPOSE OF THE STUDY /OBJECTIVES

The original alignment was along the median of Samrat Ashok road, passing in front of the Agha Khan Palace. As the NMA had refused to grant permission for this construction, a detour was required. The current alternative at Gunjan Chowk diverts towards reserved land for Metro Depot and extends through median of existing DP road which is adjacent to the Dr. Salim Ali bird sanctuary. Considering the environmental sensitivity/presence of valued environmental components around the new route alignment, ESIA study has been carried out for ascertaining the direct & indirect impact on surrounding fauna & flora including within the Bird sanctuary area and accordingly the mitigation measures have been delineated.

8.3. PROJECT BAKGROUND

The original DPR alignment of the Pune Metro East West Corridor was aligned along the Pune Ahmednagar Highway from Parna Kuti Yerwada Chowk. Alignment was provided in consort with the centre line of BRTS median and passing by the Aga Khan Palace (Ch: 12575 to Ch: 12675). The distance available from the elevated viaduct to the central core of the monument was 118.5m. Clear distance from the boundary wall of the monument to the edge of elevated viaduct was 19.80m. According to the 2016 order issued by the Bombay High Court in response to a petition filed by the city-based NGO Parisar that construction of the Metro project should not proceed without getting permissions from the NMA. As Aga Khan Palace was declared a Nationally Protected Monument in 2003, hence application for seeking NOC/Permission for construction of viaduct submitted to RD & CA on 13 April 2018 and the

Proposal forwarded to National Monuments Authority (NMA) on 31st August 2018. The National Monument Authority (NMA) has rejected the permission sought by Maharashtra Metro Rail Corporation Limited (Maha-Metro) to undertake Pune Metro alignment from Civic Court to Ramwadi near Aga Khan Palace as it falls within the prohibited area of the monument. The NMA took the decision in a meeting, as this section lies within the prohibited area of the Aga Khan palace. General Consultants of Maha Metro conducted feasibility studies and identified the following alignment. Starts at Ch: 11015 (Gunjan Chowk), turns RHS near Garbage collection center, runs along DP road and re-joins the main alignment at Ch: 13454.A small segment of this alignment runs on the median of DP road adjacent to Dr Salim Ali Bird Sanctuary. This has resulted in an increase of 920 m to the original alignment and relocation of Kalyani Nagar station.

Figure 8.1. Photograph Showing Original Alignment and Distance from Monument

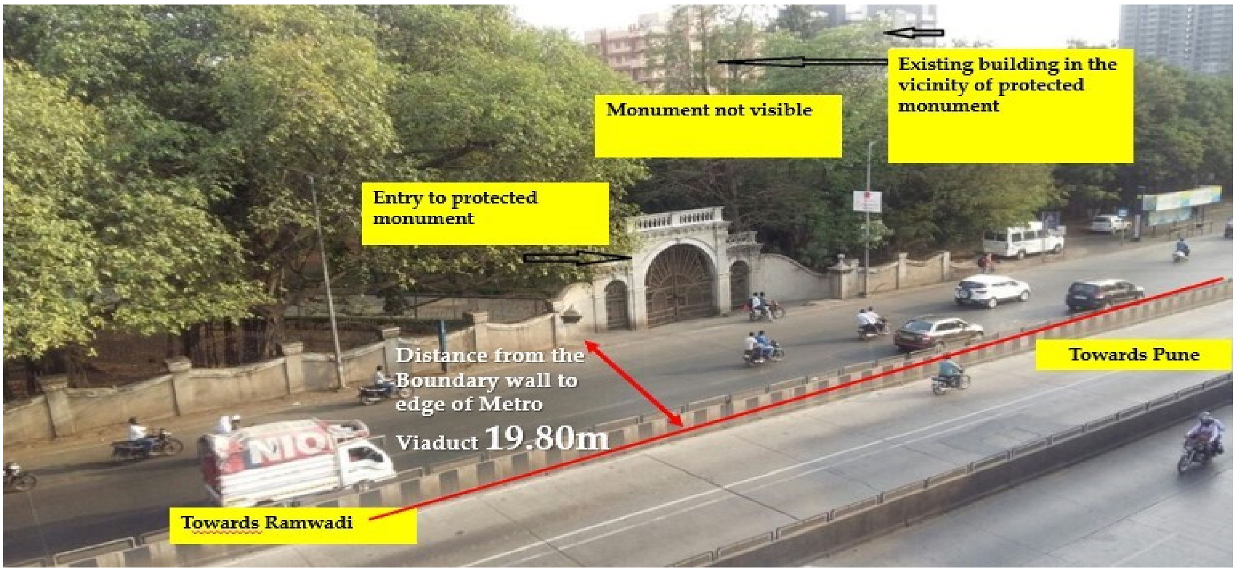
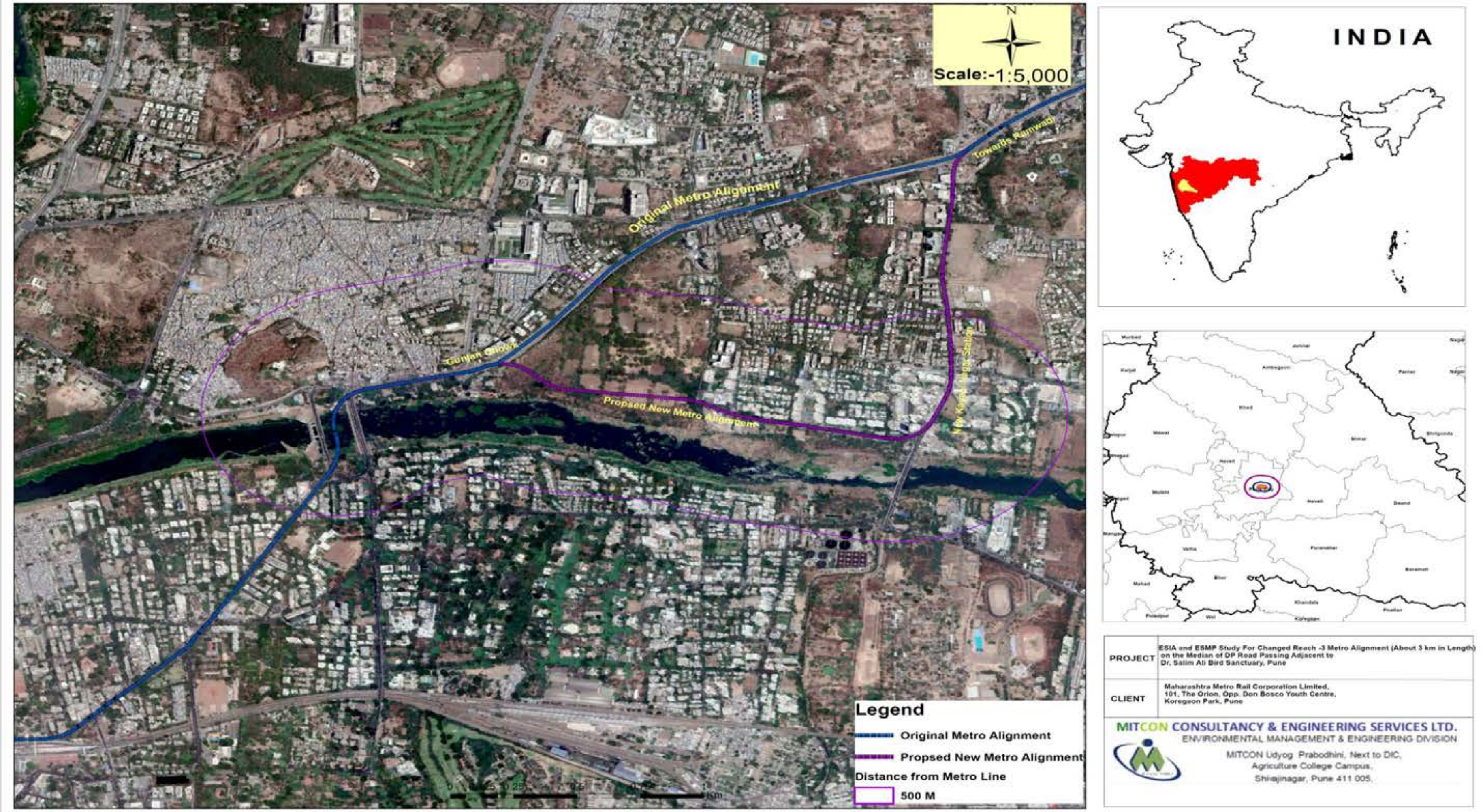
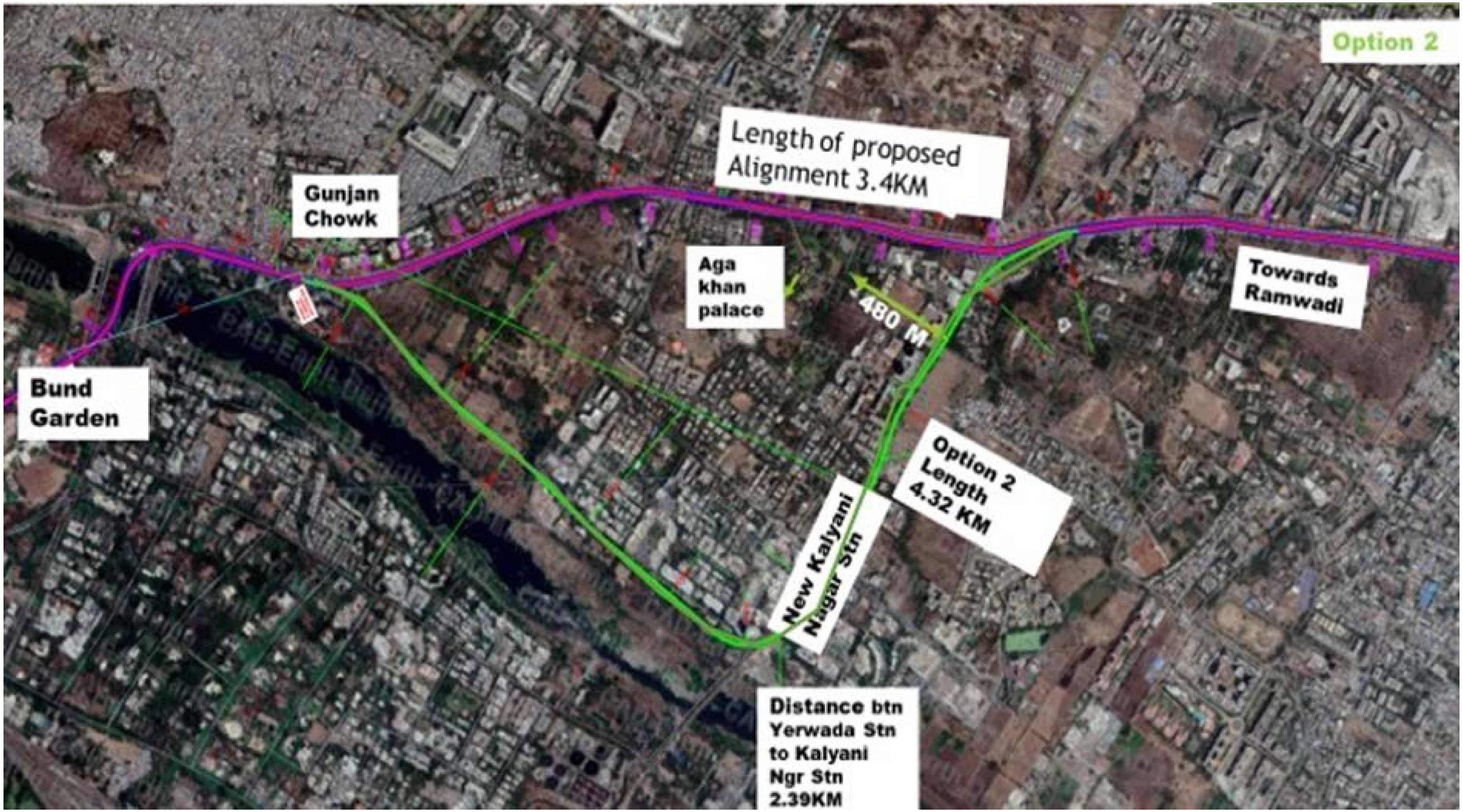


Figure 8.2. ocation Map



8.3 Proposed alternative Metro Alignment median of DP Road & passing adjacent to Dr. Salim Ali Bird Sanctuary (Reach – 3)



8.4. HISTORY OF DR. SALIM ALI BIRD SANCTUARY OR MULA MUTHA WATER BIRD SANCTUARY

Mula Mutha Water Bird Sanctuary or Dr. Salim Ali Bird Sanctuary is grossly termed as "Sanctuary", however, it is not a Notified Wildlife Sanctuary or Protected Area.

- Originally in 1977 the sanctuary, as mooted by the late Dr Salim Ali, Shri Prakash Gole and WWF-India, was planned to cover a much more extensive area on both the north and south banks of the Mula-Mutha River,
- This did not prove possible partly, due to non-acceptance by the land owners.
- Ultimately it was established on a strip of land bordering the north bank of the river, which was given by the Wadia family from Part of the following lands at village Yerwada, Pune:
    - From Survey Nos. 223,231,230 & 229 (FP 70/11,TPS Yerwada No 1)
    - From Survey Nos. 222/1 (FP 70/12).
    - From Survey Nos. 141 & 233
    - (FP 70/10), on long lease from Govt. at the time, and presently under litigation in the Bombay High court.
- From 1975 onwards **ornithologist Prakash Gole** had been making efforts to promote a water bird Sanctuary along the Mula-Mutha River in the Pune, as he knew the area to harbor an extremely rich and diverse bird population, especially of migrants during the winter.

- In 1977 **Dr. Salim Ali** himself took up the matter with the Prime Minister **Mrs. Indira Gandhi**, along with the World Wildlife Fund-India (WWF).
- At the PM's initiative, the local authorities (Div. commissioner and collector) and the WWF had dialogues with the landowners, including the Wadia group, along the river banks.
- After discussion involving WWF as the nodal agency, the Revenue authorities and Wadia group agreed to allow a strip of land bordering the river to be used for **afforestation** by the Forest Dept. so as to facilitate the formation of the Sanctuary.

- The area to be used was physically demarcated by mutual consent between Wadia Family Group and the WWF, with the agreement of the Revenue authorities, sometime around **May 1977.**

- The portion of FP No.70/10 was surrendered with the express agreement of the Revenue officials, as it was land leased from Govt. at that time (but now no longer leased-though temporarily in possession of Dr. Wadia by Order of the High Court).

- The collector (**by his letter PRL_I of 11.04.1978**) then asked Wadia Group to give written permission for afforestation by the Forest Dept. which was given in writing on 13.04.1978. Accordingly the collector requested the Deputy Conservator of Forest (DFO) to go ahead. However the Forest Dept. expressed some administrative apprehensions, so the collector (**by his letter PRL133 of 20.05.1978**) requested Wadia group to give the demarcated strip of the Forest Dept. on an **ownership basis, and urged Wadia group not to wait for formal acquisition proceedings**. (**By Wadia Group letter of 27.05.1978)**.

- Wadia group made the only condition that the Forest Dept. should **erect a barbed wire fence** on the demarcated boundary. Wadia group also clarified that **they did not wish for compensation**, as the purpose was for a public amenity in the vital cause of nature conservation and environmental education.

8.5. CONSIDERATION OF ALTERNATE SITES

As per the provision of Ancient Monuments and Archaeological Sites and Remains Act (AMASR Act), no construction is allowed within prohibited area beginning at the limit of the Protected Area or the Protected Monument as the case may be, even for public works. Hence the proposed Elevated Metro Corridor on Civil Court - Ramwadi section is impacted by this provision.

The National Monument Authority (NMA) has rejected the permission sought by Maharashtra Metro Rail Corporation Limited (Maha-Metro) to undertake Pune Metro alignment from Civil Court to Ramwadi near Aga Khan Palace as it falls within the prohibited area of the monument. The NMA took the decision in a meeting on September 10 as this section lies within the prohibited area of the Aga Khan palace.

In consequences with above and in accordance with the rejection received from NMA, for mitigating the requirement of No Construction Zone, adjacent to Agakhan Palace boundaries, actions were initiated to examine three feasible options.

As desired by Maharashtra Metro Rail Corporation (Maha-Metro), GC carried out the feasibility analysis for selecting the best feasible Option out of proposed three Options as furnished below:

Option-1: Starts at Ch:12352, diverts towards LHS and re-joins at main alignment at Ch:13071

Option-2: Starts at Ch:11015 (Gunjan Chowk), turns RHS near Garbage collection center, runs along DP road and re-joins main alignment at Ch:13454

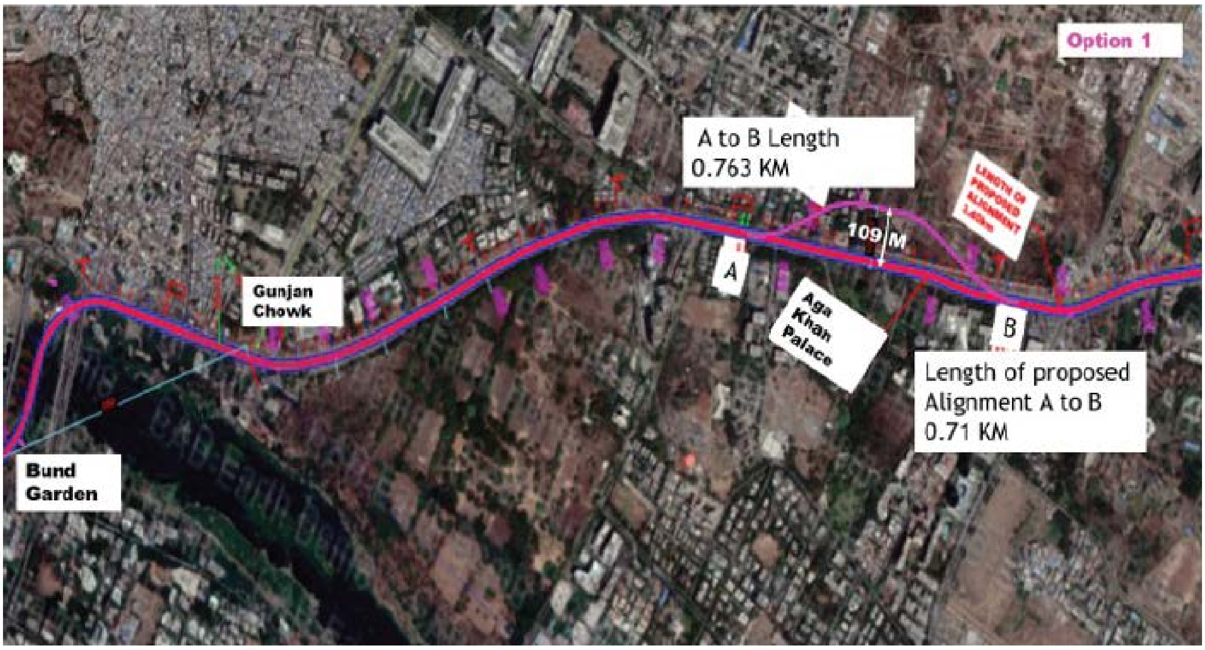
Option-3: Starts at Bund Garden station Ch:10125, runs along Koregaon Park, RHS of the river bank and re-joins the main alignment at Ch:3454

8.5.1. Option Analysis

Option-1: Salient Features

This alignment starts at Ch:12352, diverts towards left side of DPR alignment in front of Aga Khan Palace and later reconnect with the DPR alignment at Ch:13071 (Figure 3.4.). This will cause an additional length of 53.0m which will lead to an additional estimated cost of INR 140.0 Cr.

Figure 8.3. Option 1 Ch:12352, diverts towards LHS and re-joins at main alignment at Ch:13071



Merits

1) This alignment is very close to the DPR alignment
2) It will be away from clear demarcation zone of external boundaries of the Aga Khan Palace.
3) Shortest deviation from the present alignment.
4) Ridership will remain unaffected
5) Lesser Operation & maintenance (O&M) cost as compared to other two options.

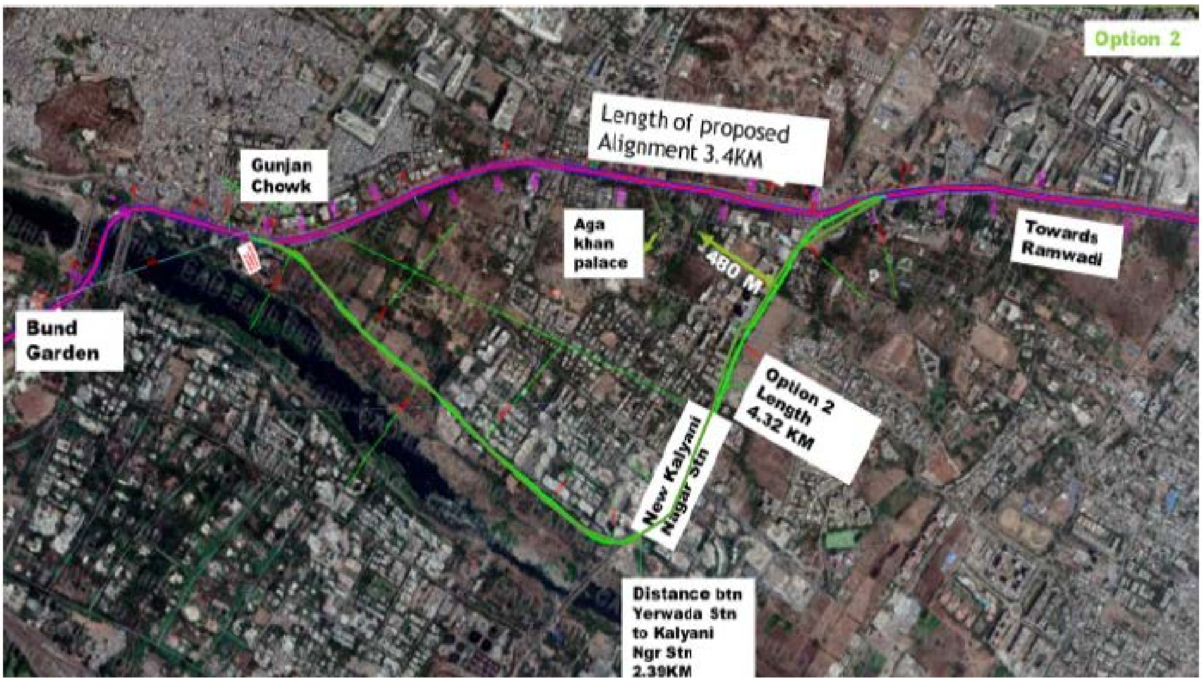
Demerits

1) R & R cost will be very high due to thickly populated locality
2) May lead to litigation cases which may delay the project
3) Since contract is already awarded and contractor is on board, it will lead to additional time and cost.

Option-2: Salient Features

This alignment starts at Ch:11015 (Gunjan Chowk), then turns right side near Garbage collection center, afterwards passes adjacent to Dr. Salim Ali Bird Sanctuary and runs along the DP road to reconnect the main alignment at Ch:13454. This alignment will cause an additional length of 920.0 m and additional cost of INR 200.0 Cr.

Figure 8.4. Option 2 : Starts at Ch:11015 (Gunjan Chowk), turns RHS near Garbage collection centre, runs along DP road and re-joins main alignment at Ch:13454



Merits

1. It will cover the new locality in Kalyani Nagar
2. It will not affect Aga Khan Palace boundaries
3. Alignment can run on the DP road median
4. Cost and time impact can be controlled

5. Expected ridership will be more

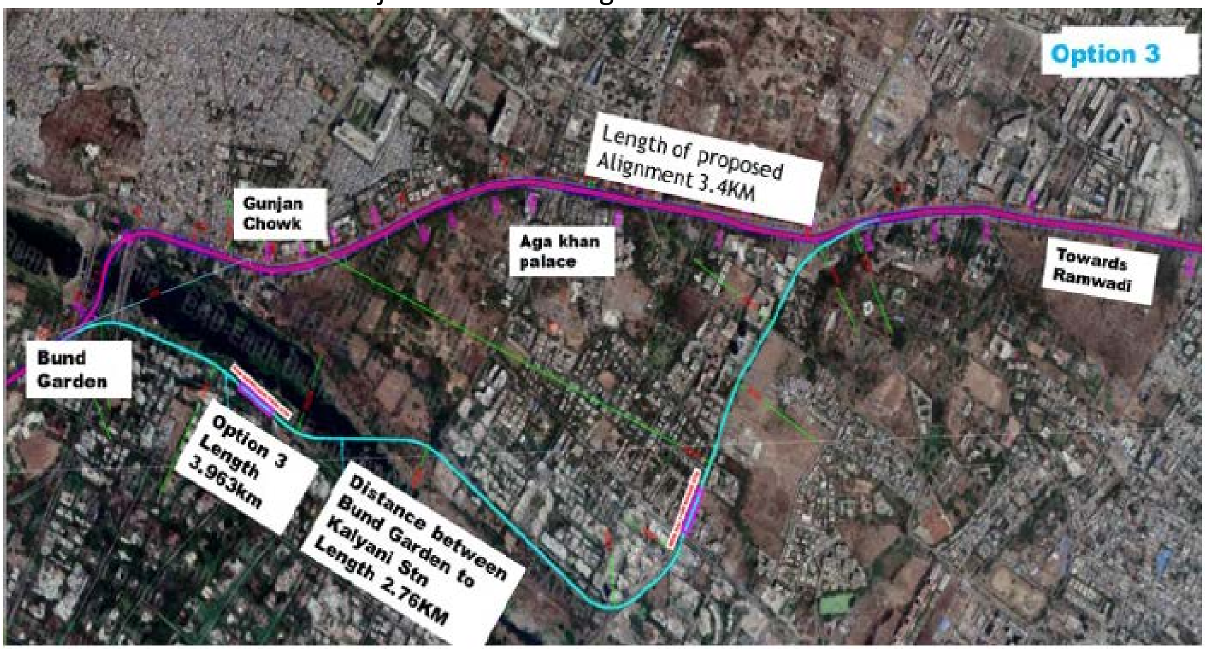
Demerits

1) Low ridership in Kalyaninagar
2) Less commercial establishments and malls along the road
3) Lead to traffic congestion in Kalyaninagar
4) Impact on environment due to existence of bird sanctuary and the river
5) Acquisition of land and approval process may take time
6) Since contract is already awarded and contractor is on board, it will lead to additional time and cost
7) Delays in completion of overall project
8) Tree cutting and transplantation will be involved
9) Operation and Maintenance (O&M) cost will be more compared to other two options

Option-3: Salient Features:

This alignment starts at Bund Garden Station at Ch:10125 then runs along Koregaon Park along river bank at right side and re-joins the main alignment at Ch:13454.91. This alignment causes an additional length of 563.0m and an additional cost of INR 170.0 Cr.

Figure 8.5. Option 3 Starts at Bund Garden station Ch:10125, runs along Koregaon Park, RHS of the river bank and re-joins the main alignment at Ch:3454



Merits

1) This will not affect the Aga Khan Palace boundaries

2) New ridership localities can be explored.

Demerits

1) Less commercial establishments or malls along the road
2) Lead to traffic congestion in Kalyaninagar and Koregaon Park
3) Since contract is already awarded and contractor is on board, it will lead to additional time and cost
4) Delays in completion of overall project
5) Existing road widths are less due to which involvement of R&R will be high
6) It will not help in decongestion of Nagar road traffic.
7) Tree cutting and transplant will be involved
8) Environmental issues will be involved due to existence of alignment along river bed that will affect migration path of bird adjacent to Dr. Salim Ali bird sanctuary.
9) The alignment crosses the river adjacent to the sanctuary, which may affect movement of birds

10) Operation and Maintenance (O&M) cost will be more than Option 1 and less than Option 2

Table 8.1. Cost comparison involved in alternative alignments

Sr. No.	Item	Cost (Cr/km)	Option 1		Option 2		Option 3	
			Extension Length (km)	Cost (Cr.)	Extension Length (km)	Cost (Cr.)	Extension Length (km)	Cost (Cr.)
1	Cost for construction of viaduct @ INR 50.75Cr/km	50.75	0.053	2.69	0.92	46.69	0.563	28.57
2	Continuous deck in curve (Special Span 2 Nos.)	-	-	-	-	45.00	-	45.00
3	Cable for 33KV ASS Power supply @ INR 0.75 Cr/km	0.75	0.053	0.04	0.92	0.69	0.563	0.42
4	OHE @ INR 5.0Cr/km	5.00	0.053	0.27	0.92	4.60	0.563	2.82
5	Track and fastening @ INR 9.3 Cr/km	9.30	0.053	0.49	0.92	8.56	0.563	5.24
6	Signaling @ INR 9.0 Cr/km	9.00	0.053	0.48	0.92	8.28	0.563	5.07

Sr. No.	Item	Cost (Cr/km)	Option 1		Option 2		Option 3	
			Extension Length (km)	Cost (Cr.)	Extension Length (km)	Cost (Cr.)	Extension Length (km)	Cost (Cr.)
7	Telecom and viaduct lighting @ INR 0.25 Cr/km	0.25	0.053	0.01	0.92	0.23	0.563	0.14
	Sub Total			**3.98**		**114.05**		**87.26**
8	General charges including PMC @ 5%			0.20		5.70		4.36
	Sub Total			**4.18**		**119.75**		**91.62**
9	Contingencies @ 3%			0.12		3.42		2.62
	Sub Total			**4.30**		**123.17**		**94.23**
10	Land and R&R : Lumpsum			100.0		11.96		9.050
11	EOT/Project over run by three months			31.25		62.50		62.50
	Grand Total			**135.55**		**197.63**		**165.78**

Table 8.2. Comparative Analysis of alternative alignments

SN	Detail	DPR Alignment	Option 1	Option 2	Option 3
1	Additional length	N/A	0.053km	0.920km	0.563km
2	Introduction of New Station / Station shifting	N/A	N/A	0/1	1/1
3	Land acquisition	N/A	Involved	N/A	Involved
4	R & R	N/A	Involved	N/A	Involved
5	Extra cost	N/A	Involved	Involved	Involved
6	Tourist potential	High	Nil	Nil	Nil
7	Decongestion of existing Nagar Road	Yes	Partial	No	No
8	Delay in construction	N/A	Yes	Yes	Yes
9	Tree cutting	N/A	Yes	Yes	Yes
10	Ridership	High	High	Low	Low
11	O & M cost	Low	Low	High	High
12	Environmental issues	N/A	Partial	Yes	Yes
13	Extra cost	N/A	140	200	170

Recommendation

With reference to above analysis Option 2 has been found as the most feasible option among all these three Options. Further, the option 2 (revised alignment) is approved by Board of Directors of Maha-Metro in the meeting held on 17th January,2019 and PMC on 18.12.2018 and GoM on 16.02.2019. The Govt. of India, Ministry of Housing and Urban Affairs vide Gazette notification S. O. 3706 (E) dated 14th October,2019 has also notified the revised alignment . All the related approvals and notification are presented in Annexure- 3.1

8.6. BASELINE STUDY

8.6.1. Study Area and Period

The studies were conducted for the period from December 2018 to February 2019 All the sampling locations are shown and presented on toposheet.

Details of the study area for preparation of ESIA & ESMP study are given below.

- Proposed alignment passing adjacent to Dr. Salim Ali Bird Sanctuary (Figure 8.1)
- Project site photographs as shown in Figure 8.7
- Study area for primary data (up to 2 km) and secondary data (up to 10 km) from the site (Figure 8.8 & 8.9 respectively).

Figure 8.6. Photographs of proposed alternative Metro alignment

Entry Point

Tree likely to be affected

Tree likely to be affected

Experts discussion at the alignment

Turning towards Median of DP Road

Figure 8.7. Image Showing 500 m Study area

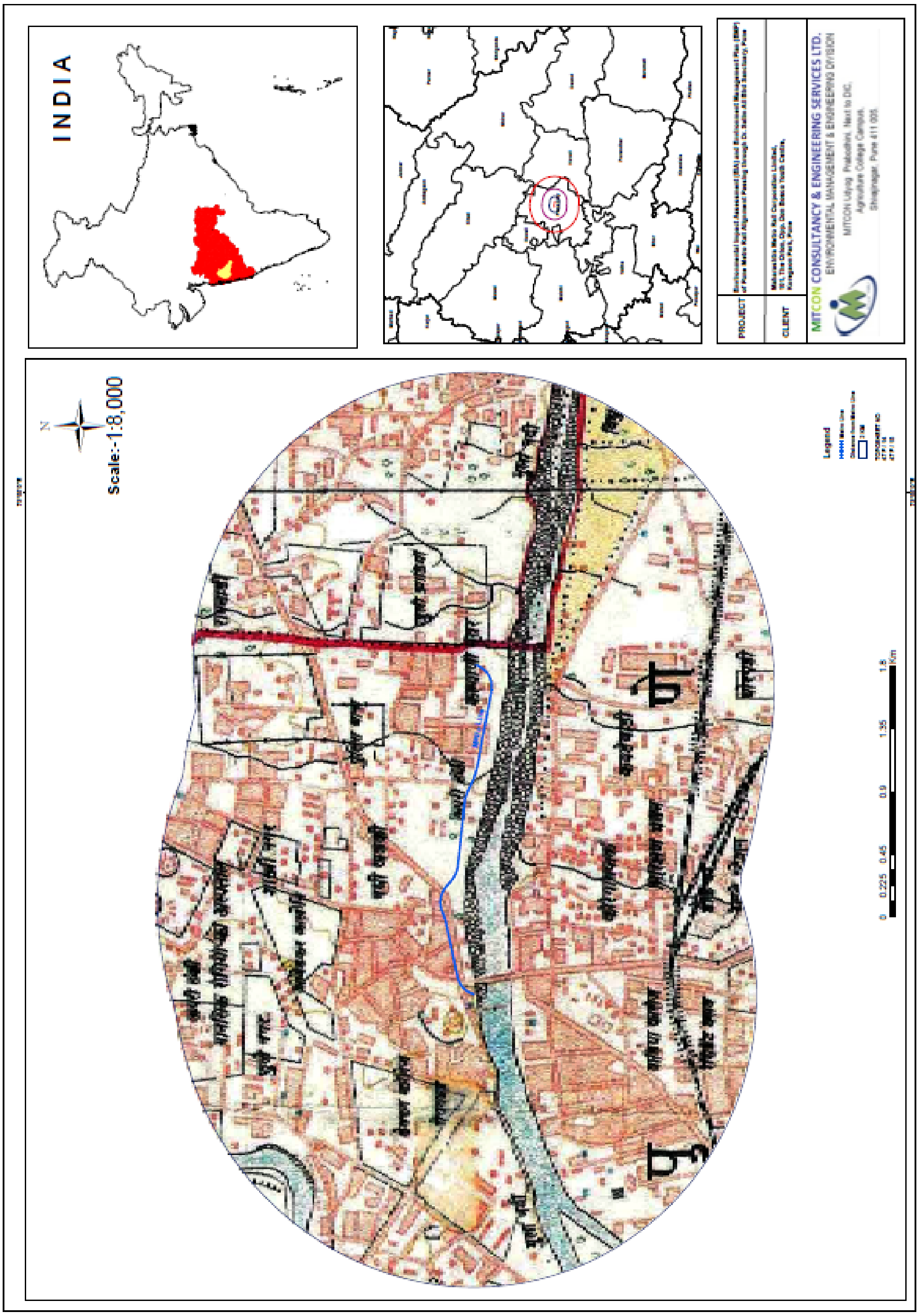


Figure 8.8. Toposheet Showing 10 km Radius Study Area

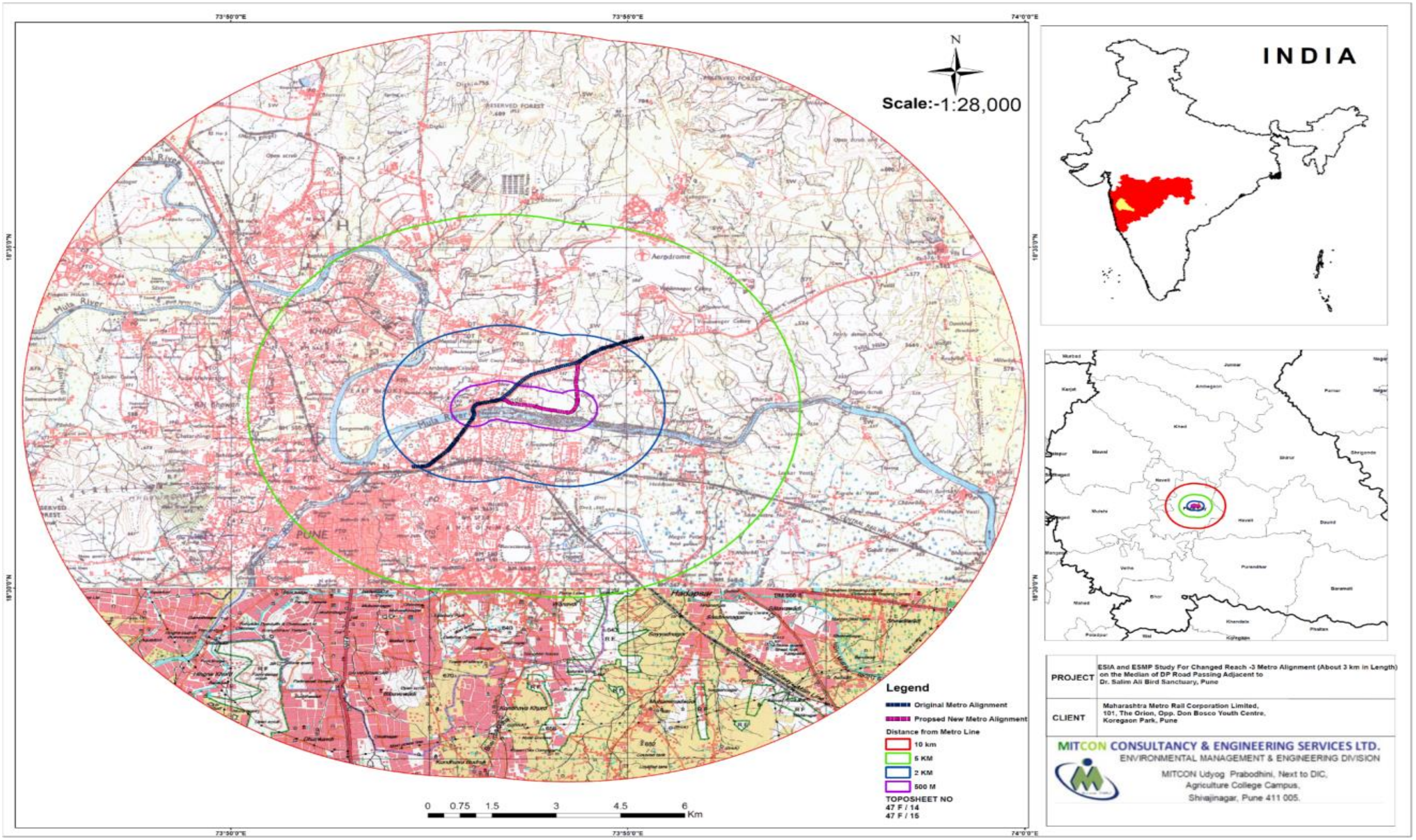


Table 8.3. Environmental & Infrastructure Setting of the Study Area

Sr. No.	Particulars	Details	Distance from project site (km)
1.	Project Location	Alternative Alignment passing adjacent to Dr. Salim Ali Bird Sanctuary	-
2.	Water Bodies	Mula Mutha River	0.07
3.	Roads	State Highway 27, Pune to Ahmednagar	Adjacent
4.	Railway station	Shivajinagar Rly station Pune Rly station	6.7 3.4
5.	Bridges crossing	Yerwada Bridge Bharat Ratna Dr Babasaheb Ambedkar Setu	1.2 1.5
6.	Nearest School/College	Vibgyor High School Yerwada S S English Medium School SNBP college Deccan college	1.5 5.8 2.8 7.1
7.	Nearest Hospital	Kataria hospital Amit hospital Shah Accidental hospital Sahyadri super specialty hospital	0.028 0.070 0.275 0.940
8.	Nearest Heritage site	Aga Khan Palace	0.48
9.	International Air port	Lohagaon	6.1

8.6.2. Environmental Parameters

Details of environmental parameters were monitored and their frequency is presented in table 8.4

Table 8.4. Environmental Parameters and Monitoring Details

SN	Components	Parameters	Details of Monitoring	Methodology adopted
1.	Meteorology	Wind speed and direction, temperature, relative humidity and rainfall	Data collected from IMD Pune and installed Automatic Weather Station	-
2	Ambient Air Quality	$PM_{2.5}$, PM_{10}, SO_2, NO_x and CO	Ambient air quality samples were monitored at 4 locations	$PM_{10}/PM_{2.5}$: Gravimetric method SO_2 : Modified West and Gaeke Method (IS : 5182, Part II) NOx : Jacobs and Hochheiser Method (IS 5182 Part VI) CO : CO analyzer / monitor

SN	Components	Parameters	Details of Monitoring	Methodology adopted
3	Noise Level	Noise levels in dB (A)	Samples were monitored at 5 locations	IS: 4954 as adopted by CPCB.
4	Water quality	Physical, Chemical and Biological parameters.	surface water 4 nos. were collected	Standard methods for Examination of Water and Wastewater' published by Amercian Public Health Association (APHA) & IS Method
5	Soil	Physico-chemical	Sampling at 4 locations	IS Method
6	Ecology & Biodiversity	Terrestrial flora, fauna & River ecology	Field survey conducted by frequent visits during the study period	Checklist Sampling & Analysis
7	Socio –economic aspects	Socio –economic characteristics of local population	Secondary data	Views and concerns obtained from the frequent discussion

8.6.3. Reconnaissance Survey Visit

The reconnaissance visit was conducted in first week of December 2018 with officials of Maha-Metro. During the visit, sampling sites were identified and finalized for monitoring of environmental parameters.

Figure 8.9. Photographs during baseline survey


07.02.2019 12:24


07.02.2019 11:00


07.02.2019 10:46


12.02.2019 12:30

8.6.4. Ambient Air Quality

The ambient air quality monitoring were carried out at four locations in the study area. The sampling station location and number were selected upstream, downstream side of this alignment and at Dr. Salim Ali Bird Sanctuary. The monitoring was carried out as per CPCB/ MoEF&CC guideline. Secondary information on ambient air quality was collected from Maharashtra Pollution Control Board (MPCB) for study period.

Ambient air quality of the study area has been assessed for two weeks, at four locations.

The concentrations of PM_{10}, $PM_{2.5}$, SO_2 and NO_X samples were collected as average by drawing air at the rate of 1.0 -1.5 m^3/min through glass fiber filter paper and analyzing by the gravimetric method. Pre-calibrated fine dust particulate samplers were used for monitoring of PM_{10} & $PM_{2.5}$. Concentrations of SO_2 and NO_X were analyzed by Modified West and Gaeke & Jacob & Hochheiser method respectively.

Table 8.5. Techniques followed for monitoring of Ambient Air Quality Parameters

Sr. No	Parameter	Technique	Technical Protocol
1	PM_{10} & $PM_{2.5}$	Gravimetric method	IS -5182 (Part-4)
2	Sulphur Dioxide	Modified West and Gaeke	IS-5182 (Part-2)

Sr. No	Parameter	Technique	Technical Protocol
3	Nitrogen Oxide	Jacob & Hochheiser	IS-5182 (Part-6)
4	Carbon Monoxide	CO analyzer / monitor	IS-5182 (Part-10)

Table 8.6. Ambient Air Quality Monitoring Locations

Sr. No.	Name of the Location	Latitude	Longitude
1	Dr. Salim Ali Bird Sanctuary	18° 32' 42.314" N	73° 53' 23.668" E
2	Yerwada Police Station	18° 32' 41.865" N	73° 53' 4.410" E
3	Ramwadi Jakat Naka	18° 33' 19.016" N	73° 54' 22.070" E
4	Kalyaninagar	18° 32' 36.014" N	73° 54' 17.376" E

Figure 8.10. Ambient Air Quality Monitoring Location Map

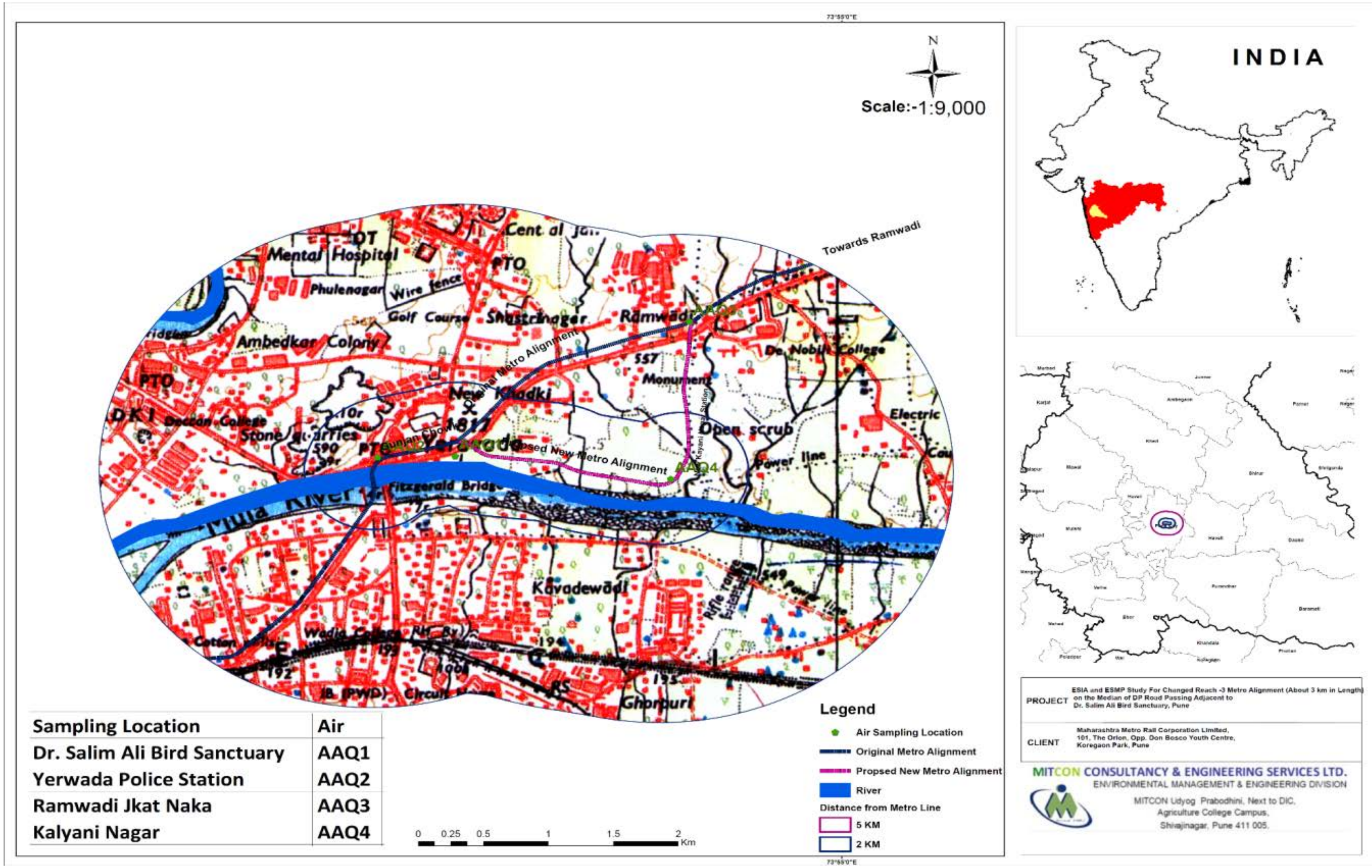


Table 8.7. Test Methods Used for Analysis of Ambient Air Parameter

Sr. No.	**Parameter**	**Unit**	**Test Method**
01	Nitrogen dioxide, NOx	µg/m^3	IS: 5182 (Part-IV) 2006, First Revision
02	Sulphur dioxide SO_2	µg/m^3	IS 5182 Part-II .2001 First Revision
03	Particulate Matter PM_{10}	µg/m^3	IS 5182 (Part 23) :2006 Reaff 2012
04	Particulate Matter $PM_{2.5}$	µg/m^3	USEPA (40 CFR Ch. I (7–1–14 Edition) Appendix L to Part 50)
05	Carbon Monoxide (CO)	mg/m^3	IS 5182 part 10-1974 Reaff 2014

Table 8.8. Results of Analysis of Ambient Air Parameter (µg/m3)

Parameter	Dr. Salim Ali Bird Sanctuary	Yerwada Police Station	Ramwadi Jakat Naka	Kalyaninagar	NAAQ Standards
PM_{10} µg/m^3	58.20	60.73	91.50	78.97	100
$PM_{2.5}$ µg/m^3	34.60	31.20	68.87	43.73	60
SO_2 µg/m^3	20.50	22.70	33.20	26.10	80
NO_2 µg/m^3	33.20	34.50	46.37	37.10	80
CO mg/m^3	0.30	0.33	0.87	0.63	4

Result:

Study revealed that concentration of PM_{10} was minimum at Dr. Salim Ali Bird Sanctuary (58.20 µg/m^3) & Maximum at Ramwadi Jakat Naka (91.50 µg/m^3). The concentration of $PM_{2.5}$ in the study area was minimum at Dr. Salim Ali Bird Sanctuary (31.20 µg/m^3) and maximum at Ramwadi Jakat Naka (68.87 µg/m^3).

Recorded values of SO_2, were minimum at Dr. Salim Ali Bird Sanctuary (20.50 µg/m^3) and maximum at Ramwadi Jakat Naka (33.20 µg/m^3). Observed values of NO_2, were minimum at Dr. Salim Ali Bird Sanctuary (33.20 µg/m^3) and maximum at Ramwadi Jakat Naka (46.37 µg/m^3). Similarly CO concentration was minimum at Dr. Salim Ali Bird Sanctuary (0.30 µg/m^3) and maximum at Ramwadi Jakat Naka (0.87 µg/m^3).

Ambient Air Quality was monitored at four different locations including Dr. Salim Ali Bird Sanctuary area. It is concluded that concentrations of PM_{10} and $PM_{2.5}$, were as higher sides to approaches towards NAAQ standards due to vehicular pollution. However, the level of SO_2 and NO_2, were substantially less as compared to above referend standard. Air quality inside the Dr. Salim Ali Bird Sanctuary is comparatively good.

However, all the concentrations of PM_{10}, $PM_{2.5}$, SO_2, NO_2, and CO were found well within standards of NAAQ at all stations except $PM_{2.5}$ at Ramwadi Jakat Naka.

8.6.5. Ambient Noise Level

Methodology of Noise Level Monitoring

Noise levels monitoring was carried out at five locations (Table 8.9) within the study area. Ambient Noise Level monitoring at various location has been carried out as per standard guidelines of MoEF&CC and CPCB (IS 4954, 1968 Reaff 2014).

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). In this monitoring, the maximum & minimum values of noise levels were monitored at each locations and presented in table 8.9

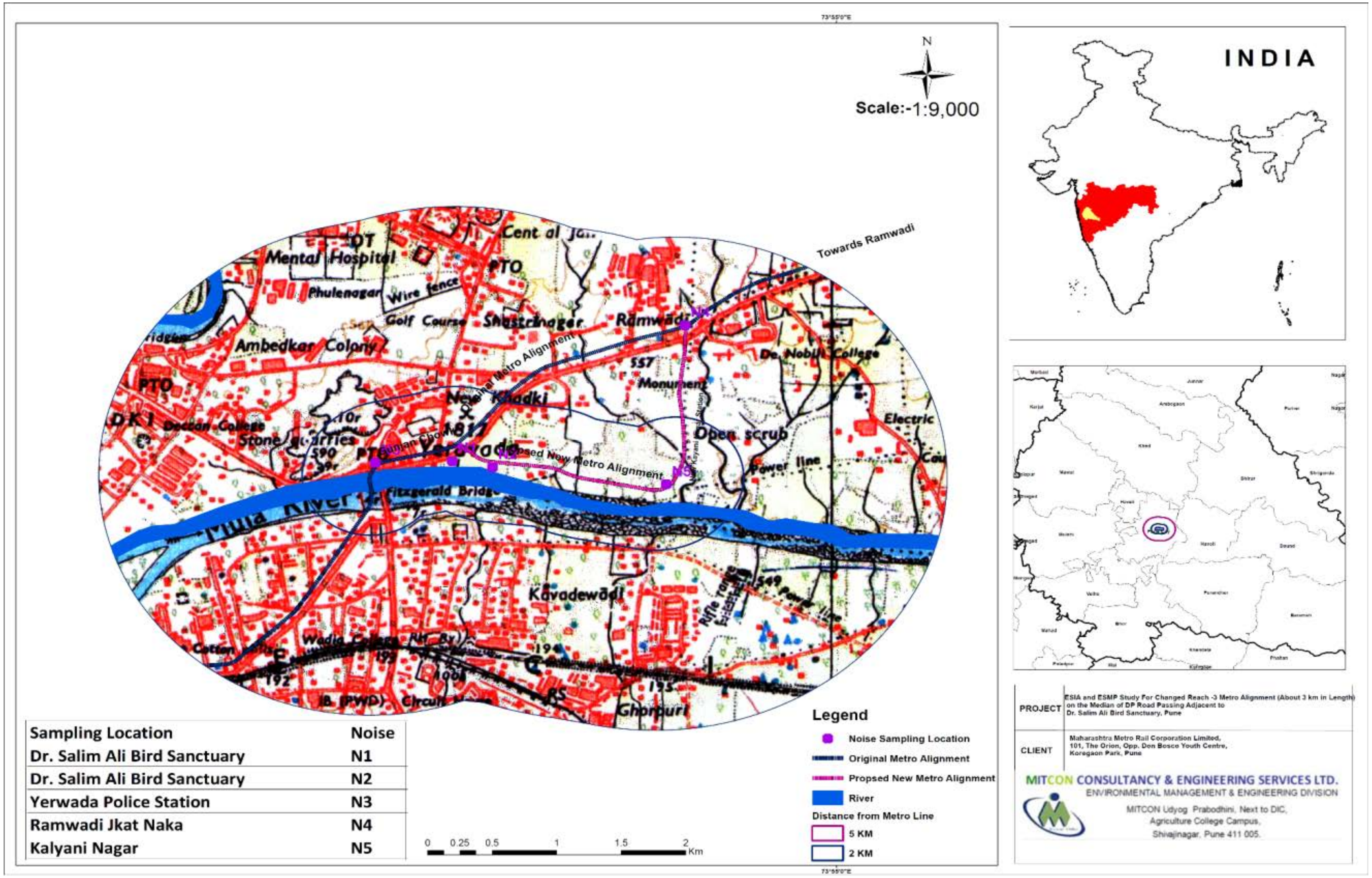
Table 8.9. Ambient Noise Level Monitoring Locations

Sr. No.	Name of the Location	Category of Area/ Zone	Latitude	Longitude
1	Dr. Salim Ali Bird Sanctuary	Commercial Zone	18° 32' 42.314" N	73° 53' 23.668" E
2	Dr. Salim Ali Bird Sanctuary	Commercial Zone	18° 32' 40.72" N	73° 53' 33.21" E
3	Yerwada Police Station	Commercial Zone	18° 32' 41.865" N	73° 53' 4.410" E
4	Kalyaninagar	Commercial Zone	18° 32' 36.014" N	73° 54' 17.376" E
5	Ramwadi Jakat Naka	Commercial Zone	18° 33' 19.016" N	73° 54' 22.070" E

Table 8.10.Results of Analysis of Ambient Noise Level at various locations

Monitoring Locations	Day		Night	
	L_{Max}	L_{Min}	L_{Max}	L_{Min}
Dr. Salim Ali Bird Sanctuary	66	42	52	40
Dr. Salim Ali Bird Sanctuary	60	40	48	37
Yerwada Police Station	77	84	62	53
Ramwadi Jakat Naka	83	68	72	53
Kalyaninagar	76	82	64	48

Figure 8.11. Ambient Noise Level Monitoring Location Map



Noise Pollution Standards in India

The Schedule of Noise Pollution (Regulation and Control) Rules 2001 amendment 2002, 2006 are followed.

Table 8.11.Ambient Air Quality standards in respect of Noise

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

Note:

- Day time shall mean 6.00 a.m. to 10.00 p.m.
- Night time shall mean from 10.00 p.m. to 6.00.a.m.
- Silence zone is defined as an area comprising not less than 100 meters around hospitals, educational institutions and courts. The silent zones are zones which are declared as such by the competent authority.
- 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,

Source: Ministry of Environment & Forests, Government of India vide 'The Noise Pollution (Regulation and Control) Rules, 2000.

Noise levels at different Locations

Monitoring Locations	Day			Night		
	L_{Max}	L_{Min}	Leq	L_{Max}	L_{Min}	Leq
Karve road	72	63	68.58	65	56	62.02
Pimpari Chnichwad	72	61	67.48	64	54	60.54
Swargate	68	52	65.40	65	57	61.24
Nalstop	73	68	70.67	67	61	64.35
Khadaki Rly Station	70	62	66.66	62	57	60.01
Agriculture University	70	62	67.09	64	58	61.95
Law College	67	55	62.62	62	53	58.33

(Source: Final Detailed Project Report for Pune Metro November 2015)

Ambient Noise Level were monitored at five different location including Dr. Salim Ali Bird Sanctuary. Noise levels recorded at various stations were higher than the permissible level. In the Dr. Salim Ali Bird Sanctuary Nosie level almost equivalent to Ambient Air Quality standards in respect of Noise.

8.6.6. Water Quality Study

River water sampling locations were selected at upstream, along the alignment and downstream of the alternative alignment.

Methodology

- The surface and ground water sampling was carried out by using central pollution control board (CPCB) guidelines.
- A sample container was properly cleaned and rinsed with sample for three times before it was filled.
- Sample containers were labeled properly and sample code, sampling date and sample location was clearly marked on container.
- Surface water samples were collected from well mixed section of stream about 30 cm below the water surface using a weighted bottle.
- Water samples from various locations in and around the project site were collected for assessment of the physico-chemical and bacteriological quality.

Table 8.12.Surface Water Sampling Locations

SN	Name of the Location	Type	Latitude	Longitude
1	Bund Garden Bridge u/s (About 200 m from Alignment)	Mula Mutha River	18° 32' 36.543" N	73° 53' 6.600" E
2	Along Proposed Metro Alignment (u/s of Salim Ali Sanctuary)	Mula Mutha River	18° 32' 38.984" N	73° 53' 26.387" E
3	Along Proposed Metro Alignment (d/s of Salim Ali Sanctuary)	Mula Mutha River	18° 32' 34.359" N	73° 53' 45.018" E
4	Kalyaninagar Bridge d/s (About 250 m from Alignment)	Mula Mutha River	18° 32' 27.292" N	73° 54' 14.443" E

Figure 8.12. Surface Water Sampling Location Map

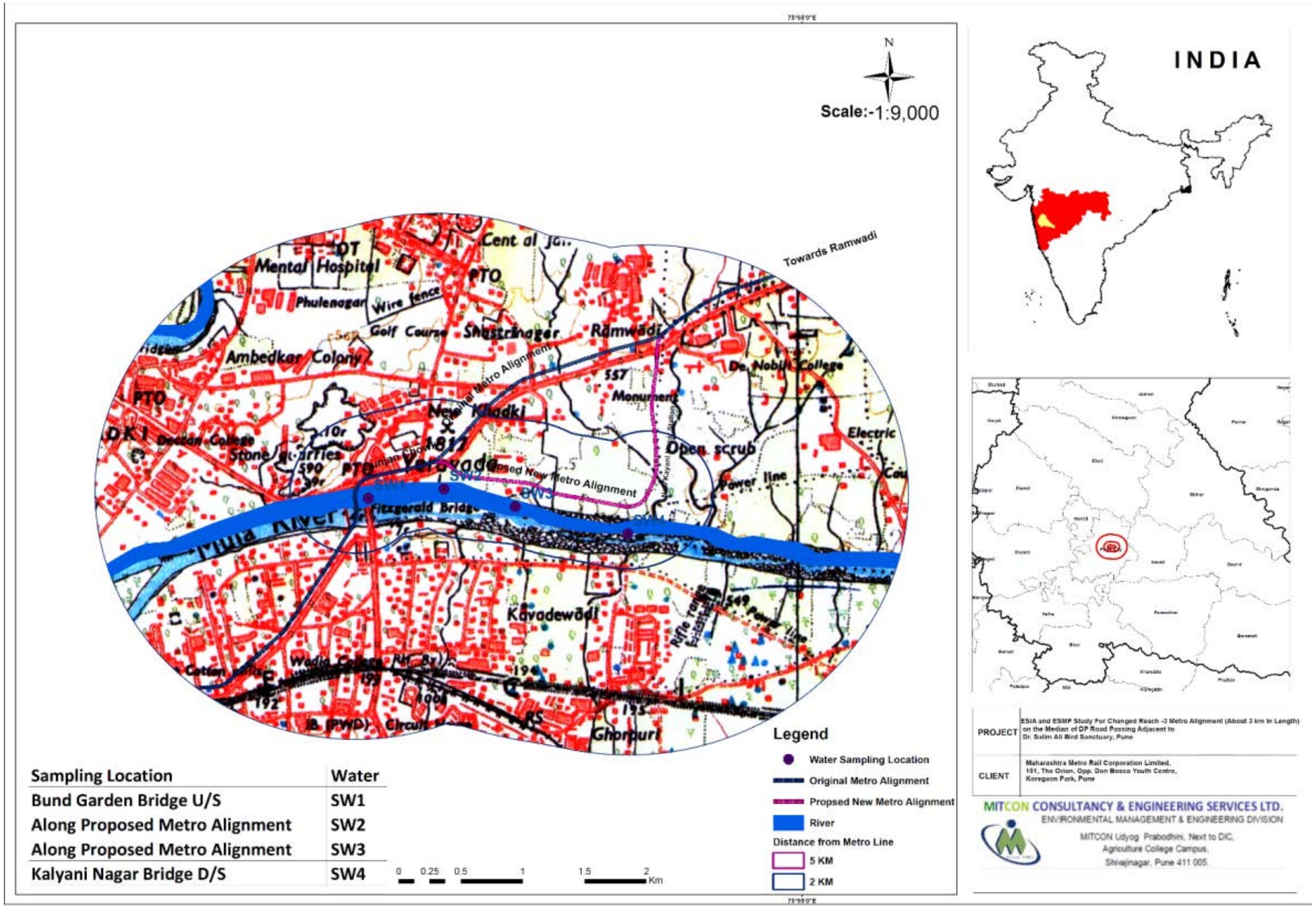


Table 8.13.Methods Used for Surface Water Parameter

Sr. No	Parameter	Unit	Method	IS 10500 :2012	Inland Surface Water
1	Colour	HZ	IS: 3025 Part-4 (Rev.1,R.A:2012)	N.S	-
2	Odour	-	IS: 3025 Part-5 (Rev.1,R.A:2012)	N.S	-
3	pH	-	APHA 4500 H+,a, 4-91,22nd Ed.2012	6.5-8.5	5.5-9.0
4	Temp	OC	APHA 2550 B, 2-69 to 2-70 22ne Ed.	N.S	-
5	EC	µS/cm	APHA 2510 B, 2-54 to 2-55 22 nd Edition	N.S	-
6	Turbidity	NTU	IS: 3025 Part-10 (Rev.1,R.A: 2012)	<1	-
7	TDS	mg/l	APHA 2540 C, 2-65,22nd Ed.2012	<500	-
8	Total solids	mg/l	APHA 2540 B, 2-65, 22nd Ed. 2012	N.S	-
9	TSS	mg/l	IS 3025 (part 17)-1984 (Rev.1,R.A:2012)	N.S	<100
10	BOD	mg/l	IS 3025 (part 44)-1993 (Rev.1,R.A:2012)	N.S	<30
11	COD	mg/l	IS 3025 (Part 58)-2006 (Rev.1,R.A: 2012)	N.S	<250
12	Dissolved Oxygen	mg/l	IS 3025 (Part 38)- 1989 (RA 2014)	N.S	-
13	Acidity	mg/l	IS 3025 (Part22): 1986 (Rev.1,R.A:2014)	N.S	-
14	Alkalinity	mg/l	APHA 2320 B, 2-34, to 2-35,22 nd ed 2012	<200	-
15	Carbonate	mg/l	APHA 2320 B, 2-34, to 2-35,22 nd ed 2012	N.S	-
16	Bicarbonate	mg/l	APHA 2320 B, 2-34, to 2-35,22 nd ed 2012	N.S	-
17	Total Hardness	mg/l	APHA 2340 C, 2-44 to 2-46 ,22nd Ed-2012	<200	-
18	calcium	mg/l	APHA 3500 Ca B, 3-67 to 3-68,22 nd Ed.2012	<75	-
19	Magnesium	mg/l	APHA 3500 Mg B, 3-84, 22 nd Ed.2012	<30	-
20	Chloride	mg/l	APHA 4500 H+,a, 4-91,22nd Ed.2012	<250	-
21	Sulphate	mg/l	APHA 4500-E SO4, 4-190 to 4-191,22 nd Ed.2012	<200	-
22	Nitrate	mg/l	APHA 4500 NO3- B 22nd Ed.2012	<45	-

Sr. No	Parameter	Unit	Method	IS 10500 :2012	Inland Surface Water
23	Nitrite	mg/l	IS 3025 (Part 34) 9088	N.S	-
24	Ammonical Nitrogen	mg/l	APHA 4500 NH3 F,4-116,22nd edition	N.S	<50
25	TKN	mg/l	APHA 4500 N org.	N.S	<100
26	Fluoride	mg/l	APHA 4500 F-D 4-87 to 4-88 22nd Ed.2012	<1	<2
27	Total Phosphorous	mg/l	APHA 4500 P-C, 4-153 to 4-154,22nd Ed2012	N.S	<5
28	Slica	mg/l	APHA 4500 SIO 2 C, 4-167 to 4-167 to 4-168	N.S	-
29	Sodium	mg/l	APHA 3111 B, 3-18 to 3-22, 22ndEd.2012. (using AAS)	N.S	-
30	Potassium	mg/l	APHA 3111 B, 3-18 to 3-22 22nd Ed 2012(using AAS)	N.S	-
31	Hexavalent chromium	mg/l	APHA 3500 cr .B, 3-69 to 3-70 22 nd Edition	N.S	<0.1
32	Fe	mg/l	APHA 3111B.3-18 TO 3-22, 22nd Ed 2012 using AAS	<0.3	<3
33	Cu	mg/l	APHA 3111 B, 3-18 to 3-22 22nd Ed.2012,(using AAS)	<0.05	<3
34	Zn	mg/l	APHA 3111 B, 3-18 to 3-21 22nd Ed 2012 (using AAS)	<5	<5
35	Ni	mg/l	APHA 3111b, 3-18 to 3-22 22nd Ed 2012.(using AAS)	<0.02	<3
36	B	mg/l	APHA 4500 B-C 4-27, 22nd Ed.2012	<0.5	-

Surface Water Quality

Table 8.14. Physico-chemical Characteristics of Surface Water

Parameter	Location/ Unit	Bund Garden Bridge U/S Mula Mutha River		Along the Proposed Metro Alignment Mula Mutha River		Along the Proposed Metro Alignment Mula Mutha River		Kalyaninagar Bridge D/S Mula Mutha River	
		12/1/2019	**7/2/2019**	**12/1/2019**	**7/2/2019**	**12/1/2019**	**7/2/2019**	**12/1/2019**	**7/2/2019**
Colour	HZ	<5	<5	<5	<5	<5	<5	<5	<5
Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
pH	-	7.88	7.54	7.76	7.72	7.57	7.68	7.66	7.62
Temp	^{O}C	23	23	23	23	23	23	23	23
EC	µS/cm	530.6	567.6	536	590.8	514.1	568.3	683	601.4
Turbidity	NTU	3.8	4	4.5	4.1	3.3	3.5	3.1	3
TDS	mg/l	383	427	398	431	390	424	417	439
Total solids	mg/l	395	456	415	453	412	451	431	458
TSS	mg/l	12	29	17	22	22	27	14	19
BOD	mg/l	19	19	18	27	16	21	20	24
COD	mg/l	64	70	64	90	58	77	68	70
Dissolved Oxygen	mg/l	1.8	1.4	1.9	1.3	1.5	1.1	2.1	1.2
Acidity	mg/l	<5	<5	<5	<5	<5	<5	<5	<5
Alkalinity	mg/l	180.79	179.78	175.74	185.84	170	183.82	161.6	181.8
Bicarbonate	mg/l	180.79	179.78	175.74	185.84	170	183.82	161.6	181.8
Total Hardness	mg/l	150.12	164.13	156.12	152.12	148.11	164.13	164.13	156.12
Calcium	mg/l	37.67	43.28	39.27	41.68	42.48	44.88	46.49	41.68
Magnesium	mg/l	13.61	13.61	14.09	11.66	10.21	12.64	11.66	12.64
Chloride	mg/l	48.56	47.98	50.5	45.98	42.73	46.98	57.79	49.98

Parameter	Location/ Unit	Bund Garden Bridge U/S Mula Mutha River		Along the Proposed Metro Alignment Mula Mutha River		Along the Proposed Metro Alignment Mula Mutha River		Kalyaninagar Bridge D/S Mula Mutha River	
		12/1/2019	**7/2/2019**	**12/1/2019**	**7/2/2019**	**12/1/2019**	**7/2/2019**	**12/1/2019**	**7/2/2019**
Sulphate	mg/l	22.06	19.07	20.1	31.44	28.04	22.16	24.94	20.61
Nitrate	mg/l	<1	5.15	1.28	<1	<1	<1	<1	1.65
Nitrite	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ammonical Nitrogen	mg/l	0.38	1.95	0.78	1.34	0.68	1.2	0.54	1.96
TKN	mg/l	1.82	2.13	0.92	1.72	0.89	1.52	0.78	2.12
Fluoride	mg/l	<0.1	0.35	<0.1	0.48	<0.1	0.58	<0.1	0.42
Total Phosphorous	mg/l	1.23	2.92	<1	2.17	<1	3.03	<1	2.01
Slica	mg/l	9.66	8.04	11.48	7.48	7.5	6.34	8	9.49
Sodium	mg/l	28	23	25	22	24	26	32	27
Potassium	mg/l	3	2	4	3	2	3	3	2
Hexavalent chromium	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fe	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cu	mg/l	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Zn	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ni	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
B	mg/l	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04

Observations:

The observed pH values were from 7.54-7.88 indicating water is slightly alkaline.

The electrical conductivity was highest (683 µS/cm) at Kalyaninagar Bridge and minimum (514.1µS/cm) near the Dr. Salim Ali Bird Sanctuary. The BOD ranged from 16- 27 mg/l while COD ranged from 58 -90 mg/l.

The DO values indicate the degree of pollution in water bodies. DO values varied from 1.1 to 2.1 mg/lit. All the sampling locations of Mula Mutha River showed low DO values indicating heavy contamination by organic matter.

Total Alkalinity ranged from 161.6 to 185.84 mg/l. Maximum calcium 46.49 mg/l was found at Kalyani nagar while minimum 39.27 mg/l at Bund garden. Total hardness ranged from 148.11 to 164.13 mg/l.

While chloride concentration fluctuated between 42.73 and 57.79 mg/l, ammonical nitrogen ranged from 0.38 to 1.96 mg/l.

The total phosphorus was highest (3.03 mg/l) along Metro alignment, the maximum (32 mg/l) concentration of sodium was highest at Kalyani nagar.

8.6.7. Soil Quality

Soil is the naturally occurring, unconsolidated or loose covering on the Earth's surface. This is composed of particles of broken rock that have been altered by physical, chemical, biological and environmental processes including weathering and erosion.

Procedure for Soil Sampling

Selection of the sampling stations were based on the reconnaissance visit of the entire study area

The following standard method is used for the collection of soil samples

- A small tool called "*Khurpi*" was used for sample collection.
- Sampling were taken from the surface to plough depth up to 0 -22 cm at 15 spots in the field of uniform nature.
  - Locations such as recently fertilized, old bunds, marshy spots, near trees, compost heaps and farm sheds etc. were avoided at the time of sampling.
  - Each collected Sample was a uniformly thick 2cm slice of soil from the exposed soil face V- shaped hole.
  - Information sheet on each sample was filled out completely.

- Collected soil samples were delivered to the laboratory for physical and chemical analysis.

Table 8.15.Soil Sampling Locations

Sr. No.	Name of the Location	Latitude	Longitude
1	Bund Garden Park	18° 32' 28.895" N	73° 53' 0.584" E
2	Along Proposed New Metro Alignment	18° 32' 43.358" N	73° 53' 29.905" E
3	Dr. Salim Ali Bird Sanctuary	18° 32' 38.626" N	73° 53' 41.419" E
4	Near Ramwadi Jakat Naka	18° 33' 6.251" N	73° 54' 23.641" E

Figure 8.13. Soil Sampling Location Map

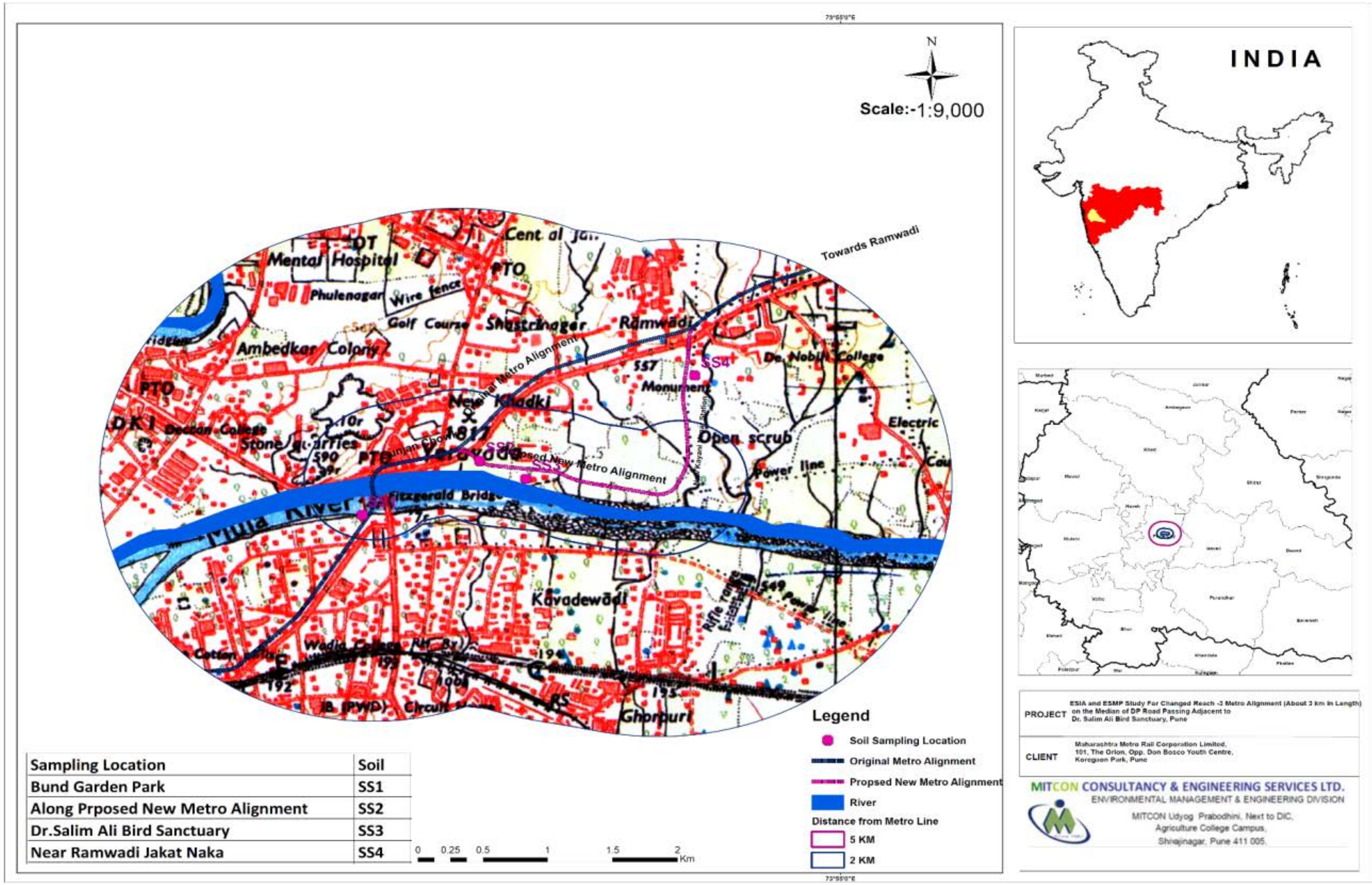


Table 8.16.Test Methods Used for Soil Quality Analysis

Sr. No.	Parameters	Unit	Test Method
01	Texture	-	EME/SOP/SOIL/Texture
02	Percentage Of Different Components Sand Silt Clay	%	EME/SOP/SOIL/Texture
03	Soil Moisture	%	IS 27720 Part II 1973
04	Bulk Density	g/cm^3	EME/LAB/SOIL/Bulk Density.
05	Water Holding Capacity	%	EME/LAB/SOIL/Water Holding Capacity.
06	pH	-	IS 27720 (Part 26) 1987,Rev.2,Reaff.2011
07	Conductivity	µS/cm	IS 14767, 2000, Reaff.2016
08	Organic Carbon	%	Part 2(90-3) C.A. Black American society of Agronomy,1965
09	Calcium (as Ca)	mg/kg	EME/LAB/SOIL/CALCIUM
10	Magnesium (as Mg)	mg/kg	EME/LAB/SOIL/Magnesium
11	Available Nitrogen	Kg/ha	EME/LAB/SOIL/Available Nitrogen
12	Phosphorous (as P)	Kg/ha	EME/LAB/SOIL/Phosphate
13	Potassium (as K)	Kg/ha	EME/LAB/SOIL/Potassium
14	Iron (as Fe)	mg/kg	EME/LAB/SOIL/Micronutrients/AAS
15	Zinc (as Zn)	mg/kg	EME/LAB/SOIL/Micronutrients/AAS
16	Copper (as Cu)	mg/kg	EME/LAB/SOIL/Micronutrients/AAS
17	Sodium	mg/kg	EME/LAB/SOIL/Micronutrients/AAS
18	Manganese (as Mn)	mg/kg	EME/LAB/SOIL/Micronutrients/AAS
19	Total Chromium (as Cr)	mg/kg	EME/LAB/SOIL/Micronutrients/AAS
20	Nickel (as Ni)	mg/kg	EME/LAB/SOIL/Micronutrients/AAS
21	Cadmium (as Cd)	mg/kg	EME/LAB/SOIL/Micronutrients/AAS
22	Lead (as Pb)	mg/kg	Methods Manual Soil Testing in India, Page No.105-115
23	Sodium Adsorption Ratio	-	By calculation

Table 8.17.Physico-chemical Characteristics of Soil

Sr. No.	Parameter	Location/ Unit	Dr. Salim Ali Bird Sanctuary		Bund Garden Park		Along Proposed New Metro Alignment		Near Ramwadi Jakat Naka	
			12/1/2019	7/2/2019	12/1/2019	7/2/2019	12/1/2019	7/2/2019	12/1/2019	7/2/2019
1	Texture			Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay loam
2	% of different components									
	Sand	%	20	22	24	27	23	30	24	27
	Silt	%	28	30	33	32	31	35	33	34
	Clay	%	52	48	43	41	46	35	43	39
3	Soil moisture	%	11.5	9.8	7.8	9.2	12.4	11.8	10.12	8.8
4	Bulk density	g/cm^3	1.08	1.15	1.32	1.18	1.21	1.27	1.11	1.04
5	Water Holding capacity	%	55.2	50.2	60.2	56.1	54.2	53.7	50.2	54.2
6	pH	-	8.72	8.45	8.51	8.34	8.48	8.11	8.52	8.37
7	Conductivity	µS/cm	522.9	545.9	508.6	473.8	383.4	207.8	283.1	338.1
8	Organic carbon	%	0.72	0.62	0.42	0.5	0.62	0.7	0.55	0.63
9	Calcium	mg/kg	65.2	60.1	68.3	63.7	64.1	62.1	58.4	61.2
10	Magnesium	mg/kg	38.1	34.3	32.3	35.2	39.2	37.4	33.4	36.2
11	Available Nitrogen	Kg/ha	178.5	165.4	155.1	145.4	168.2	158.2	171.7	164.1
12	Phosphorous	Kg/ha	11.5	8.55	13.4	9.55	9.8	10.2	14.2	12.8
13	Potassium	Kg/ha	190.2	178.2	168.1	171.4	183.2	173.1	175.9	171.4
14	Iron	mg/kg	4.83	3.58	6.2	5.82	4.12	3.58	3.83	4.28
15	Zinc	mg/kg	0.34	0.45	0.28	0.37	0.21	0.33	0.25	0.38
16	Copper	mg/kg	0.48	0.42	0.22	0.28	0.33	0.31	0.39	0.37
17	Sodium	mg/kg	34.2	32.1	33.1	31.8	30.1	35.4	33.2	34.7
18	Manganese	mg/kg	0.48	0.52	0.42	0.38	0.78	0.64	0.48	0.52
19	Total chromium	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
20	Nickel	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
21	Cadmium	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
22	Lead	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
23	Sodium Absorption Ratio	-	4.76	4.67	4.66	4.52	4.19	5.02	4.94	4.97

Observations

Soil water samples from 4 representative areas were taken from sources near the alignments and described in Table 8.17.

The pH values ranged from 8.11 to 8.75. Electrical Conductivity was maximum at Dr. Salim Ali Bird Sanctuary (545.9 µs/cm) and minimum (207.8 µs/cm) along Metro alignment.

Organic carbon ranged from 0.42 to 0.72 %. Maximum Calcium of 68.3 mg/kg was found at Bund Garden Park. Minimum Calcium of 58.4mg/kg was found at Near Ramwadi Jakat Naka. Similarly, maximum Magnesium of 0.78 mg/kg was found at Metro Alignment and minimum magnesium (0.38 mg/kg) was found Bund Garden Park.

Nitrogen (178.5 kg/ha) was higher near Dr. Salim Ali Bird Sanctuary and lower (145.4 kg/ha) at Bund Garden Park. Phosphorous ranged from 8.55 to 14.2 kg/ha. Maximum concentration of Potassium (190.2 kg/ha) was found at Dr. Salim Ali Bird Sanctuary while minimum amount (168.1kg/ha) was found at Bund Garden Park.

Maximum concentration of Iron (6.2 kg/ha) was found at Bund Garden Park and minimum amount (3.58 kg/ha) was found at along proposed New Metro Alignment.

It is concluded that generaly the soils in the study area are moderate to highly fertile, while the same in the Dr. Salim Ali Bird Sanctuary were found to be fertile. These soils are favorable to nurture herbaceous flora as well arboreal flora in the project area.

8.6.8. Ecology and Biodiversity

8.6.8.1 Preamble

Ecology and biodiversity studies were conducted during December 2018 to February 2019

8.6.8.2 Floral Diversity

Individual species were identified including trees, shrubs and herbs by observing the species randomly from the study area. Primary data were generated by preparing a general checklist of the trees (Table 8.18) around stud area. Checklist of shrub and Herb presented in Table 8.19

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), *Pistia stratiotes* L. (Araceae), *Azolla pinnata* R.Br. ssp. Asiatica (Azollaceae) and *Lemna minor* L. (Lemnaceae) were recorded in Mula Mutha River during study period. Excessive growth of these weeds itself points out the increased nutrient levels in the water body. Likely to be affected trees are summarized in **Table 8.20**

Table 8.18.List of Tree diversity recorded in the study area

SRL	Botanical_Name	Common_Name	Family	Colour_of Flower	Origin
1	*Acacia auriculiformis A. cunh ex Benth.*	Earleaf Acacia	Mimosaceae	Golden Yellow	Exotic
2	*Acacia catechu (L.f.) Willd.*	Gum Arabic Tree	Mimosaceae	Pale Yellow	Indigenous
3	*Acacia farnesiana (Linn.) Willd.*	Sweet Acacia	Mimosaceae	Deep Yellow	Exotic
4	*Acacia ferruginea DC.*	Safed Khair	Mimosaceae	Pale Yellow	Indigenous
5	*Acacia horrida (Linn.) Willd.*	Robber Thorn Tree	Mimosaceae	White	Exotic
6	*Acacia leucophloea (Roxb.) Willd.*	White Bark Acacia	Mimosaceae	Pale Yellow	Indigenous
7	*Acacia mangium Willd.*	Vilayati Babhul	Mimosaceae	Yellow	Exotic
8	*Acacia nilotica (Linn.) Del.*	Babul	Mimosaceae	Bright Yellow	Indigenous
9	*Acacia polyacantha Willd.*	White Catechu	Mimosaceae	White	Indigenous
10	*Adansonia digitata Linn.*	Baobab Tree	Bombacaceae	White	Exotic
11	*Adenanthera pavonina Linn.*	Ratangunj	Mimosaceae	Pale Yellow	Exotic
12	*Adonidia merrillii Becc.*	Manilla Palm	Arecaceae	Green	Exotic
13	*Aegle marmelos (Linn.) correa*	Bael Tree	Rutaceae	Greenish-White	Indigenous
14	*Agathis robusta F.M.Bailey*	Agathis	Araucariaceae	NA	Exotic
15	*Ailanthus excelsa Roxb.*	Indian Tree Of Heaven	Simaroubaceae	Green	Indigenous
16	*Albizia julibrissin Durazz*	Silk Tree	Mimosaceae	Pink	Exotic
17	*Albizia lebbeck (Linn.) Benth.*	Indian Sirish	Mimosaceae	Pale Yellow	Indigenous
18	*Albizia procera (Roxb.) Benth.*	White Shirish	Mimosaceae	Yellowish-Green	Indigenous
19	*Albizia saman (Jacq.) Merr.*	Rain Tree	Mimosaceae	Pink	Exotic
20	*Alstonia macrophylla Wall ex G.Don*	Hard Alstonia	Apocynaceae	White	Indigenous
21	*Alstonia scholaris (Linn.)R.Br.*	Saptaparni	Apocynaceae	Greenish-White	Indigenous
22	*Anacardium occidentale Linn.*	Cashew Nut	Anacardiaceae	Pink	Exotic
23	*Annona muricata Linn.*	Soursop	Annonaceae	Green	Exotic
24	*Annona reticulata Linn.*	Bull's Heart	Annonaceae	Green	Exotic

SRL	Botanical_Name	Common_Name	Family	Colour_of Flower	Origin
25	*Annona squamosa Linn.*	Custard Apple	Annonaceae	Yellowish-Green	Exotic
26	*Aphanamixis polystachya (Wall.) Parker*	Rohitak	Meliaceae	Yellowish-Green	Indigenous
27	*Araucaria columnaris (G.Forst.) Hook.*	X-Mas Tree	Araucariaceae	NA	Exotic
28	*Areca catechu L.*	Areca Nut	Arecaceae	Greenish-Yellow	Indigenous
29	*Areca Concinna Thw.*	Pinanga Palm	Arecaceae	Yellowish-Green	Exotic
30	*Artocarpus altilis (Parkison) Fosberg*	Nirphanas	Moraceae	Greenish-Yellow	Exotic
31	*Artocarpus heterophyllus Lamk.*	Jackfruit	Moraceae	Green	Indigenous
32	*Averrhoa bilimbi Linn.*	Bilimbi	Oxalidaceae	Bluish-Pink	Exotic
33	*Averrhoa carambola Linn.*	Starfruit	Oxalidaceae	Bluish-Pink	Indigenous
34	*Azadirachta indica Juss.*	Neem	Meliaceae	White	Indigenous
35	*Balanites aegyptiaca (L.) Del.*	Desert Date	Balanitaceae	Green	Indigenous
36	*Barringtonia acutangula (Linn.) Gaertn.*	Tivar	Lecythidaceae	Dark Scarlet	Exotic
37	*Barringtonia racemosa (L.) Spreng.*	Fish-poison Tree	Lecythidaceae	Pink	Indigenous
38	*Bauhinia purpurea L.*	Orchid Tree	Caesalpiniaceae	Purple	Exotic
39	*Bauhinia racemosa Lamk.*	Apta	Caesalpiniaceae	Greenish-White	Indigenous
40	*Bauhinia tomentosa Linn.*	Yellow Bell Orchid Tree	Caesalpiniaceae	Yellow	Indigenous
41	*Beaucarnea recurvata Lem.*	Ponytail Palm	Asparagaceae	Creamy White	Exotic
42	*Bismarckia nobilis Hildebr & Wendle.*	Bismarckia Palm	Arecaceae	Greenish-Yellow	Exotic
43	*Bombax ceiba Linn.*	Silk Cotton Tree	Bombacaceae	Red	Indigenous
44	*Brassaia actinophylla Endl.*	Umbrella Tree	Araliaceae	Pink	Exotic
45	*Broussonetia papyrifera (Linn.) L'Herrit ex Vent*	Paper Mulberry	Moraceae	White	Exotic
46	*Brownea grandiceps Jacq.*	Rose Of Venezuela	Caesalpiniaceae	Red	Exotic
47	*Butea monosperma (Lamk.) Taub.*	Flame Of The Forest	Fabaceae	Red	Indigenous
48	*Caesalpinia ferrea C.Mart.*	Brazilian Ironwood Tree	Caesalpiniaceae	Green	Exotic
49	*Caesalpinia pulcherrima (Linn.) Sw.*	Peacock Flower	Caesalpiniaceae	Red	Exotic

SRL	Botanical_Name	Common_Name	Family	Colour_of Flower	Origin
50	*Callistemon citrinus (curtis) Skeels.*	Bottle Brush	Myrtaceae	Pink	Exotic
51	*Callitris columellaris Muell.*	White cypress pine	Cupressaceae	NA	Exotic
52	*Calophyllum inophyllum Linn.*	Sultan Champa	Clusiaceae	White	Indigenous
53	*Capparis divaricata Lam.*	Spreading Caper	Capparidaceae	Orange	Indigenous
54	*Caryota urens Linn.*	Fish Tail Palm	Arecaceae	Bright Green	Indigenous
55	*Cascabela thevetia (L.) Lippold*	Bitti	Apocynaceae	Yellow	Exotic
56	*Cassia biflora Mill.*	Twin Flowered Cassia	Caesalpiniaceae	Yellow	Exotic
57	*Cassia fistula Linn.*	Indian Laburnum	Caesalpiniaceae	Yellow	Indigenous
58	*Cassia glauca Lam.*	Scrambled Egg Bush	Caesalpiniaceae	Yellow	Exotic
59	*Cassia grandis L.f.*	Pink Shower	Caesalpiniaceae	Pink	Exotic
60	*Cassia javanica L.*	Java Cassia	Caesalpiniaceae	Yellow	Exotic
61	*Cassia renigera Benth.*	The Burmese Pink Cassia	Caesalpiniaceae	Pink	Exotic
62	*Cassia roxburghii DC.*	Red Shower Tree	Caesalpiniaceae	Red	Indigenous
63	*Casuarina equisetifolia L.*	Whistling Pine	Casuarinaceae	Pink	Exotic
64	*Ceiba pentandra (Linn.) Gaertn.fruct.*	Kapok Tree	Bombacaceae	Dirty-White	Indigenous
65	*Chorisia ventricosa Arruda ex Nees & Mart.*	Chorisia	Bombacaceae	Yellow	Exotic
66	*Chrysaldocarpus lutescens H.Wendl*	Areca Palm	Arecaceae	White	Exotic
67	*Cinnamomum tamala Nees & Ebern.*	Tejpata	Lauraceae	Yellow	Indigenous
68	*Citharexylum spinosum L.*	Fiddle Wood	Verbenaceae	White	Exotic
69	*Citrus aurantiifolia (christ.)Swingle*	Lemon	Rutaceae	White	Indigenous
70	*Citrus aurantium Linn..*	Orange	Rutaceae	White	Indigenous
71	*Citrus maxima (Burm.) Merr.*	Pomelo	Rutaceae	White	Indigenous
72	*Citrus medica L.*	Idlimbu	Rutaceae	White	Exotic
73	*Citrus sinensis (L.) Osbeck*	Sweet Lime	Rutaceae	White	Indigenous
74	*Clusia rosea Jacq.*	Balsam Tree	Clusiaceae	Pink	Exotic

SRL	Botanical_Name	Common_Name	Family	Colour_of Flower	Origin
75	*Cochlospermum religiosum (Linn.) Alston.*	Yellow Silk Cotton Tree	Cochlospermaceae	Yellow	Indigenous
76	*Cocos nucifera Linn.*	Coconut	Arecaceae	Green	Indigenous
77	*Cordia myxa Linn.*	Gunda	Boraginaceae	Green	Indigenous
78	*Cordia sebestena Linn.*	Scarlet Cordia	Boraginaceae	Scarlet	Exotic
79	*Cordia sinensis L.*	Grey Leaved Saucerberry	Boraginaceae	White	Exotic
80	*Couroupita guianensis Aubl.*	Cannon Ball Tree	Lecythidaceae	Pink	Exotic
81	*Crescentia cujete Linn.*	Calabash Tree	Bignoniaceae	Yellowish-Purple	Exotic
82	*Cryptomeria japonica (Thunb.ex L.f.) D.Don*	Japnese Cedar	Cupressaceae	NA	Exotic
83	*Cupressus macrocarpa Hartw.*	Monterey Cypress	Cupressaceae	NA	Exotic
84	*Cycas circinalis Roxb.*	Queen Sago	Cycadaceae	NA	Exotic
85	*Cycas revoluta Thunb.*	Sago Cycad	Cycadaceae	NA	Exotic
86	*Dalbergia lanceolaria Linn.f.*	Dandus	Fabaceae	White	Indigenous
87	*Dalbergia latifolia Roxb.*	Indian Rosewood	Fabaceae	Pink	Indigenous
88	*Dalbergia melanoxylon Guill. & Perr.*	African Black wood	Fabaceae	White	Exotic
89	*Dalbergia sissoo DC.*	Sesam	Fabaceae	Whitish-Green	Indigenous
90	*Delonix regia (Hook.) Raf.*	Gulmohar	Caesalpiniaceae	Pinkish-Red	Exotic
91	*Dillenia indica Linn.*	Elephant Apple	Dilleniaceae	White	Indigenous
92	*Dillenia pentagyna Roxb.*	Nepalese Elephant Apple	Dilleniaceae	Yellow	Indigenous
93	*Diospyros malabarica (Desr.) Kostel*	Jangali Chicko	Ebenaceae	Green	Indigenous
94	*Diospyros montana Roxb.*	Bistendu	Ebenaceae	Green	Indigenous
95	*Dypsis decaryi (Jum.)Beentje & J.Dransf.*	Triangular Palm	Arecaceae	Green	Exotic
96	*Ehretia laevis Roxb.*	Datrang	Ehretiaceae	White	Indigenous
97	*Elaeis guineensis Jacq.*	Oil Palm	Arecaceae	Green	Exotic
98	*Elaeocarpus sphaericus (Gaertn.) K.Schum*	Rudraksha	Elaeocarpaceae	Greenish-White	Indigenous
99	*Erythrina variegata L.*	Indian Coral Tree	Fabaceae	Red	Indigenous

SRL	Botanical_Name	Common_Name	Family	Colour_of Flower	Origin
100	*Eucalyptus globulus Labil.*	Nilgiri	Myrtaceae	White	Exotic
101	*Ficus amplissima Sm.*	Payar	Moraceae	Green	Indigenous
102	*Ficus auriculata Lour.*	Elephant Ear Fig	Moraceae	Greenish-Yellow	Exotic
103	*Ficus benghalensis Linn.*	Banyan Tree	Moraceae	Yellowish-Green	Indigenous
104	*Ficus benjamina L.*	Benjamin Fig	Moraceae	Yellowish-Green	Exotic
105	*Ficus carica Linn.*	Anjir	Moraceae	Yellowish-Green	Indigenous
106	*Ficus elastica Roxb. ex Hornem*	Indian Rubber Tree	Moraceae	Yellowish-Green	Exotic
107	*Ficus hispida L.f.*	Hairy Fig	Moraceae	Yellowish-Green	Indigenous
108	*Ficus microcarpa Linn.f.*	Chinese Banyan	Moraceae	Yellowish-Green	Indigenous
109	*Ficus natalensis Hochst. subs. Leprieurii (Miq.) Berg.*	Triangular Ficus	Moraceae	Green	Exotic
110	*Ficus racemosa L.*	Cluster Fig Tree	Moraceae	Green	Indigenous
111	*Ficus religiosa Linn.*	Pipal	Moraceae	Yellowish-Green	Indigenous
112	*Ficus rumphii Blume.*	Rumpf's Ficus Tree	Moraceae	Yellowish-Green	Indigenous
113	*Ficus virens Aiton*	White Fig	Moraceae	Yellowish-Green	Indigenous
114	*Filicium decipiens (Wight & Arn.) Thawaites*	Fern Tree	Sapindaceae	Yellowish-Green	Exotic
115	*Flacourtia montana Grahm.*	Governor's Plum	Flacourtiaceae	Greenish-Yellow	Indigenous
116	*Gardenia resinifera Roth.*	Dikemali	Rubiaceae	White	Indigenous
117	*Gliricidia sepium (Jacq.) Walp.*	Giripushpa	Fabaceae	Pink	Exotic
118	*Gmelina arborea Roxb.*	Shivan	Verbenaceae	Orange	Exotic
119	*Grevillea robusta A.Cunn. ex R.Br.*	Silver Oak	Proteaceae	Orange	Exotic
120	*Grewia tiliifolia Vahl.*	Dhaman	Tiliaceae	Yellow	Indigenous
121	*Guazuma ulmifolia Lamk.*	Bhadraksha	Sterculiaceae	Yellow	Indigenous
122	*Haldina cordifolia (Roxb.) Ridsdale*	Haldu	Rubiaceae	White	Indigenous
123	*Hardwickia binata Roxb.*	Anjan	Caesalpiniaceae	Yellowish-Green	Indigenous
124	*Heterophragma quadriloculare (Roxb.) K.Schum.*	Varas	Bignoniaceae	White	Indigenous

SRL	Botanical_Name	Common_Name	Family	Colour_of Flower	Origin
125	*Holoptelia integrifolia (Roxb.) Planch*	Indian Elm	Ulmaceae	Green	Indigenous
126	*Hyophorbe lagenicaulis (Baily) Moore.*	Hyophorbe Palm	Arecaceae	Green	Exotic
127	*Ixora parviflora Lamk.*	Lokhandi	Rubiaceae	White	Exotic
128	*Jacaranda mimosifolia D.Don*	Blue Jacaranda	Bignoniaceae	Blue	Exotic
129	*Jatropha curcas Linn.*	Jatropha	Euphorbiaceae	Greenish-Yellow	Exotic
130	*Jatropha multifida L.*	Coral Bush	Euphorbiaceae	Green	Exotic
131	*Joanesia princeps Vell.*	Boleira	Euphorbiaceae	Green	Exotic
132	*Khaya senegalensis (Desr.)A.Juss.*	African Mahogani	Meliaceae	Green	Exotic
133	*Kigelia africana (Lam.) Benth.*	Sausage Tree	Bignoniaceae	Red	Exotic
134	*Kleinhovia hospita Linn.*	Guest Tree	Sterculiaceae	Pink	Exotic
135	*Koelreuteria paniculata Laxm.*	Panicled Golden Raintree	Sapindaceae	Yellow	Exotic
136	*Lagerstroemia speciosa (Linn.)Pers.*	Pride Of India	Lythraceae	Rose Colored	Indigenous
137	*Lagerstroemia thorelii Gagnep.*	Chota Taman	Lythraceae	Light Pink	Indigenous
138	*Lawsonia inermis Linn.*	Heena	Lythraceae	White	Indigenous
139	*Leucaena leucocephala (Lamk.)De.wit.*	Subabul	Mimosaceae	Pale Yellow	Exotic
140	*Limonia acidissima L.*	Wood Apple	Rutaceae	Greenish-White	Indigenous
141	*Litchi chinensis Sonn.*	Litchi	Sapindaceae	Greenish-White	Indigenous
142	*Livistona chinensis (Jacq.) R. Br. Ex Mart.*	Fan Palm	Arecaceae	Greenish-White	Exotic
143	*Livistona rotundifolia (Lam.) Mart.*	Footstool Palm	Arecaceae	Green	Exotic
144	*Madhuca indica Gmel.*	Indian Butter Tree	Sapotaceae	Green	Indigenous
145	*Madhuca longifolia (Koenig) MacBr*	South Indian Mahua	Sapotaceae	Green	Indigenous
146	*Mangifera indica Linn.*	Mango	Anacardiaceae	Yellow	Indigenous
147	*Manilkara hexandra (Roxb.) Dubard.*	Ceylon Iron Wood Tree	Sapotaceae	Green	Indigenous
148	*Manilkara zapota (L.) P.Royen*	Sapodilla	Sapotaceae	White	Indigenous
149	*Markhamia lutea (Benth.) Schum.*	Markhamia	Bignoniaceae	Yellow	Exotic

SRL	Botanical_Name	Common_Name	Family	Colour_of Flower	Origin
150	*Melaleuca alternifolia (Maiden & Betche) Cheel*	Tea Tree	Myrtaceae	White	Exotic
151	*Melaleuca bracteata Muell.*	Black Tea Tree	Myrtaceae	White	Exotic
152	*Melia azedarach L.*	Bakneem	Meliaceae	Lilac	Indigenous
153	*Melia dubia Cav.*	Malabar Neem	Meliaceae	White	Indigenous
154	*Meyna spinosa Roxb.ex Link*	Muyna	Rubiaceae	Greenish-White	Indigenous
155	*Michelia alba DC.*	White Champaca	Magnoliaceae	White	Indigenous
156	*Michelia champaca Linn.*	Sonchapha	Magnoliaceae	Yellow	Indigenous
157	*Millettia peguensis Ali*	Moulmein Rosewood	Fabaceae	Blue	Exotic
158	*Millingtonia hortensis Linn.*	Indian Cork Tree	Bignoniaceae	White	Exotic
159	*Mimusops elengi Linn.*	Bakul	Sapotaceae	White	Indigenous
160	*Mitragyna parvifolia (Roxb.) Korth*	Kalam	Rubiaceae	Greenish-Yellow	Indigenous
161	*Morinda pubescens Sm.*	Bartondi	Rubiaceae	Greenish-White	Indigenous
162	*Moringa oleifera Lam.*	Drum Stick	Moringaceae	White	Indigenous
163	*Morus alba Linn.*	Mulberry	Moraceae	Green	Indigenous
164	*Morus indica L.*	Indian Mulberry	Moraceae	Green	Indigenous
165	*Muntingia calabura L.*	Singapor Cherry	Muntingiaceae	White	Exotic
166	*Murraya koenigii (L.) Spreng.*	Curry Leaf	Rutaceae	White	Indigenous
167	*Murraya paniculata (Linn.) Jack.*	Kunti	Rutaceae	White	Exotic
168	*Neolamarckia cadamba (Roxb.) Bosser*	Kadam	Rubiaceae	Orange	Indigenous
169	*Nyctanthes arbor-tristis Linn.*	Parijatak	Nyctaginaceae	White	Indigenous
170	*Oncoba spinosa forssk.*	Fried Egg Ttee	Flacourtiaceae	White	Exotic
171	*Parkia biglandulosa Wt. & Arn.*	Badminton Ball Tree	Mimosaceae	Green	Exotic
172	*Parkinsonia aculeata Linn.*	Jerusalem Thorn	Mimosaceae	Green	Exotic
173	*Peltophorum pterocarpum (DC.) Baker*	Copper Pod	Caesalpiniaceae	Bright Yellow	Exotic
174	*Persea americana Mill.*	Avacado	Lauraceae	Green	Exotic

SRL	Botanical_Name	Common_Name	Family	Colour_of Flower	Origin
175	*Phoenix roebelenii O'Brien*	Pygmy Date Palm	Arecaceae	Yellowish-Green	Indigenous
176	*Phoenix sylvestris Roxb.*	Wild Date Palm	Arecaceae	White	Indigenous
177	*Phyllanthus acidus (L.) Skeels*	Malay Gooseberry	Euphorbiaceae	Reddish	Indigenous
178	*Phyllanthus emblica Linn.*	Amla	Euphorbiaceae	Greenish-Yellow	Indigenous
179	*Pimenta dioica (Linn.) Merrill.*	All Spice Tree	Myrtaceae	White	Exotic
180	*Pisonia alba Spanoghe*	The Lettuce Tree	Nyctaginaceae	Green	Exotic
181	*Pithecellobium dulce (Roxb.)Benth.*	Manila Tamarind	Mimosaceae	Pale Yellow	Exotic
182	*Platycladus orientalis (L.) Franco*	Morpankhi	Cupressaceae	NA	Exotic
183	*Plumeria alba Linn.*	Safed Chapha	Apocynaceae	White	Exotic
184	*Plumeria obtusa Linn.*	Chapha (O)	Apocynaceae	White	Exotic
185	*Plumeria rubra Linn.*	Red Chapha	Apocynaceae	Pure White	Exotic
186	*Plumeria rubra Linn. forma tricolor (Roem. & Schult)*	Chapha (T)	Apocynaceae	Whitish-Pink	Exotic
187	*Podocarpus elongatus (Aiton) L'H'er. ex Pers.*	Podocarpus	Podocarpaceae	NA	Exotic
188	*Polyalthia longifolia (sonnerat) Thwaites*	Ashoka	Annonaceae	Yellowish-Green	Exotic
189	*Polyalthia longifolia var.angustifolia*	Ashoka (M)	Annonaceae	Yellowish-Green	Exotic
190	*Polyalthia longifolia var.pendula*	Ashoka (D)	Annonaceae	Yellowish-Green	Exotic
191	*Pongamia pinnata (L.) Pierre*	Pongam Tree	Fabaceae	Pinkish-White	Indigenous
192	*Populus deltoides Marshall*	Populas Tree	Salicaceae	Green	Exotic
193	*Pouteria campechiana (Kunth.) Baehni*	Canistel	Sapotaceae	Green	Exotic
194	*Pritchardia pacifica Seems. & Wendl.*	Pritchardia Palm	Arecaceae	Greenish-Yellow	Exotic
195	*Prosopis juliflora (Sw.)Dc.*	Mesquite	Mimosaceae	Yellowish-Green	Exotic
196	*Psidium gaujava L.*	Guava	Myrtaceae	White	Indigenous
197	*Pterospermum acerifolium (L.) Willd.*	Kanak Champa	Sterculiaceae	White	Indigenous
198	*Pterygota alata (Roxb.) R.Br.*	Budda's Coconut	Sterculiaceae	Red	Indigenous
199	*Punica granatum L.*	Pomegranate	Punicaceae	Red	Indigenous

SRL	Botanical_Name	Common_Name	Family	Colour_of Flower	Origin
200	*Putranjiva roxburghii Wall.*	Lucky Bean Tree	Euphorbiaceae	Green	Indigenous
201	*Roystonea regia (Kunth) O.F.Cook*	Bottle Palm	Arecaceae	Pink	Exotic
202	*Salix tetrasperma Roxb.*	Salix	Salicaceae	Yellow	Indigenous
203	*Santalum album Linn.*	Sandalwood	Santalaceae	Brownish-Purple	Indigenous
204	*Sapindus trifoliatus L.*	Phenil	Sapindaceae	Yellowish-Green	Indigenous
205	*Saraca asoca (Roxb.) Willd.*	Ashok	Caesalpiniaceae	Red	Indigenous
206	*Schleichera oleosa (Lour.) Merr.*	Ceylon Oak	Sapindaceae	Yellowish-White	Indigenous
207	*Senna siamea (Lam.) Irwin & Barneby*	Siamese Cassia	Caesalpiniaceae	Bright Yellow	Indigenous
208	*Senna spectabilis (DC.) Irwin & Barneby*	Golden Cassia	Caesalpiniaceae	Yellow	Exotic
209	*Spathodea campanulata Beauv.*	Fountain Tree	Bignoniaceae	Red	Exotic
210	*Spondias pinnata (Linn.f.)Kurz.*	Ambada	Anacardiaceae	Green	Indigenous
211	*Sterculia foetida Linn.*	Devil's Tree	Sterculiaceae	Redish-Orange	Exotic
212	*Streblus asper Lour.*	Sand Paper Tree	Moraceae	Green	Indigenous
213	*Swietenia macrophylla King.*	Bigleaf Mahogani	Meliaceae	Greenish-Yellow	Indigenous
214	*Swietenia mahagoni (L.) Jacq.*	Mahogai	Meliaceae	Greenish-Yellow	Indigenous
215	*Syzygium cumini (Linn.)Skeels.*	Jamun	Myrtaceae	Dirty-White	Indigenous
216	*Syzygium jambos (Linn.) Alston.*	Water Apple	Myrtaceae	White	Indigenous
217	*Syzygium samarangens (Blume) Merr. & Perry*	Jamb	Myrtaceae	White	Indigenous
218	*Tabebuia aurea (Silva Manso) Benth. & Hook.f.ex S.Moore*	Yellow Tabebuia	Bignoniaceae	Yellow	Exotic
219	*Tabebuia pallida (Lindl.) Miers*	Cuban Pink Trumpet Tree	Bignoniaceae	White	Exotic
220	*Tabebuia pentaphylla (Linn.) Hemsi*	Pink Tecoma	Bignoniaceae	Pink	Exotic
221	*Tabebuia rosea (Bartol.) DC.*	Pink Truphet Tree	Bignoniaceae	Pink	Exotic
222	*Tamarindus indica Linn.*	Tamarind	Caesalpiniaceae	Yellowish-Green	Indigenous
223	*Tecoma alata DC.*	Orange Bell	Bignoniaceae	Orange	Exotic
224	*Tecoma stans (L.) Juss.ex Kunth*	Yellow Bells	Bignoniaceae	Yellow	Exotic

SRL	Botanical_Name	Common_Name	Family	Colour_of Flower	Origin
225	*Tectona grandis Linn.f.*	Teak Wood Tree	Verbenaceae	Yellowish-Green	Indigenous
226	*Terminalia arjuna (Roxb.) Wt. & Arn.*	Arjun	Combretaceae	Green	Indigenous
227	*Terminalia bellirica (Gaertn.) Roxb.*	Behada	Combretaceae	Greenish-Yellow	Indigenous
228	*Terminalia catappa Linn.*	Indian Almond	Combretaceae	Green	Indigenous
229	*Terminalia chebula Retz.*	Chebulic Myrobalan	Combretaceae	Greenish-Yellow	Indigenous
230	*Terminalia mantaly H.Perrier*	China Almond Tree	Combretaceae	Green	Exotic
231	*Thespesia populnea (L.)Soland ex.Correa*	Indian Tulip Tree	Malvaceae	Yellow	Indigenous
232	*Trema orientalis (Linn.) Bl.*	Indian Charcoal Tree	Ulmaceae	Green	Exotic
233	*Vitex nigundo L.*	Chaste Tree	Verbenaceae	White	Indigenous
234	*Wodyetia bifurcata A.K.Irvine*	Fox Tail Palm	Arecaceae	White	Exotic
235	*Ziziphus jujuba Mill.*	Indian Jujube	Rhamnaceae	Green	Indigenous
236	*Ziziphus mauritiana Lamk.*	Ber	Rhamnaceae	Greenish-Yellow	Indigenous

Table 8.19.Checklist of Herbs and Shrubs

Sr. No.	Scientific Name	Family	Common Name
Herbs			
	Abutilon indicum (l.)	Malvaceae	Petari
	Achyranthes aspera L.	Amaranthaceae	Aghara
	Alocasia macrorrhizos (L.) G.Don	Araceae	Alu
	Alternanthera ficoidea (l.)	Amaranthaceae	Kusal
	Amaranthus polygamus L.	Amaranthaceae	Green amaranth
	Argemone mexicana	Papaveraceae	Firangi Dhotra
	Blumea lacera	*Asteraceae*	*Bhamurda/Burando*
	Blumea lacera (Burm.f.) DC.	Compositae	Kakronda
	Boerhavia diffusa L.	Nyctaginaceae	Punarnava
	Brassica juncea (L.) Czern.	Brassicaceae	Indian mustard
	Cardiospermum halicacabum l	Sapindaceae	Kanphuti/ Thorny Nightshade
	Chromolaena odorata	Compositae	Bitter Bush/ Triffid Weed
	Commelina communis l.	Commelinaceae	Day Flower/ Kena
	Croton bonplandianus Baill	Euphorbiaceae	Ban tulsi
	Croton gibsonianus Nimmo	Euphorbiaceae	-
	Cullen corylifolium (L.) Medik.	Leguminosae	-
	Cyanthillium cinereum (L.) H.Rob.	Compositae	-
	Cyathocline purpurea	*Asteraceae*	*Gangotra*
	Cynodon dactylon	Poaceae	Dhurva
	Cynodon dactylon (L.) Pers.	Poaceae	Durva
	Cyperus compressus L.	Cyperaceae	-
	Cyperus rotundus	Cyperaceae	Nagarmotha
	Datura metal L.	Solanaceae	Kala Dhotra
	Datura metel	Solanaceae	Dhotra
	Echinops Echinatus Roxb	Asteraceae	Utanti
	Echinops Echinatus Roxb	Asteraceae	Utanti
	Eclipta prostrata (L.)	Compositae	Bhringaraj
	Flueggea leucopyrus	Phyllanthaceae	Pandharphali
	Hydrocotyle rotundifolia Roxb.	Apiaceae	Mandukparni
	Hygrophila auriculata (Schumach.) Heine	Acanthaceae	-
	Ludwigia octovalvis	Onagraceae	Pan Lavang
	Malvastrum coromandelianum (l.)	Malvaceae	Malvastiam
	Melilotus officinalis (L.)	Leguminosae	Ran Methi
	Parthenium hysterophorus L.	Asteraceae	Gajar Gavat
	Phyla nodiflora (L.)	Verbenaceae	Jalapimpali

Sr. No.	Scientific Name	Family	Common Name
	Phyllanthus amarus	Phyllanthaceae	Bhuiavali
	Pisum sativum l	Leguminosae	Pisum Sativam
	Portulaca oleracea l.	Portulacaceae	Ghol
	Setaria glauca Kunth	Ceraniaceae	Wire weed
	Sida cordifolia l	Malvaceae	Sida/ Bala, Chikana, Tupkaria
	Solanum virginianum l.	Solanaceae	Kateringani
	Sphaeranthus indicus l.	Compositae	Gorakhmundi
	Synedrella nodiflora	Compositae	Synedrella
	Xanthium strumarium	Asteraceae	Sankeshwara
Shrubs			
1.	*Agave americana L.*	Asparagaceae	Ghaypat
2.	*Allamanda cathartica* L.	Apocyanaceae	Golden Trumpet
3.	*Asclepias curassavica* L.	Asclepiadaceae	Haldi Kunku
4.	*Bougainvillea spectabilis* Willd.	Nyctaginaceae	Boganvel
5.	*Breynia retusa* (Dennst.) Alston	Phyllanthaceae	Dolfodi, Kangli
6.	*Callistemon citrinus* (Curtis) Skeels	Myrtaceae	Bottle Brush
7.	*Calotropis procera* (Aiton) Dryand.	Apocynaceae	Rui
8.	*Capparis zeylanica* L.	Capparaceae	Waghati
9.	*Cocculus hirsutus* (L.) W. Theob	Menispermaceae	Jaljamni
10.	*Combretum albidum* G. Don.	Combretaceae	Shendari
11.	*Duranta erecta* L.	Verbenaceae	Da-myanti
12.	*Lantana camara*	Verbenaceae	Tantani /Ghaneri
13.	*Leptadenia reticulata*	Apocynaceae	Leptadema Reticulata
14.	*Phyllanthus reticulatus*	Phyllanthaceae	Panjuli, Panpoi
15.	*Plumbago zeylanica*	Plumbaginaceae	Chitrak
16.	*Senna gaudichaudii*	Leguminosae	Cassia Glauca
17.	*Senna tora (l.)*	Leguminosae	Cassia Tora
18.	*Senna uniflora*	Caesalpiniaceae	Sonamukhi/Bhitarvada
19.	*Typha angustifolia*	*Typhaceae*	*Typha*
20.	*Vitex negundo L.*	*Lamiaceae*	*Nirgudi*
	Climbers		
1.	*Passiflora foetida L*	*Passifloraceae*	*Vel-ghani*
2.	*Tinospora sinensis (Lour.)*	*Menispermaceae*	*Gulvel*
3.	*Lpomoea cairica (L.)*	*Convolvulaceae*	*Pomoea palmate (Gakhale)*
4.	*Cocculus hirsutus*	*Menispermaceae*	*Vasanvel*
5.	*Argyreia nervosa (Burm. f.)*	*Convolvulaceae*	*Gugguli*
6.	*Pergularia daemia*	*Araceaeae*	*Utaran*
7.	*Momordica dioica*	*Cucurbitaceae*	*Momordica dioica*

Sr. No.	Scientific Name	Family	Common Name
8.	*Clematis gouriana*	*Ranunculaceae*	*Morvel*
9.	*Clitoria ternatea*	*Fabaceae*	*Gokarna*
10.	*Asparagus racemosus*	*Asparagaceae*	*Shatavari*

Table 8.20.List of trees likely to be affected due to proposed alternative alignment

No.	Local Name	Scientific Name	Number
1	Kadulimb	*Azadirachta indica L*	13
2	Karanj	*Pongamia pinnata (L.)Pierre*	7
3	Vilayati Chnich	*Pithecellobium dulce (Roxb.) Benth.*	8
4	Chandan	*Santalum album L.*	32
5	Vilayati Babhul	*Prosopis juliflora (Sw.) DC.*	2
6	Babhul	*Acacia nilotica (L.)Delile*	39
7	Subabhul	*Leucaena leucocephala (Lam.) de Wit*	16
8	Bor	*Ziziphus jujuba Lam.*	16
9	Karvand	*Carissa carandas G.Lodd.*	1
10	Kashid	*Senna siamea (Lam.) H.S.Irwin & Barneby*	1
11	Undirmari	*Gliricidia sepium (Jacq.) Kunth ex Walp*	25
		Total	**160**

8.6.8.3 Faunal Diversity

Study was conducted in the areal up to 500 m off both sides of the Mula Mutha River (From Yerwada to Kalyaninagar Bridge) and Dr. Salim Ali Bird Sanctuary area. The checklists of Butterflies, Dragonflies, Damselflies and Bird existed in the study area, are enlisted in table 8.21, 8.22 and 8.23.

Butterfly Diversity : Table 8.21 enlists the distribution patterns of 13 species of butterflies recorded during the study period.

Table 8.21.Checklist of Butterflies in and around study area

SN	Scientific Name	Common Name	IWPA Status	IUCN Status
Nymphalidae				
1.	*Danaus chrysippus*	Plain Tiger	Not Enlisted	Not Enlisted
2.	*Euploea core*	Common Indian Crow	Sch-IV	Least Concern
3.	*Hypolimnas misippus*	Danaid Eggfly	Sch-II	Not Enlisted
4.	*Neptis hylas*	Common Sailer	Not Enlisted	Not Enlisted
5.	*Parantica aglea*	Glassy Tiger	Not Enlisted	Not Enlisted
6.	*Phalanta phalantha*	Common Leopard	Not Enlisted	Not Enlisted
7.	*Tirumala limniace*	Blue Tiger	Not Enlisted	Not Enlisted
8.	*Vanessa cardui*	Painted Lady	Not Enlisted	Not Enlisted

SN	Scientific Name	Common Name	IWPA Status	IUCN Status
Pieridae				
9.	*Eurema hecabe*	Common Grass Yellow	Not Enlisted	Not Enlisted
10.	*Eurema brigitta*	Small Grass Yellow	Not Enlisted	Least Concern
11.	*Eurema laeta*	Spotless Grass Yellow	Not Enlisted	Not Enlisted
Papilionidae				
12.	*Papilio polytes*	Common Mormon	Not Enlisted	Not Enlisted
13.	*Pachliopta aristolochiae*	Common Rose	Not Enlisted	Not Enlisted

Figure 8.14. Photographs of the butterflies

Dragonflies and Damselflies : Three species of dragonflies and two species of damselflies were found in the study area during the sampling period.

Table 8.22. Checklist of Dragonflies and Damselflies in and around study area

SN	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
	Damselflies			

SN	Scientific Name	Common Name	IWPA Status	IUCN Status
4	*Ischnura senegalensis*	Senegal Golden Dartlet	Not enlisted	Not enlisted
5	*Ceriagrion rubiae*	Orange Marsh Dart	Not enlisted	Not enlisted

Avifaunal Diversity : Table 8.23 shows bird species recorded during the survey period

Table 8.23.Checklist of Avifauna within the study area
(R: Residence, LM: Local migratory, WV: Winter visitor; digit in parenthesis denotes number of individual observed within the study area)

Sl	Common Nname	Scientific Name	IUCN	IWPA
1.	Alexandrine Parakeet	*Psittacula eupatria (1) R*	*NT*	
2.	Ashy Drongo	*Dicrurus leucophaeus (1) LM*	*LC*	
3.	Ashy Prinia	*Prinia socialis (2) R*	*LC*	-
4.	Asian Koel	*Eudynamys scolopaceus (4) R*	*LC*	*Schedule IV*
5.	Barn Swallow	*Hirundo rustica (4) R*	*LC*	-
6.	Black Drongo	*Dicrurus macrocercus (6) R*	*LC*	*Schedule IV*
7.	Black Kite	*Milvus migrans (15) R*	*LC*	-
8.	Black eared kite	*Milvus migrans lineatus (2)*	*LC*	-
9.	Black Redstart	*Phoenicurus ochruros (1) LM*	*LC*	
10.	Black-headed Ibis	*Threskiornis melanocephalus (25)*	*NT*	*Schedule IV*
11.	Black-winged Stilt	*Himantopus himantopus (36)LM*	*LC*	*Schedule IV*
12.	Blyth's Reed Warbler	*Acrocephalus dumetorum (3) LM*	*LC*	
13.	Booted Eagle	*Hieraaetus pennatus (Gamelin)*	*LC*	
14.	Cattle Egret	*Bubulcus ibis (60) R*	*LC*	*Schedule IV*
15.	Cinereous Tit	*Parus major (3) R*	*LC*	*Schedule IV*
16.	Clamorous Reed Warbler	*Acrocephalus stentoreus (1)LM*	*LC*	-
17.	Common Greenshank	*Tringa nebularia (1) WV*	*LC*	-
18.	Common Kingfisher	*Alcedo atthis (1) R*	*LC*	*Schedule IV*
19.	Common Myna	*Acridotheres tristis (8) R*	*LC*	*Schedule IV*
20.	Common Pigeon	*Columba livia (250) R*	*LC*	*Schedule IV*
21.	Common Sandpiper	*Actitis hypoleucos (4) LM*	*LC*	*Schedule IV*
22.	Common Tailorbird	*Orthotomus sutorius (2) R*	*LC*	-
23.	Common Teal	*Anas crecca (30) WV*	*LC*	*Schedule IV*
24.	Common Snipe	*Gallinago gallinago*	*LC*	*Schedule IV*
25.	Common Hoopoe (3)	*Upupa epops*	*LC*	
26.	Coppersmith Barbet	*Megalaima haemacephala (1) R*	*LC*	*Schedule IV*
27.	Eurasian Coot	*Fulica atra (3) WV*	*LC*	*Schedule IV*
28.	Eurasian Marsh Harrier	*Circus aeruginosus (1) WV*	*LC*	-
29.	Gadwall	*Anas strepera (67) WV*	*LC*	-
30.	Garganey	*Anas querquedula (35) WV*	*LC*	-
31.	Green Bee-eater	*Merops orientalis (6) R*	*LC*	-
32.	Green Sandpiper	*Tringa ochropus (4) WV*	*LC*	-
33.	Grey Francolin	*Francolinus pondicerianus (1)R*	*LC*	-
34.	Grey Heron	*Ardea cinerea (4) R*	*LC*	-
35.	Gull-billed Tern	*Gelochelidon nilotica (1) LM*	*LC*	-
36.	Glossy Ibis	*Plegadis falcinellus (2)*	*LC*	*Schedule IV*

SI	Common Nname	Scientific Name	IUCN	IWPA
37.	House Crow	*Corvus splendens (15) R*	*LC*	*Schedule IV*
38.	Indian Cormorant	*Phalacrocorax fuscicollis (1) R*	*LC*	*Schedule IV*
39.	Indian Jungle Crow	*Corvus culminatus (6) R*	*NE*	-
40.	Indian Pond Heron	*Ardeola grayii (10) R*	*LC*	-
41.	Indian River Tern	*Sterna aurantia (17) R*	*NT*	-
42.	Indian Spot-billed Duck	*Anas poecilorhyncha (98) R*	*LC*	*Schedule IV*
43.	Indian Robin	*Copsychus fulicatus (2)*	*LC*	-
44.	Intermediate Egret	*Mesophoyx intermedia (2) R*	*LC*	*Schedule IV*
45.	Jungle Myna	*Acridotheres fuscus (96) R*	*LC*	-
46.	Large Grey Babbler	*Turdoides malcolmi (9) R*	*LC*	*Schedule IV*
47.	Laughing Dove	*Stigmatopelia senegalensis (3) R*	*LC*	*Schedule IV*
48.	Little Cormorant	*Phalacrocorax niger (1) R*	*LC*	*Schedule IV*
49.	Little Egret	*Egretta garzetta (15) R*	*LC*	*Schedule IV*
50.	Little Stint	*Calidris minuta (2) WV*	*LC*	-
51.	Little Grebe	*Tachybaptus ruficollis (1)*	*LC*	*Schedule IV*
52.	Long-tailed Shrike	*Lanius schach (3) R*	*LC*	-
53.	Indian Roller	*Coracias bengalensis (1)*	*LC*	*Schedule IV*
54.	Northern shoveller	*Anas clypeata (3)*	*LC*	-
55.	Oriental Magpie Robin	*Copsychus saularis (2) R*	*LC*	-
56.	Painted Stork	*Mycteria leucocephala (9) R*	*NT*	*Schedule IV*
57.	Pied Bushchat	*Saxicola caprata (2) R*	*LC*	-
58.	Purple Heron	*Ardea purpurea (1) R*	*LC*	-
59.	Purple Swamp hen	*Porphyrio porphyrio (3) R*	*LC*	*Schedule IV*
60.	Purple-rumped Sunbird	*Leptocoma zeylonica (1) R*	*LC*	*Schedule IV*
61.	Red-breasted Flycatcher	*Ficedula parva (2) LM*	*LC*	
62.	Red Avadavat	*Amandava amandava (2)*	*LC*	*Schedule IV*
63.	Little Swift	*Apus affinis*	*LC*	-
64.	Red-vented Bulbul	*Pycnonotus cafer (4) R*	*LC*	*Schedule IV*
65.	Red-wattled Lapwing	*Vanellus indicus (29) R*	*LC*	-
66.	Rose-ringed Parakeet	*Psittacula krameri (2) R*	*LC*	*Schedule IV*
67.	Ruddy Shelduck	*Tadorna ferruginea (42) LM*	*LC*	*Schedule IV*
68.	Ruff	*Philomachus pugnax (5) WV*	*LC*	-
69.	Southern Coucal	*Centropus parroti (3) R*	*LC*	*Schedule IV*
70.	Spotted owlet	*Athene brama (2)*	*LC*	*Schedule IV*
71.	Shikra	*Accipiter badius (1)*	*LC*	-
72.	Sulphur-bellied Warbler	*Phylloscopus griseolus (1) LM*	*LC*	
73.	Siberian Stonechat	*Saxicola maurus (1)*	*NE*	-
74.	Whiskered Tern	*Chlidonias hybrida (5) WV*	*LC*	-
75.	White Wagtail	*Motacilla alba (1) LM*	*LC*	-
76.	White-breasted Water hen	*Amaurornis phoenicurus (1) R*	*LC*	*Schedule IV*
77.	White-browed Wagtail	*Motacilla maderaspatensis (2)R*	*LC*	-
78.	White-spotted Fantail	*Rhipidura albogularis (3) R*	*LC*	*Schedule IV*
79.	White-throated Kingfisher	*Halcyon smyrnensis (2) R*	*LC*	*Schedule IV*
80.	Wood Sandpiper	*Tringa glareola (4) LM*	*LC*	*Schedule IV*
81.	Woolly necked stork	*Ciconia episcopus (2)*	*VU*	*Schedule IV*
82.	Yellow Wagtail	*Motacilla flava (8) WV*	*LC*	-
83.	Taiga Flycatcher	*Ficedula albicilla (1)*	*LC*	-

SI	Common Nname	Scientific Name	IUCN	IWPA
84.	Night Jar (1)	*Caprimulgus asiaticus*	*LC*	*Schedule IV*
85.	Dusky martin	*Ptyonoprogne concolor (2)*	*LC*	-
86.	Common swallow	*Hirundo rustica (1)*	*LC*	-
87.	Indian grey hornbill	*Ocyceros birostris (2)*	*LC*	-

Key Observations on Avifauna survey

1. One of the most important aspect of anthropogenic pressure along the Mula-Mutha Rivers is the disposal of huge amount of non-biodegradable solid waste. It occupies each and every micro-habitat of the river basin. They include the islets, rocky outcrops, stagnant and flowing waters and even the most fragile banks of the river.
2. The emergent vegetation, small bushes, medium-sized trees are the most affected type of vegetation as they are entangled in the loads of plastic and other non-bio-degradable stuff. In some cases plants even can't photosynthesize properly eventually suppressing their growth. It is not the only the inflow of untreated sewage and waste water but an unprecedented amount of garbage is **'THE'** issue.
3. The pair of the spotted owlet (*Athena brama*) were sighted on the vegetation along the northern banks of the river. Residence of such a bird is depended on ecosystem.
   A. The type of vegetation
   B. Anthropogenic disturbances in the form of visitors, especially the so called avian photographers and the trespassers.
4. Native trees that provide dense foliage is the key factor. The trees like *Mango, Jamun, Karanj* and *Cluster-fig* trees are recommended in this area and it is far more important in protecting each and every existing native plant, be it in private or public place. It may be mentioned that on the left side of Mula Mutha River there is a space for strengthening green belt, then development of DP road which is under progress, followed by space that can be strengthened for green belt. Beyond these space the Metro rail alignment is proposed. It is evident that the proposed Metro line, in addition to DP road, will enlighten the erstwhile dark corners. Light control barriers are highly recommended near Sanctuary area.
5. A rare adult Woolly necked Stork (*Ciconia episcopus*) was found dead on the northern banks of the river. It was unclear how it happened, however, it was evident that the bird was killed by human being.
6. Over the past decade or more, a small cluster of trees has come up in the midst of the river. It looks like a riverine island. It mainly consists of the native Jamun (Known as the 'Lendi Jambhul' or the 'Panjambhul') trees in addition to a few other shrubs. It serves as an important resting and nesting place for many birds like the little cormorants, Grey Herons, Indian Pond Herons, Cattle Egrets and even the non-water birds like the House Crows and the Indian Jungle Crows. The House crows are presently nesting there.
7. Although this cluster is not completely inaccessible to humans, its geographic location has afforded it protection from the axe of urban illicit woodcutters.

8. Dumping of waste in the sanctuary and adjoining area should be prohibited. Illegal tree cutting and felling activities should be stopped.
9. The grass covered mounds, rocky outer crops and low-lying bushes on the banks of the river provide excellent perching and foraging facilities to various species of birds including the locally migratory common Stonechat, the resident pied Bushchat and the Red Avadavat.
10. The Common Hoopoe was sighted digging into the moist ground for worms. A few species of migratory wagtails were also seen to search for food in this area.
11. Surprisingly, this stretch of habitat between the actual river flow and the vegetation on the Northern and Southern banks has also been extensively littered with plastic, thermocol, old synthetic clothes, pieces of iron sheet, glass bottles, containers etc.
12. Small puddles, ditches and drain water ponds along the stretch of this habitat is recorded. The Indian Spot billed Ducks occasionally venture to feed here. They are often disturbed by the Buffalo herders.
13. More than 50 species of birds have been recorded in a small cluster of the Indian Silk Cotton Tree. An essential ingredient of the food of many birds, nectar is rich in carbohydrates.
14. Almost fully matured Babul (*Acacia nilotica*) and Karanj (*Pongamia pinnata*) trees on the Northern banks are the glory of Mula-Mutha. Illicit tree felling is the biggest threat to them.
15. During survey, an adult Booted Eagle was observed to fly just above the tree line with a common pigeon in its talons. It suddenly dropped the prey about 50 meters away and flew. With a few deliberate wing beats the raptor disappeared soon. Earlier in the day the eagle was seen mingling with numerous Black Kites. Now and then it launched dive – bombing attacks, causing much commotion in a huge flock of pigeons. It appeared that the bird used tactics of associating itself with the kites to mask itself and launched aerial attacks on pigeons.
16. An Indian Nightjar was observed near the ruins of the forest check post. It was seen flying a short distance and settling down in the shade of an old Acacia tree, as aging of stray dogs rushed in. Nightjars are known to select desolate places to roost during the day. The Mula-Mutha bird habitat does not qualify to be deserted place, not even remotely. Destiny of many specialists' birds with specific biological needs is almost similar to that of the nightjar.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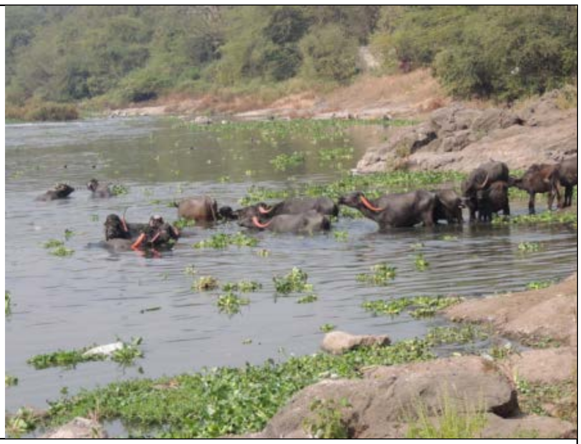

Figure 8.15. Photographs showing Bird Diversity in and around project area

8.6.8.4 Aquatic Ecology

The water samples for plankton analysis were collected from four stations along the river stretch, analyzed under microscope in the laboratory and the data are presented in Tables

8.24 and 8.25. It was clearly visual that different types of anthropogenic activities were very common in the river (Figure 8.17).

Figure 8.16. Photos showing anthropogenic activities in the Mula Mutha River.

Phytoplankton

Phytoplankton, also known as microalgae, are mostly buoyant and float in the upper part of the water, where sunlight penetrates the water. Phytoplankton also require inorganic nutrients such as nitrates, phosphates and sulfur which they convert into proteins, fats, and carbohydrates.

Most phytoplankton are too small to be individually seen with the unaided eye. However, when present in high enough numbers, they may appear as a green discoloration of the water due to the presence of chlorophyll within their cells.

Phytoplankton, being the foundation of the aquatic food chain, obtain energy through the process of photosynthesis and must therefore live in the surface layers of ocean, sea, lake, or other bodies. Phytoplankton account for half of all photosynthetic activity on earth.

Table 8.24. Phytoplankton Diversity in Mula Mutha River

Sample No.	Sampling Locations	Phyto-plankton (No/ml)	Percent Composition of algal groups			
			Cyano-phyceae	Chloro-phyceae	Bacillario-phyceae	Eugleno-phyceae
1.	Bund Garden Bridge u/s (About 200 m from Alignment)	4910	45	28	8	9
2.	Along Proposed Metro Alignment (u/s of Salim Ali Sanctuary)	4115	59	22	11	8
3.	Along Proposed Metro Alignment	4250	51	26	12	7

	(d/s of Salim Ali Sanctuary)					
4.	Kalyaninagar Bridge d/s (About 250 m from Alignment)	2980	41	27	18	9

Zooplankton

Zooplankton are microscopic aquatic animals having no resistance to currents, free floated and suspended in open or pelagic waters. The zooplankton include animals suspended in water with limited powers of locomotion.

Mula 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 and decay of macrophytes.

Table 8.25.Zooplankton Diversity in Mula Mutha River

Sample No.	Sampling Locations	Zooplankton Count No/m^3	Percent Composition of algal groups		
			Rotifera	Copepoda	Cladocera
1.	Bund Garden Bridge u/s (About 200 m from Alignment)	2560	40	25	15
2.	Along Proposed Metro Alignment (u/s of Salim Ali Sanctuary)	2450	50	30	8
3.	Along Proposed Metro Alignment (d/s of Salim Ali Sanctuary)	2110	55	35	5
4.	Kalyaninagar Bridge d/s (About 250 m from Alignment)	1670	45	25	9

8.6.9. Socio Economic Aspects

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 below six years of age are 337,062 having child sex ratio 908; however in Pune Metropolitan area, children less than six years of age are 579,681 with child sex ratio of 904.The average literacy rate of Pune city and metropolitan area is 89.56%.

School/ college and hospital and heritage sites located nearby this alignment are presented in Table 8.26 & 4.87

Table 8.26.List of Schools/college & Hospitals around the proposed new alignment

Sr. No.	Schools/Colleges	Distance	Direction
1.	Swatantra Senani Abdul Hakim Ajmal	494.10 m	NW
2.	People's Education Society English	394.60 m	NW
3.	Tree House School	438.80 m	S

Sr. No.	Schools/Colleges	Distance	Direction
4.	The Lexicon International School, Kalyani	324.50 m	N
5.	Rashmi English Medium School	1.66 km	W
6.	Vibgyor High school,Yerwada	1.56 km	NW
7.	Don Bosco High School	830.5 m	W
8.	S S English Medium School	2.83 km	NW
9.	SNBP college	1.33 km	N
10.	Deccan college	1.35 km	NW
	Hospitals		
1.	Kataria hospital	21.5 m	N
2.	Shah Accidental Hospital	277.30 m	N
3.	Sahyadri super specialty hospital	965.3 m	W
4.	Amit Hospital	60.50 m	N

Table 8.27.List of Heritage site in and around project area

Sr. No.	Heritage Site	Distance	Direction
1.	Agakhan Palace Complex	480 M	W
2.	Pune International Air port	2.41 KM	N
3.	Deccan College and campus	1.35 KM	W
4.	Yerwada Jail	1.94 KM	NW

8.6.10. Public Consultation/participation

During field survey for baseline data collection, regular interaction with the people of various sections of the society along the project alignment and influential persons of the project area were made. Emphasis was given on concerns of new metro rail alignment adjacent to Dr. Salim Ali Bird sanctuary. New Metro rail alignment resultant to increase length by 920m to the original alignment and relocation of Kalyani Nagar metro station. This changed elevated alignment starts near Gunjan Chowk and will merge to median of DP road adjacent to Dr. Salim Ali Bird Sanctuary. Small stretch of alignment from Garbage collection Centre, Gunjan chowk to DP road passing through the land belongs to the Wadia Family, which is basically proposed Metro Depot reservation EP 49 as per sanctioned DP of Pune City 2017.

Public consultation or participation was undertook for sound understanding of direct and indirect impact of metro intervention in project area and adjacent to the project area including the Dr. Salim Ali Bird Sanctuary Area as per ESRP 4. Disclosure and Commitment (IFC ESRP Manual), though this area is not part of the proposed Metro rail alignment. For active participation regular invitation and follow-up was made amongst project influential persons and bird lover groups. Visits during baseline data collection were arranged along with the experts from the various subjects. Following are views and opinions recorded during public consultation or participation held during January and February 2019

Table 8.28.Views and opinions recorded during public consultation or participation

SN	Views of citizens/ influential persons/ bird lovers	Remark
1	New metro rail alignment may cause adverse impact on Dr. Salim Ali Bird Sanctuary area. This sanctuary harbors more than 102 bird species.	Proposed new metro rail alignment is not passing physically through Dr. Salim Ali Bird Sanctuary. Indirect impacts envisaged are studied and mitigation measures are proposed accordingly. Strengthening of greenbelt with indigenous and bird attracting species of trees will mitigate the negative impacts.
2	Proposed metro rail alignment may cause tremendous impact on vegetation cover and individual trees from the project area which harbors nesting and perching sites for the birds.	About 106 individuals of tree are likely to be affected. Species recorded are *Azadirachta indica, Pongamia pinnata, Pithecellobium dulce, Santalum album Prosopis juliflora, Acacia nilotica, Leucaena leucocephala, Ziziphus jujuba Carissa carandas, Senna siamea, Gliricidia sepium* etc. These species are commonly occurring species. Compensatory plantation of native species in the adjoining area is proposed for strengthening the habitat of birds in the area which will increase nesting and perching sites for birds.
3	Development of Metrorail alignment and DP road cause illegal tree felling activities.	Tree felling activities are reported even before design of the proposed new metro rail alignment, as this area is freely accessible. Grazing and dumping of solid waste are also been reported in this area. Tree felling, grazing and dumping of solid waste activities may controlled during construction and operational phase of the project.
4	Construction activities will impact on air and noise quality in the area which may impact bird diversity in the sanctuary.	The main source for impact of air and noise quality during construction period is due to activities like excavation, dumping and vehicle movement/ transportation of materials etc. Environment Management plan will be executed to minimize impact on air and noise environment. All statutory guidelines of CPCB will be followed. Regular environmental monitoring is proposed. Impacts due to construction activity will be temporary and reversible. However it is reported that maximum diversity of birds reported in riparian area of the river which will not affect directly during construction and operation phase.

	
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Figure 8.17. Glimpses of public participation during baseline survey

8.6.11. Land Use/ Land Cover Study

The land use pattern of the project areas has been established through interpretation of the latest satellite imagery (Satellite; Landsat 8 December 2018).

The adopted methodology for interpretation of satellite imagery and development of land use pattern comprised of the following functional components:

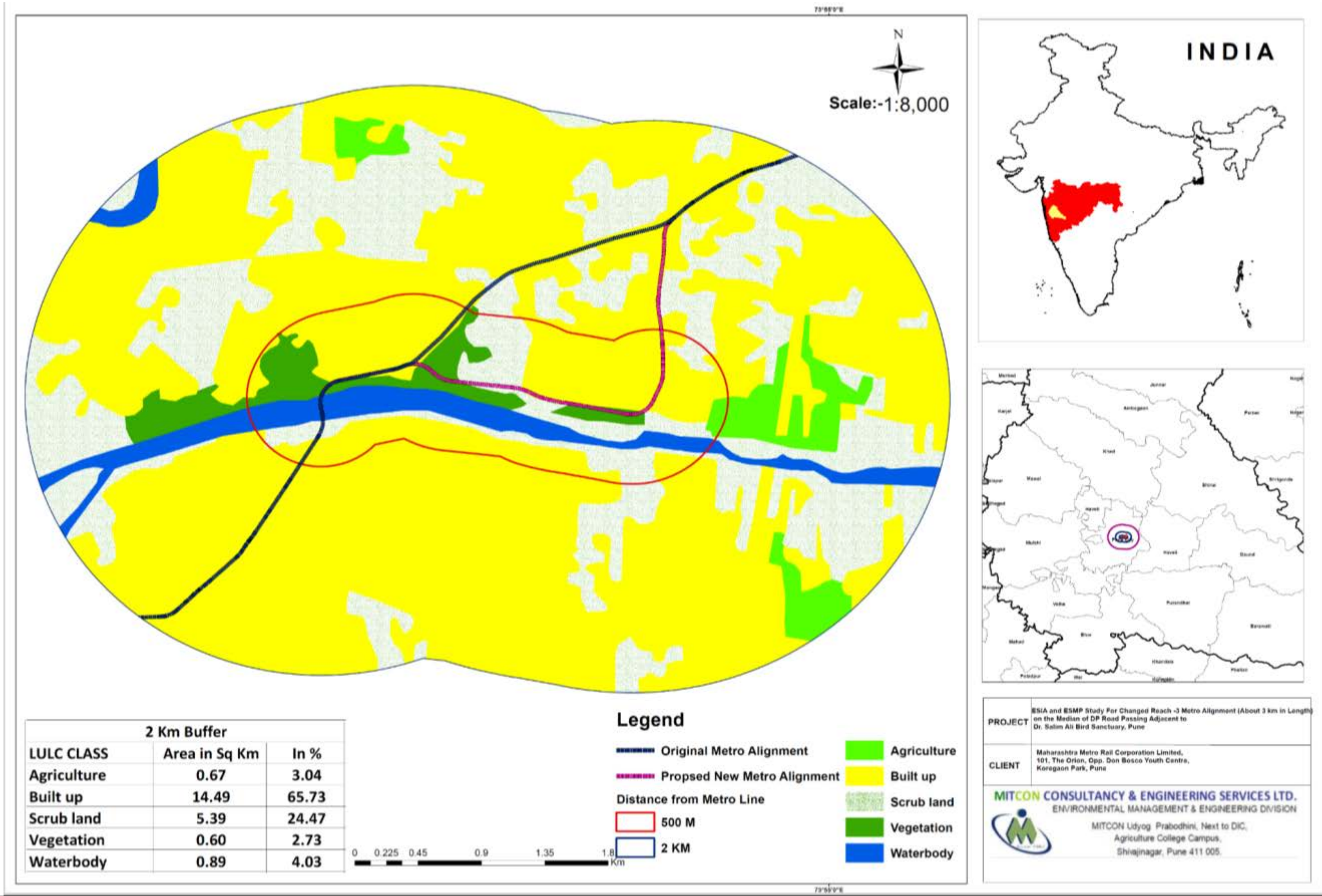
- Demarcation of area boundaries on 1:50,000 scale toposheets;
- Preparing a composite mosaic of 1:50000 scale RS imageries covering the project area;
- Interpretation of RS data;
- Ground truth collection for supervised classification;
- Refinement of land uses based on field observations;
- Computation of areas in each land use; and
- Preparation of Land Use Map

Land use classification are presented in Table 8.29 and Figure 8.19

Table 8.29.LULC Area Statement for 2 km Buffer on both sides

LULC Class	AREA in Sq. Km.	(%)
Agriculture	0.67	3.04
Built up	14.49	65.73
Scrub land	5.39	24.47
Vegetation	0.60	2.73
Water body	0.89	4.03
Total		**100**

Figure 8.18. Land Use Land Cover Map



2 Km Buffer		
LULC CLASS	Area in Sq Km	In %
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Scrub land	5.39	24.47
Vegetation	0.60	2.73
Waterbody	0.89	4.03

8.7. IMPACT ASSESSMENT

8.7.1. Impact during Construction Phase

Majority of the construction phase impacts on the environment can be considered short term impacts compared to the operational impacts. The following activities are likely to contribute towards short term impacts on the surroundings during construction phase:

- Site preparation
- Tree cutting
- Civil construction work
- Vehicular movement (Traffic Congestion and Diversion Problem)
- Impact on Air Quality and Noise Level

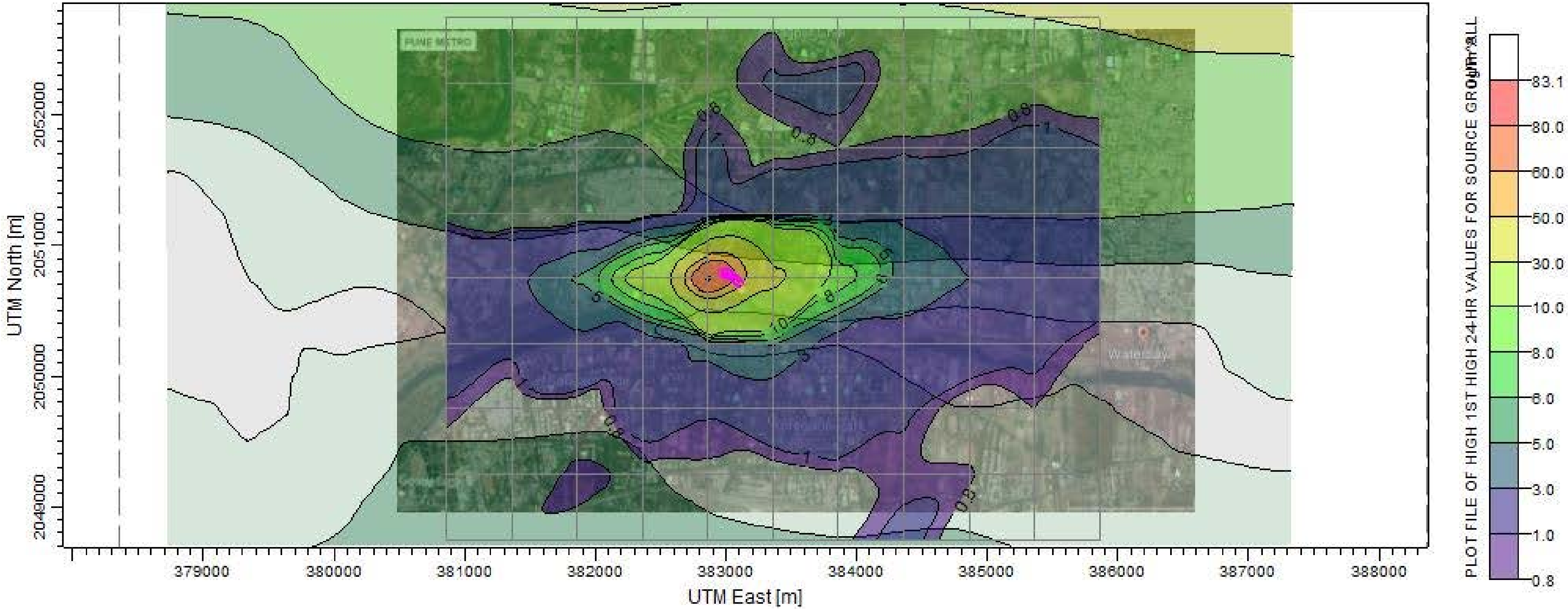
8.7.1.1 Impact on Land Environment

The current alternative at Gunjan Chowk Gunjan Chowk diverts towards proposed Metro Depot reservation EP 49 as per sanctioned DP of Pune City 2017 and then runs along the median of Shivane- Kharadi DP which is adjacent to the Dr. Salim Ali bird sanctuary. Land required will be minimum for actual construction on ground.

8.7.1.2 Impact on Air Environment

The main source for impact of air quality during construction period is the fugitive dust from the activities like excavation, dumping and vehicle movement/ transportation of materials etc. Fugitive dust emission during construction is represent in figure 8.20

Figure 8.19.Fugitive Dust Modelling during Construction phase



8.7.1.3 Impact on Noise Level and Vibration

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

Vibration level will be increased during excavation and transportation at project site.

From the dhwaniPRO® sound propagation modelling it is depicted that maximum noise level due to construction activity at receptor will be in the range of 55 to 65 dB (A). Refer figure 8.21 Predicted Noise Level during Construction Phase.

8.7.1.4 Impact on water quality

The proposed alignment is adjacent to the Dr. Salim Ali Bird Sanctuary.

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

In addition, water will be required during construction phase at about 100 to 150 kld for site activities, such as curing, concrete mixing, dust suppression etc.

No significant impacts are envisaged on surface and ground water quality due to proposed metro rail alignment. Mobile toilet facility sewage disposal facility is proposed during construction phase. No labor camps and casting yards are proposed in the Dr. Salim Ali Bird Sanctuary area.

8.7.1.5 Impact due to flood

Flood is natural hazard but intensity of it increases due to human interference. Hence it affects badly in adjoining areas of river channel. Occurrence of flood is normal behavior which alters socio-economic status of surrounding areas. Effect of normal flood is considered as regular phenomena, which leads to short term disturbances. These short term disturbances can change the physical properties of the channel and also bring changes in agricultural land as well as settlement on larger scale.

The Revised Reach-3 alignment passes through a stretch of land along the Bank of Mula-Mutha River downstream of Bund Garden Barrage and adjacent to Dr. Salim Ali Bird Sanctuary.

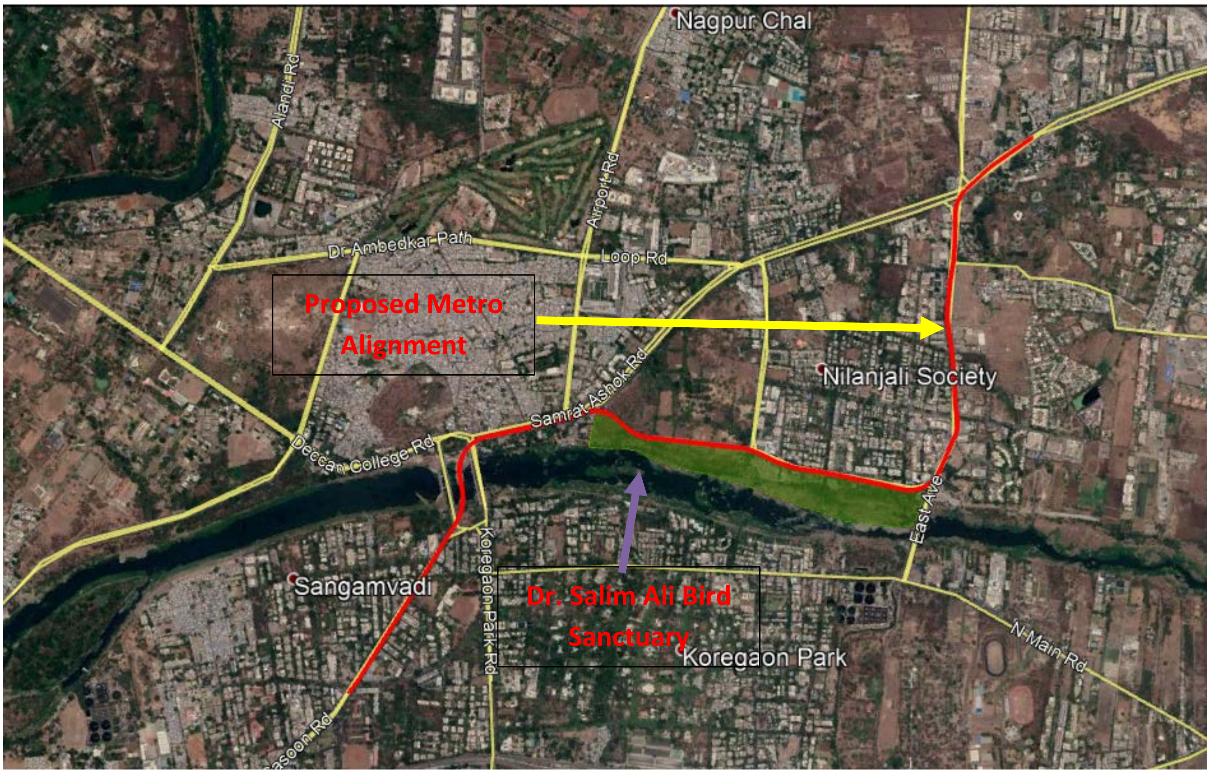


Figure : Google Earth Image showing Revised Reach-3 Metro Alignment

Methodology adopted for Flood Risk Assessment: Below mentioned methodology has been adopted for assessing the flood risk-

1. Blue line and red line maps were procured from Executive Engineer, Khadakwasla Irrigation Division, Pune and same were digitized using Arc GIS and the revised Metro Alignment was superimposed on these maps. It was observed that the nearest point of the alignment and the Red line (Danger Flood Level) lies at an approximate distance of 30 m on the landward side. Also, there is an approximate 5 m level difference between both the points (Refer the subsequent Figure).

2. Further, past occurrences of floods in the nearby area were also studied and it was observed that the past flood water has not breached the red line in any of the time in history. Based on these findings it was perceived that flood risk will not prevail in this area.

Mitigation measures : As the flood risk is not envisaged in the area hence mitigation measures has not been formulated. However, state/district disaster mangement cell & other agencies has a mechanism to avoid the flood risk in any of the area of Pune city, which are as follows

1. PMC proactively provides information about rains from concerned department like meteorological department for weather, irrigation department for level of water in dams etc. to the areas prone to floods.
2. All the water channels are cleared before monsoon to avoid logging of water and creating flash flood situation.
3. Media like TV, radio, internet, social media and mobile are used effectively to send messages and information 72 hours prior to the actual hazard.
4. The ESF, EOC and task forces, first aid team will be ready with all the equipment and resources when informed by PMC.
5. NDRF,battalion-5 is stationed at Sudumbare, near Talegaon, in Pune district to cater the Maharashtra and Goa region.

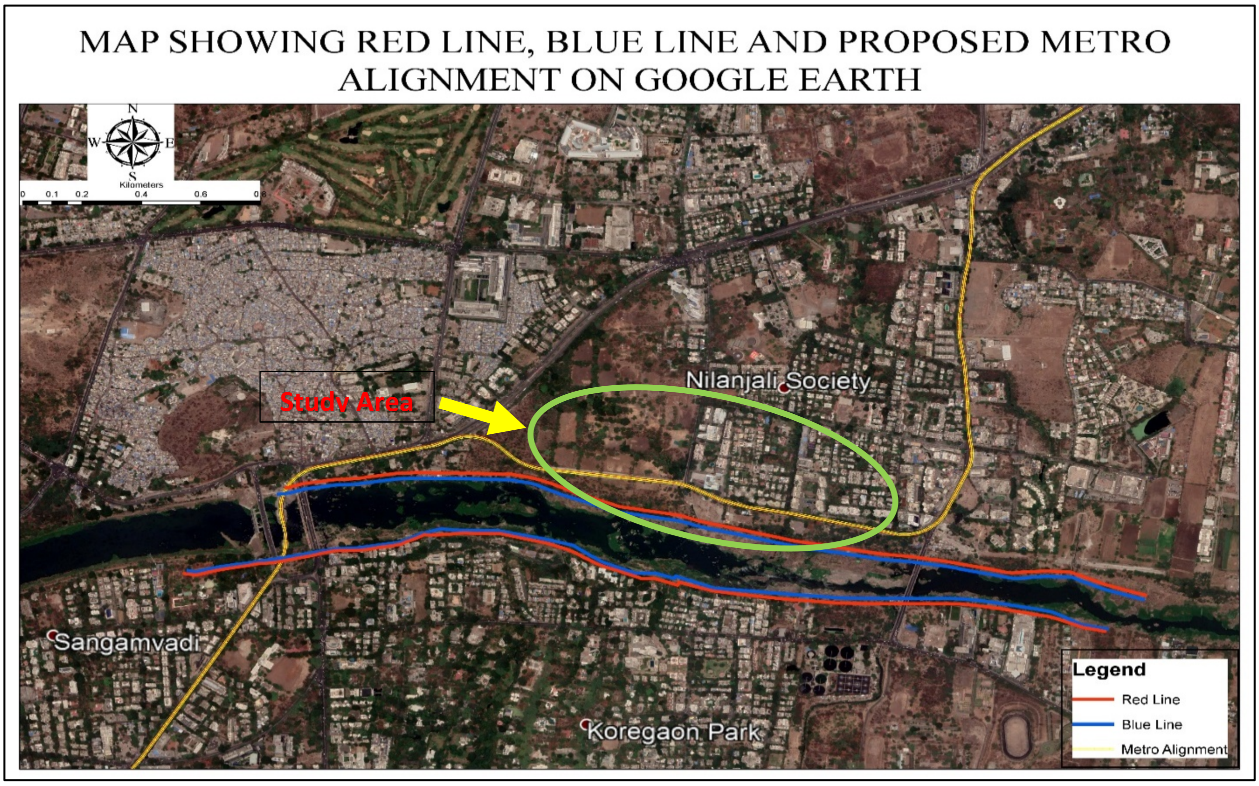


Figure : Google Earth Image showing Red Line, Blue Line and Proposed Metro Alignment

Figure 8.20. Predicted Noise Level During Construction Phase

8.7.1.6 Impact on Ecology and Biodiversity

- Total 160 Trees will be affected due to proposed Metro alignment.
- Herbaceous vegetation and top soil will be disturbed due to excavation and allied activities. Negative impacts are envisaged due to cutting, leveling and allied construction activities. The species such as *Azadirachta indica L, Pongamia pinnata* (L.)Pierre*, Pithecellobium dulce* (Roxb.), *Benth Santalum album* L., *Prosopis juliflora* (Sw.) DC*, Acacia nilotica* (L.)Delile, *Leucaena leucocephala* (Lam.) de Wit, *Ziziphus jujuba* Lam., *Carissa carandas* G.Lodd. *Senna siamea* (Lam.) H.S.Irwin & Barneby, *Gliricidia sepium* will be affected. No rare, endangered, and threatened (RET) species of herbaceous flora was observed during study period.
- During the survey 87 species of birds were observed. Less number of fish eater species were recorded in the area as turbidity of river water is higher. However, a good bird diversity was recorded along the river bed, islands and rocky outskirts of the river.
- Vegetation in this area is highly disturbed due to various anthropogenic activities and dumping of the garbage. Arboreal vegetation in the sanctuary area comprises mostly of exotic tree species. This vegetation is being used for perching and nesting site by various birds but the impacts due to construction activity may only cause temporary adverse impact on avifauna.
- Noise generated from construction will have short term reversible impacts on birds as habitat.
- In rare cases spotted owlets and nightjar were sighted during survey. Considering the place at which the activities of DP road are in progress and Metro alignment is proposed, some of the bird species might be impacted temporarly..

8.7.1.7 Impact on Socio Economic Environment

No direct impacts are envisaged on socio economic condition from the project area. Beneficial impacts are predicted on local business community. No direct impacts envisaged on historical & cultural monuments by proposed metro rail alignment. There would not be any impact on the commercial activities in the sanctuary area as it is completely vacant. beyond the sanctuary, care should be taken so that it should not be impacted.

8.7.1.8 Impact on Traffic

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

8.7.2. Operational Phase

Operational phase activities may have impacts minor or major, positive or negative.

8.7.2.1 Land Environment

The current alternative at Gunjan Chowk diverts towards reserved land for Metro Depot and extends through median of existing DP road which is adjacent to the Dr. Salim Ali bird sanctuary. Since the proposed alignment is through median of DP road, no significant land use change is expected.

8.7.2.2 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**.**

8.7.2.3 Noise Environment and Vibration

The maximum noise level has been estimated as 60-65 dB (A) including background noise level as 20 dB (A) inside the Metro.

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

From the dhwaniPRO® sound propagation modelling it is depicted that maximum noise level during operational phase at receptor will be in the range of 55 to 60 dB (A). Refer figure 5.3 Predicted Noise Level during operational phase.

8.7.2.4 Water Environment

Water demand on one station works out to be about 11 KLD, out of them 7.5 KLD waste water will be generated at each station.
Negative impacts are predicted due to generation of waste water from the metro stations.

8.7.2.5 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.

During operational phase the vehicular movement on DP road and running of metro rail adjacent to Dr. Salim Ali Bird Sanctuary may affect behavioral changes of birds.

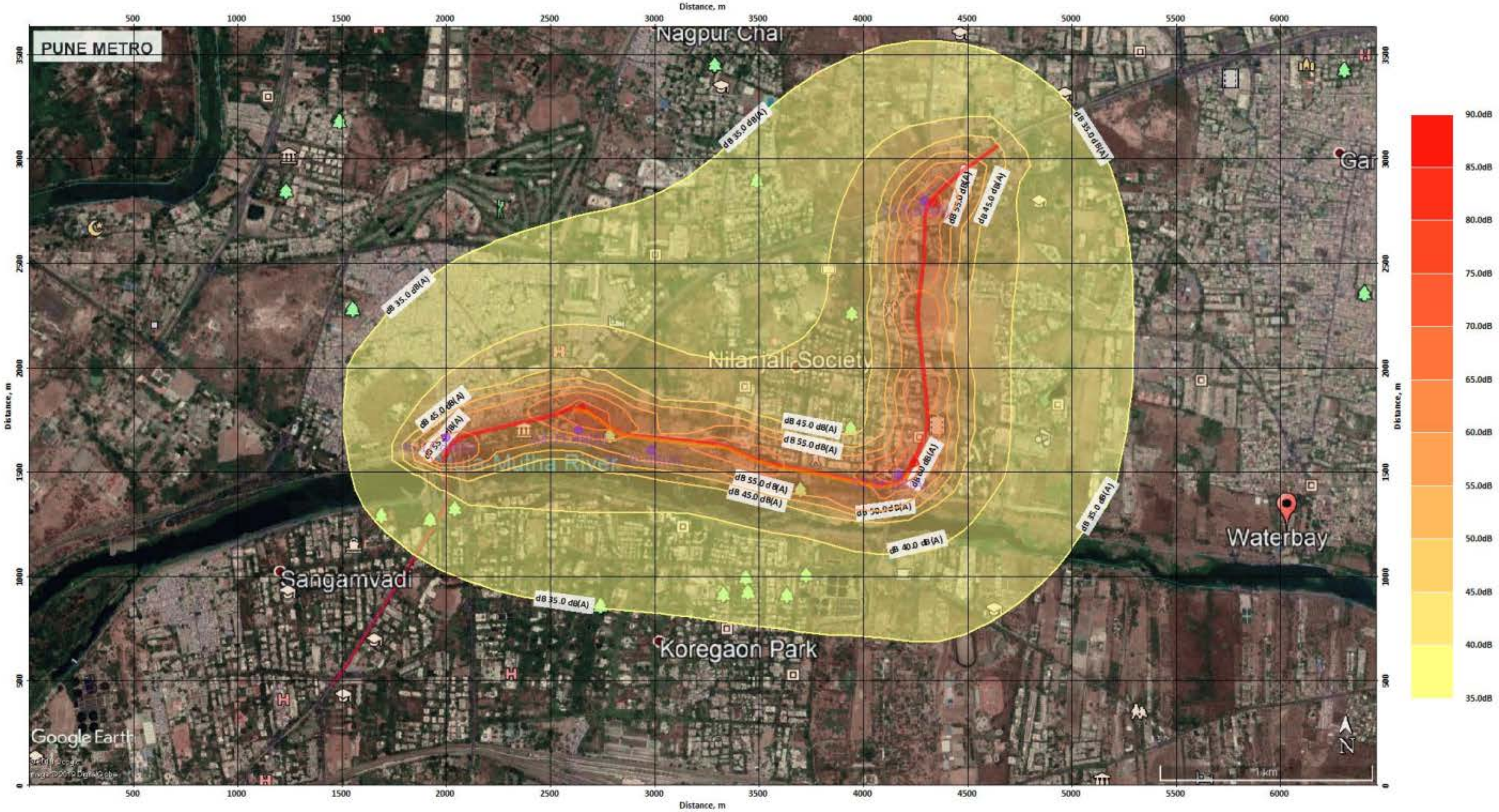
Considering the place at which the activities of DP road are in progress and Metro alignment is proposed, some of the bird species might be impacted during construction phase unless viable management plans are implemented.

8.7.2.6 Impact of Solid Waste

Solid waste will be generated only during construction phase. Since there is not any stations within the alignment under study no solid waste generation will be envisaged.

Floating population for each the station will be around 15000 thousand per day (Source: DPR). Considering 60gm solid waste generation per capita per day, 900 kg solid waste will be generated due floating 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).

Figure 8.21. Predicted Noise Level During Operational Phase



8.8. ENVIRONMENT MANAGEMENT PLAN

The management of the proposed rail alignment will take all the necessary steps to control and mitigate the environmental pollution in the designing stage of the project. While implementing the project, Maharashtra Metro Rail Corporation Limited will follow compliance with respect to environmental legislations.

8.8.1. Management Plan for Land Environment

This revised alignment passes through the proposed Metro Depot reservation EP 49 as per sanctioned DP of Pune City 2017 and then runs along the median of Shivane- Kharadi DP road and adjacent to Dr. Salim Ali Bird Sanctuary.

During Construction Phase:

Following management practices shall be followed

- Excavated material and top soil will be preserved and same shall be used for plantation.
- Excavated *murum* and hard rock shall be used for backfilling and remaining quantity will be used and disposed at identified designated site.
- Stockpiling of excessive excavated material will be avoided.
- Rainy season will be avoided for cutting and filling of earthwork.
- Solid waste management practices shall be as per Solid Waste Management Rules, 2016
- Degradable waste will be composted through organic waste composter and manure will be used for landscaping
- Non degradable waste will be handed over to authorized agency for further treatment and disposal.
- Out of total 106 affected trees maximum trees shall be transplanted at project site. Scientific methodology for transplantation shall be adapted to minimize mortality.
- Fertile top soil (Top 20 cm of soil i.e. 295 cubic meter) shall be used for plantation.
- Contractor is responsible for identifying, collecting, transporting and disposal of all the waste produced at the project site by his personnel
- Waste shall be categorized and stored separately prior to dispose from the project site.
- Unless essential, no area other than underground foundation and erection of piers will be used for this project.

8.8.2. Management of Air Quality

During Construction Phase:

The project will contribute in higher dust levels during construction phase. The concrete will be made from outside source of Ready Mix Plant. The debris and unutilized construction material and earth from the construction site shall be removed immediately to recycle within the project so that no nuisance dust is generated due to wind. Unless essential, construction activities would be avoided during night hours. Stipulated norms will be followed during construction.

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

Following measures would greatly reduce the impacts during the construction and operational phase:

- ❖ 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 monitored with PUC.
- ❖ State Pollution Control Board guideline shall be followed for exhaust of DG sets.

During Operational Phase:

- ❖ During Operational phase DG set will be used in case of power failure only, resulting in insignificant impacts on air pollution.

8.8.3. 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 precautionary measures to control noise pollution as mentioned hereunder.

During Construction Phase:

- ❖ Use of equipment generating noise of not greater than 90 dB (A).
- ❖ The noise control measures during the construction phase include provision of acoustics hoods wherever possible on the construction equipment and regular maintenance of the equipment.

- Recommend light and sound barriers to proposed activities/working areas.
- The construction workers will be provided with the personal protective equipment's like ear muffler, hand gloves etc. to reduce the impact of noise pollution.
- Noise generating activities should preferably be restricted during day time only.

During Operational Phase:

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 and piping holes
- Silent type DG sets with low noise levels that do not require a separate room for installation, are proposed.
- It is recommended to install noise barrier, which will also act as light obstacle.

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 can be achieved by provision of bolster less 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 the turnouts will have to be incorporated in LWR/CWR.

8.8.4. Management of Water Pollution

During Construction Phase

Following management measures are suggested to protect the water quality

- Avoid use of ground water for construction activities.

- Portable sanitation, treatment and disposal facility shall be provided at construction site.
- Construction activities shall be restricted to non-rainy days only.
- Mobile Community toilets shall be provided on the site during construction phase to prevent wastewater from entering the water bodies i.e. Mula Mutha River
- The contractor have to take all precautions to minimize the wastage of water in the construction process.

During Operational Phase

- The waste water will be treated by installing bio digesters at each stations and depots.

Table 8.30. Wastewater Quality Parameters (Influent & Effluent)

SN	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 8.22. Typical Cross Section of Bio Digester

8.8.5. Solid Waste Management Plan

During Construction Phase:

- ❖ Solid waste management practices shall be as per Solid Waste Management Rules, 2016
- ❖ Degradable waste will be composted and used for landscaping
  - ❖ A massive plastic and garbage collection drive, involving the youth of the city, should be conducted at least 3 times a year by the solid waste management division of the Municipal Corporation. The NGOs, Citizens, Schools etc., under the purview of the PMC, should also be involved. Attitudinal changes in the scores of Puneites, residing on the banks of Mula-Mutha, should be long-term goal.

During Operational Phase

- ❖ 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 for degradable waste will be composted at each station and the manure should be used for landscaping
- ❖ Non degradable waste will be handed over to Pune Municipal Corporation for further treatment and disposal.

Organic Waste Converter (OWC):

The OWC processes wet organic waste by employing aerobic microbial decomposition. The machine works in two stages, in the first stage it first crushes the waste and then mixes it homogeneously with the bio decomposition culture. In the second stage this homogeneous mixture is further mixed & churn with saw dust, to soak the excess water content from the biomass which ultimately deodorizes it. The critical components of the machine should be manufactured in SS304, HSD2& WPS for longer life and better results.

Curing: The pre-composted mass is kept for curing and stabilization in the curing bays/drums/Pits for about 12 days. After the 12th day the container is ready with compost and can be used as fertilizer for onsite 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

8.8.6. Traffic Management Plan

Steps to be taken by Maharashtra Metro Rail Corporation, Pune for smooth flow of traffic during construction phase:

- Install, maintain and work within temporary traffic management (using traffic lights, 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 to be taken for safe pedestrian movement.

During Operational Phase:

- Adequate parking will be provided with traffic arrangement at metro station
- Entry exit points to be planned effectively to avoid congestion
- Setting up of sign boards and display boards at metro stations to give information regarding traffic movement.

8.8.7. Management of Ecology and Biodiversity

During Construction Phase:

- Out of total 106 affected trees, maximum trees shall be transplanted at identified locations closed to project site. Scientific methodology, as delineated in separate section, for transplantation shall be adopted to minimize mortality.
- To avoid negative impact on herbaceous vegetation, Vehicle & construction machinery movements should be restricted to designated roads.
- Vegetation clearing by excess application of chemicals/ herbicides, as often used elsewhere, will not be permitted.

- Workers should be trained 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", "off-road driving", "speeding" etc.
- Workers shall report injured animals to the senior officials.
- Training cum awareness program shall be conducted for all workers before construction.
- Workers/labour colony is not proposed on-site.
- Proper management of waste material must be ensured.
- 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.
- No area other than underground foundation and for erection of piers will be used for any other project.
- It is recommended that an aquatic plant the Indian Bulllrush (*Typha angustata*) should be introduced at the edge of the water body. This plant creates an excellent micro habitat for the members of the family 'Rallidae', such as the White breasted water hen.
- In order to retain the existing tree diversity, old Subabhul (*Lucena* sp) may be replaced by nectar providing natives like Indian silk cotton tree, Indian coral tree ('Pangara' in Marathi) and the flame of the forest ('Palash' in Sanskrit) tree. These trees can also be planted on the southern bank of the river.
- Mitigation measures proposed for water, air, noise & vibration will minimize negative impacts on ecology and biodiversity of the project area. Afforestation, transplantation will have positive impacts on biodiversity..

During Operational Phase:

- Bird watching sessions can be conducted for the students/ bird watchers in the vicinity. Schools under the purview of the PMC should be targeted. Audio visual presentations emphasizing rich avifauna of the region should be conducted prior to field sessions. Every bird watching session should conclude by a symbolic plastic collection drive. All field programs should be conducted under the leadership of expert birdwatchers in the city.
- Creating awareness about the native plant culture is the need of the hour. A nursery of native or indigenous plants should be developed on existing land along the northern bank. This initiative would certainly prove to be extremely useful in creating awareness among the people at large. Such a nursery would also act as an important source of saplings of native plants for this part of the city.

- It is suggested to plant flowering trees in the project area so as to attract honey bees, butterfly and other beneficial insects. Project proponent should provide basic infrastructure and training to interested local people for scientific way of apiculture/ horticulture in this area.
- Due to elevated metro rail alignment, impact of the project on riverine ecosystem will be substantially reduced.

- Artificial habitat suitability for bird to be created

Method of transplantation of existing trees

During the process of transplantation it is necessary to see whether the tree responds to a two tier root system, and then a new system is gradually encapsulated in a root ball. The entire method is divided in following steps:

- Preliminary root investigation
- Health diagnosis of the tree
- Treating the infected trees

Root pruning and initiating fresh root growth

Root pruning shall be done systematically to initiate fresh growth of roots and make the plant adapt itself gradually into a new routine whereby after cutting the roots treat the cut parts and feed it with alternative methods. It is a gradual process and it takes about 3-4 months to actually adjust a tree into a new system of living. Before initiating root cutting process, care should be taken that the tree is not infected, otherwise it is to be treated accordingly. Certain growth promoter may be used for root initiation.

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 like pesticides during the course for general treatment. Simultaneously expert staff is needed to sew packing material properly and tightly according to the root requirement. Plant has to pack in the same environment as before. It needs external support to remain in the same position without falling down because of wind pressure. Scaffolding is required for about one and a half to three months depending upon the condition of the tree for each transplanted tree to give it external support

Transportation of trees

Crane is required to lift the packed tree and usually a trolley or truck is used to transport the tree depending upon its size, from its original location to the place where it is to be transplanted. JCB will be used for digging pits. Pruning may be required depending upon the size of the root ball, the plant canopy, health of the plant, species transplanted or because of overhead wires and spread of the road while transplantation of the tree.

Mechanical Support and Pruning

Mechanical support for trees is necessary when the tree is tall, slow to recover & heavily foliaged. Scaffolding is required for about one and a half month for each transplanted tree to give it external support. The support provided to a tree should be removed as soon as the tree can stand alone. It takes about 30 to 45 days in the growing period for the transplanted tree to grow new branches & foliage. The sooner the support will be removed, the faster the tree will become stronger.

Afforestation / Compensatory Plantation/Green Belt Development

The 22 acre (approx.) existing area of Dr. Salim Ali Bird Sanctuary will be enriched/ strengthed by the afforestation/Compensatory plantation/ Greenbelt development which will not only harmonizes with surrounding environment but also acts as pollution sink/ noise barrier. During plantation below mentioned species slection criteria would be followed.

Criteria for Selection of Species: The choice of vegetative species for planting should be based on studies of the natural vegetation in the area and on the environmental conditions.

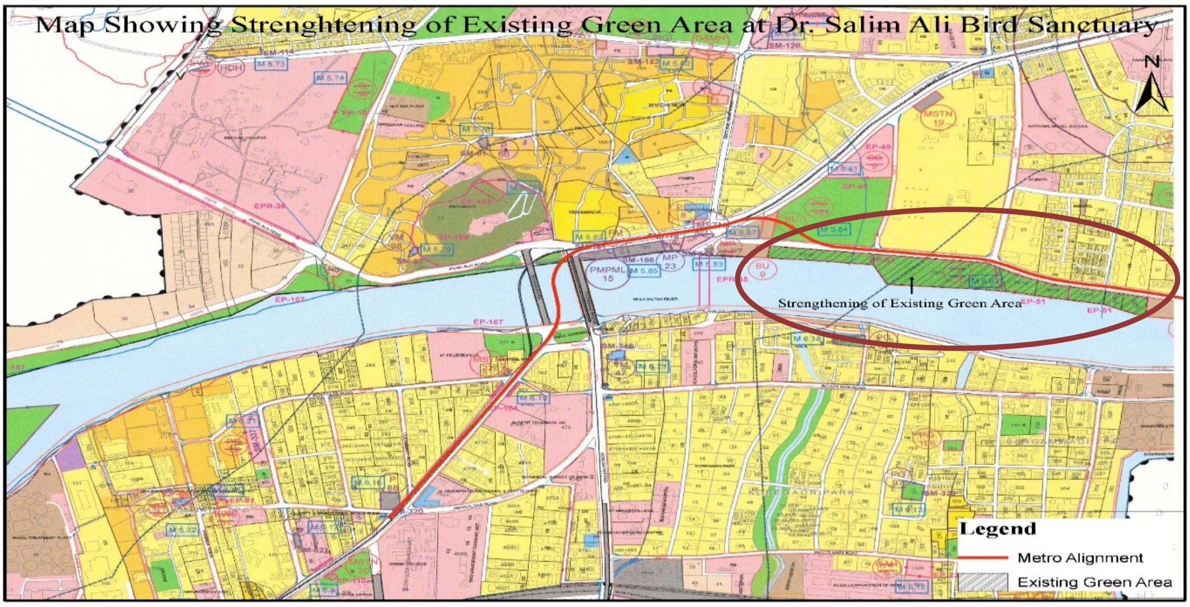
- Plant species that show higher adaptability to local climatic and edaphic conditions
- Tree species should be suitable for natural landscape of surrounding area
- Plants that show vigorous growth and higher forage value
- Preferably indigenous
- Flowering plants so that apiculture / horticulture can be encouraged
- 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 climatic extremes after initial establishment

Table 8.31. List of Tree species suitable for Plantation at Project site

SN	Botanical Name	Vernacular Name	Family
1	*Adansonia digitata* L.	Gorakh chinch	Malvaceae
2	*Aegle marmelos* (L.) Corr.	Bel	Rutaceae
3	*Azadirachta indica* A Juss.	Neem	Meliaceae
4	*Bambusa bambos* (L.) Voss	Bamboo	Poaceae
5	*Bauhinia vahlii* Wight & Arn	Apta	Leguminosae
6	*Bauhinia variegata* L.	Kanchan	Leguminosae
7	*Bombax ceiba* Linn.	Kate – Savar	Malvaceae

SN	Botanical Name	Vernacular Name	Family
8	*Butea monosperma* (Lam.) Taub..	Palas	Leguminosae
9	*Capparis grandis* L.f.	Pachunda	Capparaceae
10	*Cassia fistula* L.	Bahava	Leguminosae
11	*Couroupita guianensis* Aubl.	Kailashpati	Lecythidaceae
12	*Dalbergia latifolia* Roxb.	Shisav	Leguminosae
13	*Putranjiva roxburghii* Wall.	Putranjiva	Putranjivaceae
14	*Phyllanthus emblica* L.	Awala	Phyllanthaceae
15	*Erythrina variegata* L.	Pangara	Leguminosae
16	*Ficus benghalensis* L.	Wad	Moraceae
17	*Ficus microcarpa* L.f.	Nandruk	Moraceae
18	*Ficus racemosa* L.	Umber	Moraceae
19	*Ficus religiosa* L.	Pimpal	Moraceae
20	*Ficus virens* Aiton.	Piparni	Moraceae
21	*Limonia acidissima* Groff	Kavath	Rutaceae
22	*Melia azedarach* L.	Akashneem	Meliaceae
23	*Mangifera indica* L.	Amba	Anacardiaceae
24	*Pongamia pinnata* (L.) Pierre	Karanj	Leguminosae
25	*Salix tetrasperma* Roxb.	Salix/Walunj	Salicaceae
26	*Santalum album* L.	Chandan	Santalaceae
27	*Syzygium cumini* (L.) Skeels	Jamun	Myrtaceae
28	*Tamarindus indica* L.	Chinch	Leguminosae

As per the plan about 318 new trees (1 :3 ratio) would be planted in the existing green area of Dr. Salim Ali Bird Sanctuary for enriching/strengthening of this area. This will be completed within a period of 3 years starting from next year monsoon. A provision of Rs. 25 lakhs including the maintenance has been made in this regard (Refer section 8.8.10) The area of strengthening is shown in below figure.



8.8.8. Socio Economic Aspects

- ❖ Anacquisition of land is required for the proposed alignment
- ❖ No displacement of local shopkeepers, stall holders, residential units etc.
- ❖ No direct impact are envisaged on socio economic condition from the project area

8.8.9. Environment Management Cell

Monitoring and feedback becomes essential to ensure that the mitigation measures planned by way of environmental protection function efficiently during the entire period of operation. EMC is available with client and also to support the EMC GC is in place.

EMC will undertake regular monitoring of the environment and conduct regular audit of the environmental performance during the construction and operation of the project. It will also check whether the stipulated measures are being satisfactorily implemented and operated. It shall also co-ordinate with local authorities to see that all environmental measures are well coordinated.

EMC will perform following functions

- ❖ Monthly review of environmental problems and monitoring of installation / performance / maintenance of pollution control measures.
- ❖ Enforcement of latest rules and regulations under relevant Environmental protection acts, as enlisted in Chapter 2.
- ❖ Preparation of budgetary estimates to seek sanctions for new pollution control measures, if required and / or up-gradation of existing ones based on new technologies.

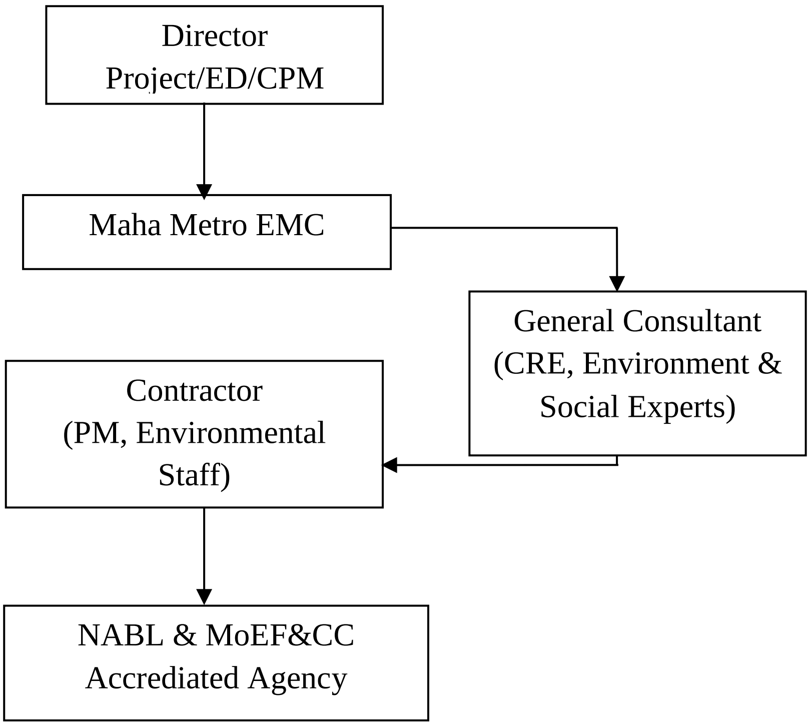
- ❖ Emergency planning

Formation of Task force :

A task force having organizational set-up comprising staff of various grades shall be constituted. The task force will ensure following tasks:

- ❖ Monitoring activities within core and buffer zone.
- ❖ Monitoring efficiency of pollution control schemes.
- ❖ Water and energy conservation.
- ❖ Good housekeeping.
- ❖ Appraising EMC on regular basis.

All the environmental practices will be monitored by the project proponent. An organizational set up, as proposed hereunder, should be formed to ensure the effective implementation of mitigation measures.



8.8.10. Budgetary Provision for ESMP

Monitoring and feedback would be essential to ensure the mitigation measures, planned by way of environmental protection, function efficiently during the entire period of operation.

SN	Pollution Control & other Environmental Infrastructure	Capital Cost in Rs. Lakhs	Annual O & M Cost in Rs. Lakhs
A}	**During Construction Phase: As a part of Civil contract**		
1	Water for Dust Suppression	10.00	-
2	Site Sanitation & Safety	15.00	-
3	Environmental Monitoring	15.00	-
4	Noise controlling practices	12.00	-
5	Traffic Management	10.00	-
6	Barricading	40.00	-
7	Training and awareness	02.00	-
B}	**During Operation Phase:**		
1	Environment Monitoring	-	30.00
2	Apiculture		15.00
3	Training and awareness		10.00
4	Light Barrier along Metro rail alignment near sanctuary area	50.00	05.00
5	Green Belt Development	25.00	05.00
	Total	**179.00**	**65.00**

Table 8.32. Environmental and Social Management Action Plan - Construction Phase

Sr. No	Project Related E & S Issues	Action to be taken	Frequency of Monitoring	Implementation Agency/Authority	Supervision Agency	Remark
1	Ambient and Workplace Air Quality	❖ Water to be sprinkled all over the exposed area using truck-mounted sprinklers on daily basis ❖ The nose-mask to be provided to workers in dust prone area. ❖ All the vehicles should be maintained and monitored with PUC regularly. ❖ Height of heaps of accumulated excavated materials should not be more than height of barricade.	❖ Monitoring shall be conducted twice a month at identified locations. ❖ Ambient air quality shall be reviewed on monthly basis for all monitoring locations. ❖ Mitigation measures to be applied on daily basis.	Contractor	MMRCL & GC	❖ Contractor should undertake monitoring work at the time of construction of work. ❖ Monitoring should be undertaken by MoEF&CC and NABL approved Laboratory. ❖ Without Prior consent of GC/NMRCL for monitoring location, contractor should not conduct air quality monitoring.
2	Ambient and Workplace Noise Level	❖ Provision of acoustics hoods wherever possible on the construction equipment and regular maintenance of the equipment. ❖ Light and sound barriers to proposed activities/ working areas.	❖ Monitoring should be conducted twice a month at identified locations. ❖ Ambient Noise Level should be reviewed on monthly basis for all monitoring locations. ❖ Mitigation measures to be applied on daily basis.	Contractor	MMRCL & GC	❖ Monitoring should be done by MoEF&CC and NABL approved Laboratory. ❖ Without prior consent of GC/NMRCL for monitoring locations, contractor should not conduct Noise level monitoring.

Sr. No	Project Related E & S Issues	Action to be taken	Frequency of Monitoring	Implementation Agency/Authority	Supervision Agency	Remark
		❖ Personal protective equipment like ear muffler, hand gloves etc. to be provided to all the workers to reduce the impact of noise pollution ❖ Movement of vehicles should be strictly restricted to existing roads and tracks				
3	Vibration Control	❖ Latest piling technologies to be deployed by contractor to reduce the impacts on nearby structures; ❖ Impact piling should not be allowed for piling works other than in very hard rock strata; ❖ Regular vibration monitoring should be conducted at sensitive locations to make sure that project vibration levels for construction phase do not exceed the permissible limits specified	❖ Monitoring should be conducted twice a month at identified locations. ❖ Regular review of vibration levels recorded during the construction phase should be done and suitable precautionary measures must be undertaken	Contractor	MMRCL & GC	❖ Contract should undertake monitoring work at the time of construction of work. ❖ Monitoring should be undertaken by MoEF&CC and NABL approved Laboratory. ❖ Without prior consent of GC/NMRCL for monitoring locations, contractor should not conduct vibration monitoring

Sr. No	Project Related E & S Issues	Action to be taken	Frequency of Monitoring	Implementation Agency/Authority	Supervision Agency	Remark
		by Director General Mines Safety, GOI (DGMS)				
4	Waste Management (At Construction site and at Utility works)	❖ The contractor should prepare the waste management plan and submit the same to the MMRCL/GC for concurrence. ❖ Contractor to ensure excavated murum and hard rock be used for backfilling and remaining quantity be disposed at Pune Municipal Corporation authorized site. ❖ used oil disposal as per hazardous waste rule ❖ Fertile top soil should be used for plantation	❖ Monitoring should be conducted regularly as and when required ❖ Monthly review of waste disposal by contractor should be undertaken	Contractor	MMRCL & GC	

Sr. No	Project Related E & S Issues	Action to be taken	Frequency of Monitoring	Implementation Agency/Authority	Supervision Agency	Remark
5	Tree protection /cutting and transplantation	❖ Approval of Tree Authority Committee of Pune Municipal Corporation for tree cutting/ felling and transplantation at the site & protection of the same ❖ Out of total 106 affected trees maximum tress to be transplanted at project site. ❖ Scientific methodology for transplantation to be adapted to minimize mortality.	Monthly review of tree protection/felling/transplantation by contractor should be done	Contractor	MMRCL & GC	
6	Soil and Water Quality	❖ Contractor should not use ground water for construction activities. ❖ Contractor should take all necessary precautions towards construction material, diesel, grease, waste oil, chemicals etc. to avoid spillage on ground	❖ Monitoring should be conducted monthly at three locations. ❖ Mitigation measures to be applied on daily basis	Contractor	MMRCL & GC	❖ Contract should undertake monitoring work at the time of construction of work. ❖ Monitoring should be done by MoEF&CC and NABL approved Laboratory. ❖ Without prior consent
7	Energy Management/ conservation	❖ All the vehicles should be maintained and monitored with PUC regularly. ¨	Monthly review towards specific energy consumption	Contractor	MMRCL & GC	

Sr. No	Project Related E & S Issues	Action to be taken	Frequency of Monitoring	Implementation Agency/Authority	Supervision Agency	Remark
		❖ Five star labeled equipment by BEE/or its equivalent shall be used at project offices.				
8	Sanitation and Sewage Management at	❖ Portable sanitation, treatment and disposal facility should be provided at construction site	❖ Monitoring should be conducted monthly. ❖ Mitigation measures to be applied on daily basis	Contractor	MMRCL & GC	
9	Ecology and Biodiversity	❖ Workers/labour colony is not proposed on-site ❖ Construction material should not be dumped on bank of river ❖ Movement of vehicle should be monitored for not blowing excessive horn. ❖ Restriction of construction activity from dawn to dusk. ❖ 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; off-road driving; speeding etc.	Monitoring should be conducted quarterly	Contractor	MMRCL & GC	

Sr. No	Project Related E & S Issues	Action to be taken	Frequency of Monitoring	Implementation Agency/Authority	Supervision Agency	Remark
		❖ Workers should report injured animals to the senior officials and inform to animal rescue facility of Pune Municipal Corporation. ❖ Monthly training/ awareness program should be conducted for all workers ❖ Landscaping and plantation should be developed by contractor				
10	Traffic	❖ Install, maintain and work within temporary traffic management (using traffic lights, cones and barriers) to keep the traffic flow safe. ❖ Regarding transportation of construction material, precaution must be taken to reduce impact of vehicular movement by restricting movement in non-peak hours.	Regular monitoring in consultation with Traffic Police as an when required at construction site	Contractor	MMRCL & GC	

Sr. No	Project Related E & S Issues	Action to be taken	Frequency of Monitoring	Implementation Agency/Authority	Supervision Agency	Remark
		❖ 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.				

Table 8.33.Environmental and Social Management Action Plan - Operation Phase

Sr. No	Project Related E & S Issues	Action to be taken	Frequency of Monitoring	Implementation Agency/Authority	Supervision Agency
1	Ambient and Workplace Air Quality	❖ Periodic monitoring of ambient air quality at all metro locations should be undertaken to study the impact of project on the Ambient Air Quality ❖ DG set stack monitoring	❖ Monitoring should be conducted quarterly at all the metro stations	Monitoring should be done by MoEF&CC and NABL approved Laboratory	MMRCL
2	Ambient and Workplace Noise Level	❖ Periodic monitoring of ambient noise level at metro locations' ❖ DG set stack noise monitoring	❖ Monitoring should be conducted quarterly at each metro station	Monitoring should be done by MoEF&CC and NABL approved Laboratory	MMRCL

Sr. No	Project Related E & S Issues	Action to be taken	Frequency of Monitoring	Implementation Agency/Authority	Supervision Agency
3	Vibration Control	❖ Periodic monitoring of vibration levels at identified sensitive locations should be conducted through-out the stretch.	❖ Quarterly monitoring of vibrations and review shall be done	Monitoring should be done by MoEF&CC and NABL approved Laboratory	MMRCL
4	Waste Management (At Construction Site and at Utility works)	❖ Separate community bins (one for wet waste and one for dry waste) of 240 liters capacity should be placed at each station ❖ Organic waste composter of 500kg/day capacity should be provided at each metro station ❖ Degradable (organic) waste of approx. 360 kg should be composted by organic waste composter and used for landscaping ❖ Non degradable waste of approx. 540 kg must be handed over to Pune Municipal Corporation for further treatment and disposal.	Monthly review of waste disposal by contractor should be done	Monitoring should be done by MoEF&CC and NABL approved Laboratory	MMRCL
5	Soil and Water Quality/Drinking water Supply / Sanitation and Sewage Management	❖ Sufficient quantity of water to be supplied at Stations and Depot for various purposes. ❖ waste water will be treated by installing bio digesters at each stations and depots ❖ Maximum treated water should be used for flushing and landscaping.	❖ Monitoring should be conducted quarterly at two locations. ❖ Mitigation measures to be applied on daily basis	Monitoring should be done by MoEF&CC and NABL approved Laboratory	MMRCL

Sr. No	Project Related E & S Issues	Action to be taken	Frequency of Monitoring	Implementation Agency/Authority	Supervision Agency
		❖ Rain water harvesting should be done at each Metro station. ❖ No STP be constructed on bank of Mula Mutha river basin. ❖ Excess treated water should be discharged to Pune Municipal corporation drainage line. ❖ Maha-Metro should install an eco-friendly Defense Research and Development Establishment (DRDE) developed Bio-digester at both the metro stations ❖ Provisions for containing oil spills should be made at depots.			
6	Energy Management/ conservation	Maha-Metro's Pune Metro Rail Project is developing Metro Station building as per IGBC norms for obtaining the prestigious Green Building Certification from Indian Green Building Council. Station will be constructed as per IGBC Certified Green Buildings norms under MRTS rating system by taking following measures: ❖ Energy efficient HVAC system, ❖ Day lighting inside buildings, ❖ Adoption of LED lighting, ❖ Solar pipe based lighting in Station Concourse,	Monthly review of specific energy consumption	Monitoring should be done by NABL approved Laboratory	MMRCL

Sr. No	Project Related E & S Issues	Action to be taken	Frequency of Monitoring	Implementation Agency/Authority	Supervision Agency
		❖ Thermal insulation through Double Glass units, ❖ Water Recycling, ❖ Rain water Harvesting, ❖ Adoption of Anaerobic Bacteria based sewage treatment plants, ❖ Building materials using materials like Fly-Ash.			
7	Traffic	❖ Traffic diversions on account of metro utilities should be planned in consultation with traffic police ❖ Adequate number of road signs with clear visibility must be installed around metro stations. ❖ Drivers and public should be educated about the road safety and traffic rules.	Regular monitoring	Third Party	MMRCL

8.9. ENVIRONMENTAL MONITORING PROGRAM

A comprehensive monitoring programme is suggested hereunder. Environmental attributes to be monitored during construction and operational phases are presented in Tables 8.34.and 8.35.

Table 8.34.Monitoring program during construction phase at three locations

Component	Parameters	Location	Frequency	Implementation by	Supervision Agency
Ambient Air Quality	PM_{10}, $PM_{2.5}$, SO_2, NOx,	1. Construction site 2. Within Dr. Salim Ali Bird Sanctuary 3. Kalyaninagar	Fortnightly	Contractor	MMRCL and GC
Noise Level	Leq day, Leq night, dB(A)	1. Construction site 2. Within Dr. Salim Ali Bird Sanctuary 3. Kalyaninagar	Fortnightly	Contractor	MMRCL and GC
Surface Water Quality	Physical, Chemical & Biological Parameters	Mula Mutha River along the Sanctuary	Monthly	Contractor	MMRCL and GC
Drinking Water	IS 10500:2012	At construction site	Monthly	Contractor	MMRCL and GC
Soil Quality	As per standards	1. Construction site 2. Within Dr. Salim Ali Bird Sanctuary	Quarterly	Contractor	MMRCL and GC
Health of employees	All relevant parameters	All working areas	Periodical check ups	Contractor	MMRCL and GC
Solid/ hazardous wastes	Depending on type of wastes	At the construction area	Monthly	Contractor	MMRCL and GC
Ecology & Biodiversity	Plantation / Green belt development, periodical monitoring of aquatic ecology	Project site and periphery	Quarterly	Contractor	MMRCL and GC

Table 8.35.Monitoring during operation phase at two locations

Component	Parameters	Frequency	Implementation by	Supervision Agency
Ambient Air Quality	PM_{10}, $PM_{2.5}$, SO_2, NOx,	Quarterly	Third Party	MMRCL
DG Sets	Particulates, SO2, NOx, CO, HC	Quarterly	Third Party	MMRCL
Noise Level	Leq day, Leq night, dB(A)	Quarterly	Third Party	MMRCL

Component	Parameters	Frequency	Implementation by	Supervision Agency
Surface and Ground Water Quality	Physical, Chemical & Biological Parameters	Quarterly	Third Party	MMRCL
Drinking Water	IS 10500:2012	Quarterly	Third Party	MMRCL
Solid/ hazardous wastes	Depending on type of wastes	Quarterly	Third Party	MMRCL
Ecology & Biodiversity	Plantation / Green belt development, Periodically monitoring of aquatic ecology	Six Monthly	Third Party	MMRCL
Waste Water (Sewage)	As per SPCB guidelines	Quarterly	Third Party	MMRCL

Chapter 9 : Environmental Management Plan

9.1. 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 Buildings and solar power
  - Use of Energy and Water
  - Utility Plan

    Socio-Economic aspects & Rehablitation of Kamgar Putla & Rajiv Gandhi Nagar slums
- **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**

9.2. EMP DURING PROJECT LOCATION AND DESIGN

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[10]. 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%[11].

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[12].

9.2.1. Compensatory Afforestation

In order to conserve/Preserve trees, Maha-Metro has taken a conscious decision not to cut trees as much as possible and affected trees are being transplanted. In this regard out of 2452 impacted trees 2264 transplanted at other available location of the city while other 188 no. trees felled due to its age and safety concern. Location wise details of transplanted and new planted saplings are presented in below tables :

Sr. No.	Project site including Stations	Trees Felled	Trees Transplanted	Transplantation Site
1.	Reach -1 (PCMC- Range Hill)	0	443	Kasarwadi STP
2.	Reach -2 (Vanaz-Civil Court) i.e.	7	158	Forest Area ARAI

[10]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
[11]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
[12]*Intermediate tree cover can maximize groundwater recharge in the seasonally dry tropics, U.Llstedtetal, February 2016, www.nature.com*

Sr. No.	Project site including Stations	Trees Felled	Trees Transplanted	Transplantation Site
3.	Reach- 3 (Civil court-Ramwadi) i.e.	17	427	Dr.Salim Ali Bird Sanctuary, Bund Garden. Nagar Road
4.	(Reach-4) – Swargate,Civil Court,Shivajinagar,Mandai ,Budhwar Peth and Are Dairy	164	569	Arey Dairy Bus Stand, Range Hill & Taljai Forest Area, Alandi MSRTC Bus Depot, Survey No.01Taljai & Survey No. 69, Dhanori & Range Hill/Command Hospital
5.	Range Hill Depot	0	506	Agriculture College, Range Hill-KCB
6.	Vanaz Depot	0	161	Vanaz Kachara Depot, ARAI
Grand Total		**188 +**	**2264**	**= 2452**

Further, Location wise details of felled trees are as below.

S.No.	Locations	Trees Felled
11.	Budhwar Peth	10
12.	Mandai	7
13.	Shivaji Nagar	10
14.	Civil Court	13
15.	Are Dairy	123
16.	Swargate	1
17.	Garware College	7
18.	Mangalwar Peth	9
19.	Ruby Hall	7
20.	Kalyani Nagar	1
Total		**188**

The survival rate of transplanted trees are about 67%,.In order to maximize the survival rate of transplanted trees a well defined method statement is in place, despite that some trees have failed their survival due to climatic factors, Hence to compensate the loss, a compensatory plantation is being done by the contractor with same species at the ratio of 1:5 and maintenance like watering, manuring, watch and ward is being done for another one year at his own cost.

In order to compensate the loss of trees,total **17,986 new saplings have been planted at various locations of the city against 2452 no. of impacted trees which is almost 8 times more and well beyond the requirement of 3 times of new plantation for each transplant/cutting**

mandated under local law i.e. Maharashtra (Urban Areas) Protection & Preservation of Trees Act 1975 and Maharashtra (Urban Areas) Protection & Preservation of Trees Rules 2009. New Sapling plantations across the Pune City and major planted species are presented in below subsequent tables:

New sapling plantations across the Pune City

Year	Sr.	Place	PMC	PCMC
2017 (A)	1	Vanvihar Taljai	3000	-
	2	Akurdi Metro Eco Park	-	100
	3	Sahyog Kendra	-	40
		Total (A)	**3000**	**140**
2018 (B)	1	I.T.I Aundh	1200	-
	2	Vanvihar Taljai	1000	-
	3	Range Hill Campus	1700	-
	4	Gref Centre, Dighi	2000	-
	5	Akurdi Railway Line	-	-
	6	Akurdi Metro Eco-Park	-	500
	7	Ordnance Factory Khadki	200	
		Total (B)	**6100**	**500**
2019 (C)	1	Kharadi Forest Surrvey No. 74	100	-
	2	Army Campus Pimple Nilakh		4700
	3	Deccan College Campus	270	
		Total (C)	**370**	**4700**
		Total A+B+C	**9470**	**5340**
2020 (D)	1	Deccan College Campus	25	-
	2	Agriculture College Campus	115	-
	3	National Institute of Naturopathy	200	-
	4	Tarkeshwar Tekdi, Yerwada	270	-
	5	Dhanori Forest Survey No. 69	275	-
	6	Wagholi Forest Area Gat No. 864	714	-
		Total D	**1599**	
2021 (E)	1	Casting Yard-Nashik Phata	-	17
	2	Pimple Nilakh	-	10
	3	Casting Yard – Kiwale	-	5
	4	College of Agriculture	55	-
	5	River Bed Deccan	15	-
	6	Yerwada J.Kumar Office	15	-

Year	Sr.	Place	PMC	PCMC
	7	Casting Yard –Wagholi	25	-
	8	Khadki Cantonment Area	1416	-
	9	HVPC Depot Kothrud	9	-
	10	Range Hill Office Campus	10	-
		Total E	**1545**	**32**
		Total A+B+C+D+E	**12614**	**5372**
		Total PMC & PCMC	**12614+5372= 17986**	

The survival rate of new saplings are about 89%. Again to compensate the dead plant, a compensatory plantation is being done by the contractor with same species @ ratio of 1:5 and maintenance like watering, manuring, watch and ward is being done for another one year at his own cost. Plantation of the new saplings is still balance and will be planted in coming months. Major species of new saplings planted across the Pune city are presented in below table.

Major Species of new plantations across the Pune City

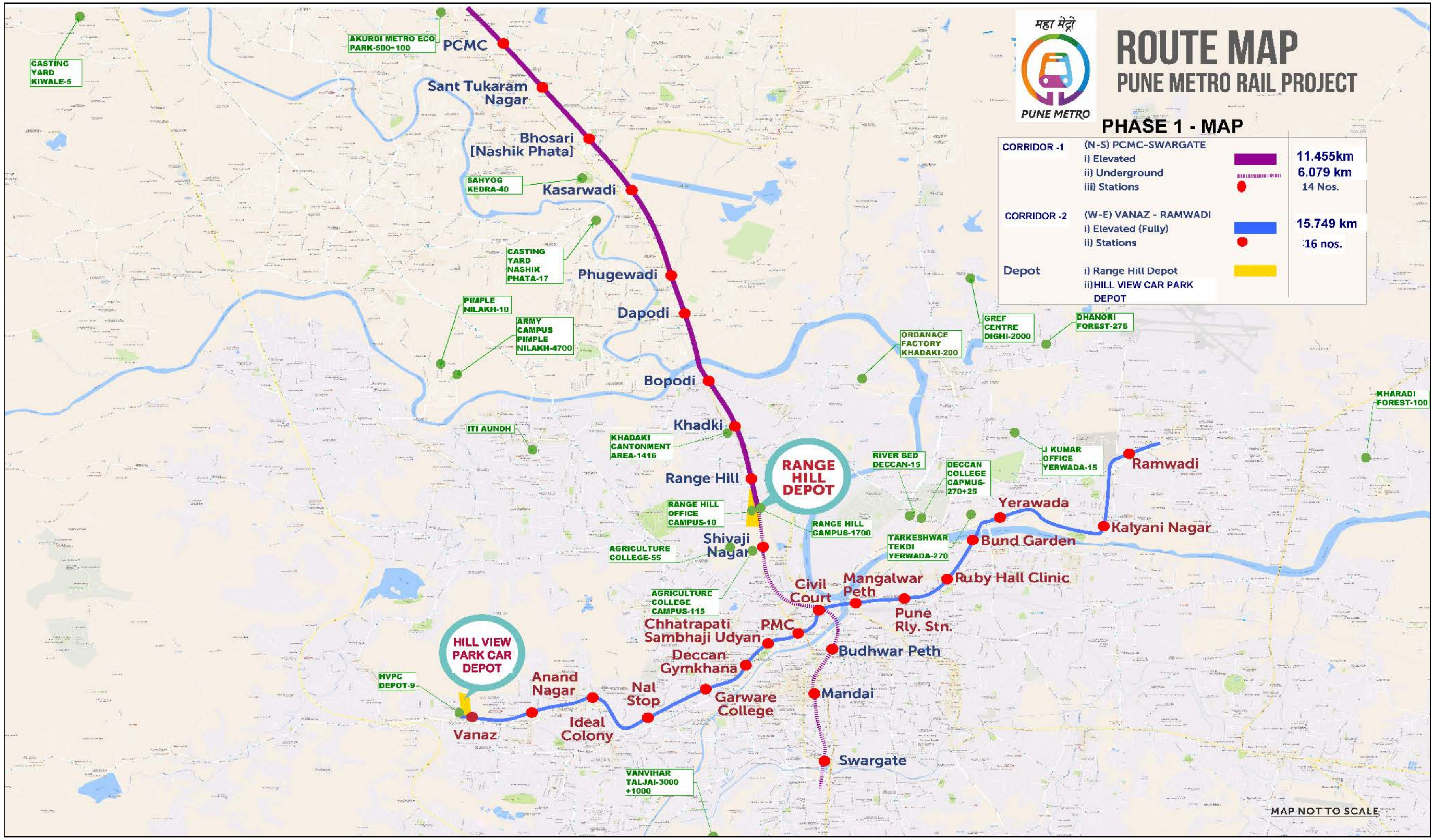
S. No.	Local Name	Botanical Name
38.	Bakul	Mimusops Elengi
39.	Jambhul	Syzygium Cumini L
40.	Mahogany	Swietenia
41.	Naral	Cocos Nucifera
42.	Pipal	Ficus Religiosa
43.	Vad	Ficus Benghalensis
44.	Karanj	Pongame oiltree
45.	Sheesham	Indian rosewood
46.	Jamun	Java Plum
47.	Kanchan	Bauhinia variegata
48.	Audumber	Cluster fig
49.	Chinch	Tamarindus Indica
50.	Bhendi	Portia tree
51.	Kadam	Neolamarckia cadamba
52.	Amba	Mangifera indica
53.	Fanas (Jack fruit)	Arthocarpus heterophyllus
54.	Peru	Myroxylon balsamum

S. No.	Local Name	Botanical Name
55.	Ramphal	Annona reticulata
56.	Malbery	Morus alba
57.	Tabobia	Lagerstroemia speciosa
58.	Badam	T. catappa
59.	Tamhan	Lagerstromia reginea/ Speciosa
60.	Sitaphal	Annona reticulata
61.	Chinch	Tamarindus indica
62.	Awala	Phyllanthus emblica/ Emblica officinali
63.	Chiku	Manilkara zapota
64.	Bel	Aegle marmelos
65.	Kavath	Limonia aciddissima
66.	Khaya	Psidium
67.	Arjun	Khaya senegalensis
68.	Shnkasur	Swietenia
69.	Gulmohar	Caesalpinia pulcherrima
70.	Kanteshawar	Delonix regia
71.	imali	Neolamarckia cadamba
72.	Neem	Azadirachta indica
73.	Sirs	Albizia lebbec
74.	Kathal	Albizia lebbeck

The location map of transplanted trees as well as newly planted trees are presented in below figures:

Locations map of transplanted trees across Pune City

Locations map of new planted trees across the Pune City



The survival rate of transplanted trees and new plantations are about 67%, and 89% respectively.In order to maximize the survival rate of transplanted trees and planted trees a well defined method statement is in place, despite that some trees have failed their survival due to climatic factors, Hence to compensate the loss, a compensatory plantation is being done by the contractor at the same place with the same species at the ratio of 1:5 and maintenance like watering, manuring, watch and ward is being done for another one year at his own cost.

Estimated compensatory afforestation cost for the proposed corridors is given in Table 9.1 by considering Plantation rate of Rs. 852/- per sapling (source: Parks and Garden Department of PMC)

Table 9.1. Cost of Compensatory Afforestation

S. No	Corridor/Depot	Compensatory Afforestation Cost
1.	N-S and E-W corridor +Range Hill Depot+ Vanaz Depot	**17986 x 852 = 15,324,072**

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.

9.2.2. 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.

9.2.3. 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).*

9.2.4. 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.

9.2.5. 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 CO_2. 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

9.2.6. Solar Power

For the utilization of renewable energy, wherever feasible, installations for solar power can be implemented on the roof of elevated stations and in Depots. It is assumed that 75% of roof area of each station is considered for solar power generation. Solar energy generation per year is estimated to be 2.74 Giga-watt-hr for both PCMC-Range Hill corridor & Vanaz-Civil Court corridor; and 2.13 Giga-watt-hr for Civil Court - Ramwadi Corridor. Details of solar power generation for each corridor are given in Table 9.2. 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 & Vanaz-Civil Court corridor; and Rs 139.69 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.

Table 9.2. Solar Power Generation Potential for each Corridor

S. No	Corridor	Stations		Power Generation in GWH per Year	Total Cost in Rs. Lakh
		No	Total Area in Sq.m		
1.	PCMC - Range Hill	9	22806	2.74	179.60
2.	Vanaz - Civil Court	9	22806	2.74	179.60
3.	Civil Court - Ramwadi	7	17738	2.13	139.69

9.2.7. 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.

9.2.8. 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 9.3.

Table 9.3. 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.

S. No.	Organization/ Department	Utility/Services
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

9.2.9. Socioeconomic Aspects and R&R of Kamgar Putla and Rajiv Gandhi Nagar

Total land requirement for both the corridors is 43.93 hectares. Out of this, 42.98 ha is Government land and balance 0.95 ha are private land. Ownership wise details of the land is given in below tables.

S.N	Ownership of the land	Area of Land (in ha)
17.	GoM	20.27
18.	PMC	16.71
19.	PCMC	2.21
20.	PMPL	0.01
21.	Railway	0.18
22.	Defence	3.47
23.	All India Radio	0.13
24.	Pvt land (Cor1 +Cor2)	0.95
Total		**43.93**

As per original plan total 688 families was affected permanently due to the N-S and W-E corridor. Out of the total 688 families, 628 are Non-Title Holders (NTH) and the 60 are Title Holders (TH). The details of the original PAF is presented in below table.

S.No.	Name of Location	Category of PAF		
		Title Holder	Non-Title Holder	Total
1.	Deccan Corner	0	28	28
2.	Ideal Colony	0	30	30
3.	Kaamgar Putla	0	132	132
4.	Nashik Phata	0	4	4
5.	Khadki	0	6	6
6.	Nal Stop	0	5	5
7.	Phugewadi	0	4	4
8.	Rajiv Nagar/Juna Topkhana	10	92	102
9.	Budhwarpeth	22	89	111
10.	Mandai	28	86	114
11.	Agriculture collage	0	33	33
12.	Shivaji Nagar Bus Stop	0	32	32
13.	Swargate	0	87	87

	Total	**60**	**628**	**688**

The Civil court area, to be developed as a multimodal integration hub wherein 2 lines of Maha Metro are interconnecting with the overhead and underground stations. The third line of PMRDA starting from Hinjewadi also culminates at Civil Court area. PMC will widen the roads for additional traffic load and the interconnectivity of the stations. The development of this area is being undertaken by these independent agencies as per their priority and timelines.

The original RAP report submitted in 2019 indicated that the Metro footprint on Kamgar Putla and Rajiv Gandhi Nagar slums was likely to affect about 234 families which is now 274 Subsequently, it was decided by the Govt. of Maharashtra that entire area of Kamgar Putla and Rajiv Gandhi Nagar is required for infrastructural development by multiple stakeholder's i.e., Pune Municipal Corporation (PMC), Pune Metropolitan Region Development Authority (PMRDA), Slum Rehabilitation Authority and Maha Metro. Due to involvement of Multiple Stake Holders at Kamgar Putla & Rajiv Gandhi Nagar a unified Rehabilitation policy was adopted by Divisional Commissioner, Pune who is the administrative head of Pune and thus the approved resettlement policy framework (RPF) and RAP of Maha-Metro could not be implemented to the letter.

Due to development of entire area of Kamgar Putla and Rajiv Gandhi Nagar by different stakeholders, the Slum Rehabilitation Authority was assigned the task for conducting the survey to determine the number of families residing in Rajiv Gandhi Nagar and Kamgarputla slums.

Upon completion of survey, it was concluded that that 1264 families are residing in this area. These 1264 families to be rehabilitated by the three agencies and share of rehabilitation had been duly allocated i.e. Maha Metro -274, PMRDA -114, PMC -322 while another 554 families (distributed among all stake holders) directly not being affected but would be impacted by the other development facilities for the commuters and need to be rehabilitated. Maha-Metro footprint is only impacting 274 families at Kamgar Putla and Rajiv Gandhi Nagar slums hence the no. of PAF get revised.

The details of the revised PAFs are presented in below table.

S.No.	**Location**	**PAFs**	**PAPs**	**Remarks**
34.	Deccan	15	60	Out of 28 only 15 PAFs are getting impacted
35.	Shivaji Nagar	32	157	-
36.	Swargate	87	257	-
37.	Agri. College	33	130	-
38.	Mandai-Residential and Commercial	50 113	220	-
39.	Kaamgar Putla	274	1370	

	& Rajiv Gandhi Nagar			
40.	Khadki	0	0	No impact due to reduction in land requirement.
41.	Budhwarpeth	2	10	Due to relocation of the Budhwarpeth station into defunct Dado ji Kondev school building, the no. of PAF has drastically reduced from earlier 111 to 2
42.	Ideal Colony	0	0	No impact due to change in design
10	Nashik Phata	0	0	No impact due to change in design
43.	Nal Stop	0	0	No impact due to change in design
44.	Phugewadi	0	0	No impact due to change in design
Total		**606**	**2769**	

After Revision in PAFs numbers, Shri Nitin Udhaas, Dy. Commissioner, PMC (Zone 2) was appointed vide letter 05.07.2019 and 1.10.2020 as the Competent Authority for SRA to undertake this assignment and to determine the eligibility of the families.

The Competent Authority initiated the process of survey in January 2020 and the residents were asked to submit their documents to the SRA office for verification, but the families has not came forward till October 2020. Then Rajiv Gandhi Nagar slum dwellers came forward with their papers to initiate the eligibility process.

Subsequently, a series of meetings were held among the various stake holders PMC, PMRDA and Maha Metro and the residents of Kamgar Putla and Rajiv Gandhi Nagar were informed that the entire area under survey No 806, 806A, 807, 808, 809 and 810 is required by the State Govt. for development work of Khardi to Shiveni – D.P. (Development Plan) Road, Red line and blue line of Irrigation Department, Maha Metro and PMRDA lines. This was communicated to all the individual slum dwellers residing in the said slum areas vide letter no. 4213 dated 01.01.2021 and signed by Maha-Metro, PMRDA, PMC, SRA and Divisional Commissioner.

In the same letter it was clarified by the Competent Authority that there is no possibility for in situ rehabilitation. The families residing on the said premises, on meeting the eligibility criteria would be entitled to ready to move in residential units at Viman Nagar or Hadapsar. Location of other houses available with SRA /PMC schemes was also shared but those were rejected by the families in favour of Viman Nagar and Hadapsar. Initially, the SRA cut-off date was 1.1.2000 but this was extended up to 23.12.2016 (Metro cut-off date) on humanitarian grounds to accommodate more residents under the benefit which is in line with the definition of "Cut-off date" defined in World Bank Guidelines on Environment and Social Impact.

Fixing Eligibility of Affected Families:

To fix the eligibility criteria, proof of residence like Aadhaar card, gas bills, ration cards, water bills, and electricity bills etc. prior to Metro cut-off date was required. As per SRA Minimum three documents were necessary to establish proof of residence. In some cases, marriage cards and vaccination certificates were also accepted as proof of same.

Out of 1264 families, 1063 (84%) families had met the eligibility criteria and were entitled to housing facilities. As per directive of the Divisional Commissioner, Pune, all eligible families were to be given the same benefits since any discrimination in benefits would evidently lead to chaos, unrest and even create a law-and-order situation.

After fixing the eligibility, the Competent Authority on 24.03.2021 published a public notice in newspapers Lokmat Daily Pudari, intimating the slum dwellers to raise objections if any to this process.

Maha-Metro footprint is only impacting 274 families (earlier it was 234). Of these 12 are commercial units and balance 262 are residential families of the 12 commercial units, 10 have collected compensation while 2 have been rejected. The rejection for commercial units was on inadequate papers in one case and Family had claimed a housing unit in another scheme. Out of these 262 families, 26 families have been rejected due to the reasons mentioned in the below.

- 4 Families claimed in other scheme and not eligible under current R&R Scheme.
- 14 Families already received one unit in current R&R Scheme,
- 4 Families - No claim was submitted,
- 2 Families are unable to provide proof of residence prior to cut off date.
- 1 Family has to establish their legal heir,
- 1 Family submitted fake claim

Grievance Redressal Mechanism:

A grievance redressal mechanism is in place for the aggrieved families with reference to disagreement regarding their eligibility. These affected families had the option of meeting the Competent Authority of SRA (Slum Rehabilitation Authority) for confirming their eligibility. In case of dispute, they could prefer a first appeal to SRA; then a second appeal to the Divisional Commissioners Office; then the district court at Pune and subsequently the Bombay High Court. Some of the residents approached the Bombay High court and District court pertaining to this rehabilitation process and honorable court has observed that joint action of rehabilitation taken up by SRA, PMRDA, PMC and Maha-Metro has been strictly according to due process of law.

Allotment Process:

On 24.03.2021, the Competent Authority published a notice in the newspapers Lokmat Daily Pundari, intimating the slum dwellers to raise objections if any by 26.03.2021. Since the families meeting the eligibility criteria were entitled to drawing lottery for the allocation of apartments. This process of lottery was initiated on 31.03.2021. It was also intimated that the final list of allottees would be published on 01.04.2021.

Special camps were arranged in the vicinity of Civil Court for registration of Sale Agreements between SRA and joint ownership of husband and wife of the rehabilitated family. Those families who completed the registration formalities were handed out the keys of the new flats at Viman Nagar / Hadapsar. The families were provided the actual transportation cost from Civil Court to Viman Nagar /Hadapsar.

Clearing the Kamgar Putla and Rajiv Gandhi Nagar Land Parcel:

After availing all legal recourse by the affected families, the process for vacating the area was initiated. Accordingly, intimation was sent to individuals and notices were published in the newspapers. It was posted at all prominent places in the area, informing the residents that the area will be cleared out. Announcements were made over microphone so residents who had failed to read these notices are aware that on the given date and time demolition activity will be undertaken and they are requested to take their belongings and move away from the area. The eligible slum dwellers already had tenements allotted to them with proper registration of sale deeds. This process has been underway since March 2021 and affected families had been given sufficient time to vacate the land.

PMC officers with support of man and machinery provided by Maha Metro undertook the evacuation process. In order to avoid any law-and-order problem district administration had provided adequate police protection which included female police personnel. The slum dwellers were treated with utmost dignity and there was no instance of man handling. The belongings of the non-eligible residents were packed and a Panchama (i.e., a list) is written covering the details of the items packed. This is signed by the resident and the PMC officer before being moved to a warehouse from where it can be collected on showing of valid document.

Kamgar Putla & Rajiv Gandhi Nagar land parcel and its Utilization by Stakeholders:

Kamgar Putla land is 7135.927 sq. meters and belongs to Govt. of Maharashtra (Pune District Soldier, Sailor and Airmen Board). There are 651 families living on these premises. Metro footprint on this area is 1114 sq.m i.e. 15.61% of the total area and impacts 59 families living in this area. The total Area for Rajiv Gandhi Nagar is 13433.513 sq.m. and belongs to Pune Municipal Corporation (PMC). Besides the PMC land this land parcel comprises three private land holdings measuring a total of 3731.05 Sq.m. In this case Metro impact is about 49% of the land which is inclusive of the private land holdings and affecting 215 families. The land details and their distribution among stakeholders are presented in below Table .

Table : Area Requirement by different stakeholders

S. No.	Description	Area in S.Q.M	Remarks
Kamgar Putla			
12.	Maha-Metro Corridor-2	917.011	Govt land

13.	PMRDA Line-3	1462.484	Govt land
14.	Maha-Metro and PMRDA Combined	393.966	Govt land
15.	MMI and Public Conveniences	3838.103	Govt land
16.	Area for PMC DP Road	524.363	Govt land
Total		7135.927	Govt land
Rajiv Gandhi Nagar			
17.	Maha-Metro Corridor-2	2096.212	Govt land
18.	FP807B/1&2 Maha-Metro	1171.29	*Private Land
19.	FP808 Maha-Metro	2225.76	**Private Land
20.	CTS 20 Maha-Metro	334	***Private Land
21.	Maha-Metro + PMC DP Road Combined	774.623	Govt land
22.	Area for PMC DP Road	6831.628	Govt land
Total		13433.513	Govt +Private land

*Private land 807 B1&2 is owned by several owners; family has dispute on ownership and the matter is under discussion for procurement.
**Private land owned by Mr. Pathan has been negotiated privately and acquired By Maha Metro.
***Private land -CTS 20 is owned by Mr. Bairagi. Discussions are underway for procurement of property.

9.3. 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.

9.3.1. 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.

9.3.2. 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.

9.3.3. 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.

9.3.4. 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.

9.3.5. 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.

9.3.6. 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:

- Disposal sites shall be cleaned ad then treated so that leached water does not contaminate the Ground Water.
- 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.

9.3.7. Energy Management

The contractor shall use and maintain lighting, tools and equipment of appropriate specifications so as to conserve energy.

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

Health care awareness and clinics: Construction workers are more prone to Infectious diseases such as HIV/AIDS. It should be prevented by following actions: Counselling, community events, clinic, and coordination with local health authorities.

9.3.9. 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.

9.3.10. 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. Prevention of harassment including sexual harassment
c. Working at Height and Falling objects and Danger areas
d. Lifting Appliances
e. Launching Operation
f. Construction machinery, tools equipment - Safe worthiness

g. employ qualified electrical personnel on site and requirements of electrical equipment, distribution etc
h. Lighting
i. Exposure of worker to use of exhaust or harmful gases in confined locations
j. Fire prevention, protection and fighting system
k. Corrosive substances
l. Demolition
m. Excavation and Tunnelling
n. Traffic Management
o. Personal Protective Equipment (PPE)
p. Reporting which will contain results of monitoring and inspection programs
q. Process of response to Inquiries, complaints and requests for information from private and government entities
r. Physical fitness of workmen
s. Medical Facilities on site : Occupational Health Centre, Ambulance van and room HIV/ AIDS prevention and control
t. Exposure to Noise – prevention measures
u. Ventilation and illumination

9.3.11. 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 9.1, 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.

Figure 9.1. Silo top Aero Filter

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.

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.

9.3.12. 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.

9.3.13. 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.

9.3.14. 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.

9.3.15. 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.

9.3.16. 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.

9.3.17. 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.

9.3.18. 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.

9.3.19. 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.

9.4. EMP DURING OPERATION

9.4.1. 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.

Even though the predicted noise levels due to metro operations are less than the existing ambient noise levels, noise barriers are proposed at sharp curved portion and at sensitive receptors like educational institutes and hospitals. Details of noise barriers proposed for each reach are given in Table 9.4. Project proponent need to monitor the noise environment at these sensitive locations before erecting the noise barriers during operation.

Table 9.4. Details of Noise Barriers

Chainage in m	Length of Barrier in m	Total Cost of the Barrier in Rs. Lakh	Remarks
Reach 1: PCMC - Range Hill			
4780 to 4920	280	11	Both sides of the Station
5650 to 5700	50	42	RHS
7190 to 7250	60	8	LHS
8870 to 8940	70	9	LHS
9300 to 9550	263	39	RHS
Sub-Total	**723**	**108**	
Reach 2: Vanaz- Civil Court			
-255 to -205	50	8	RHS
25 to 41	16	2	LHS
525 to 575	50	8	LHS
685 to 766	81	12	RHS
1775 to 1810	35	5	RHS
2300 to 2400	100	15	LHS
3675 to 3775	100	15	RHS
3800 to 3940	140	21	RHS
4120 to 4230	110	17	LHS
Sub-Total	**682**	**102**	
Civil Court – Ramwadi			
8088 to 8220	180	20	LHS
8040 to 8220	132	27	RHS
8850 - 8950	100	15	RHS
9075 - 9165	90	14	LHS
9385 - 9475	90	14	RHS
10810 - 10845	35	5	LHS
10885 - 10955	70	11	LHS
12530 - 12575	45	7	LHS
13540 to 13600	60	9	LHS
Sub-Total	**802**	**120**	

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[13]. Deep and narrow trenches in the ground shall be tested at vibration-sensitive structures.

9.4.2. 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 9.5.

Table 9.5. Capacity of Bio Digester at Each Station

S. No.	Station Name	Waste Water in KLD	Capacity of Bio Digester System in KLD	Cost of Bio Digester in Rs Lakh
PCMC - Range Hill				
1	PCMC	63.0	65	5.2
2	Tukaram Nagar	23.6	25	2.0
3	Bhosari (Nashik Phata)	13.1	15	1.2
4	Kasarwadi	20.4	20	1.6
5	Fugewadi	38.7	40	3.2
6	Dapodi	7.3	10	0.8
7	Bopodi	19.1	20	1.6
8	Khadki	3.6	10	0.8
9	Range Hill	13.1	15	1.2
	Total	**202**	**220**	**18**
Range Hill – Swargate				
10	Shivaji Nagar	16.9	20	1.6
11	ASI	1.4	10	0.8
12	PMC	9.9	10	0.8
13	Budhwar Peth	7.3	10	0.8
14	Mandai	15.0	15	1.2
15	Swargate	47.1	50	4.0
	Total	**98**	**115**	**9**
Vanaz - Civil Court				

[13]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	Cost of Bio Digester in Rs Lakh
1	Vanaz	20.8	20	1.6
2	Anand Nagar	1.7	10	0.8
3	ideal Colony	0.1	10	0.8
4	Nal Stop	30.1	30	2.4
5	Garware College	5.5	10	0.8
6	Deccan	26.9	30	2.4
7	ASI	8.8	10	0.8
8	Civil Court	25.1	25	2.0
	Total	**119**	**145**	**12**
Civil Court – Ramwadi				
9	Mangalwar Peth	13.5	15	1.2
10	Pune Railway Station	20.5	20	1.6
11	Ruby Clinic	4.6	10	0.8
12	Bund Garden	8.0	10	0.8
13	Yerawada	8.0	10	0.8
14	Kalyani Nagar	15.1	15	1.2
15	Ramwadi	7.3	10	0.8
	Total	**77**	**90**	**7**

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 bacteria that has been adapted to work at temperatures as low as -5°C and as high as 50°C act as inocula (seed material) to the bio-digesters and convert the organic human waste into water, methane, and carbon-dioxide. The anaerobic process inactivates the pathogens responsible for water-borne diseases and treats the fecal matter without the use of an external energy source. 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 not require sewage connectivity and because the process is self-contained, bio-toilets are also maintenance-free. Anticipated influent & effluent wastewater quality parameters from the bio-digesters are given in Table 9.4 and typical cross section of a Bio Digester is shown in Figure 9.2.

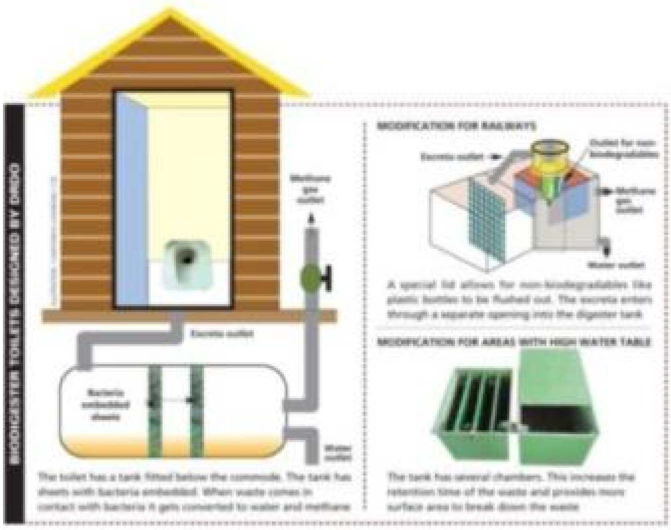
Table 9.6. Wastewater Quality Parameters (Influent & Effluent)

S. No	Parameter	Unit	Characteristics	
			Influent	Effluent
8.	pH	-	7.0 - 7.5	7.0 - 7.5
9.	Turbidity	NTU	70 - 90	2 - 5
10.	Total Suspended Solids	mg/l	90 - 120	50 - 80
11.	Total Dissolved Solids	mg/l	350 - 450	100 - 300
12.	Bio Chemical Oxygen Demand at 5 days and 20^{O}C	mg/l	70 - 120	2-4
13.	Chemical Oxygen Demand	mg/l	250 - 300	15 -25
14.	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 9.2. Typical Cross Section of Bio Digester



9.4.3. 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 1.77 lakh cubic meters per year. Estimated cost for rainwater harvesting for viaduct and elevated stations is Rs 214.88 Lakh for PCMC-Range Hill; Rs 128.70 Lakh for Vanaz-Civil Court and Rs 133.65 Lakh for Civil Court-Ramwadi.

9.4.4. 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 Effluent treatment plant. Water required for the Range Hill Depot is 22.80 KLD and for Vanaz depot is 18.73 KLD.

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 6.43 Thousand cum for Range Hill Depot and 7.32 Thousand cum for Vanaz depot. The cost of rainwater harvesting structures will be roughly Rs. 20.00 lakh for each depot.

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 9.5.

Table 9.7. Capacity of Bio Digester at Depots

S. No.	Station Name	Waste Water in KLD	Capacity of Bio Digester System in KLD	Cost of Bio Digester in Rs Lakh
1	Range Hill Depot	18.24	20	1.6
2	Vanaz Depot	14.98	20	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. In addition to the compensatory afforestation, green belt is recommended inside the Depots. Greenbelt Cost will be 24.92 Lakh for Range Hill Depot and 22.89 Lakh for Vanaz Depot. Treated sewage and effluent can be used for green belt development.
Details of the Green Belt Development cost:

Sr. No.	Particulars	Range Hill Depot	Vanaz Depot
1.	Area of Depots (in ha)	13.3	11.9
2.	Considering 20% area for plantation (in ha)	2.7	2.4
3.	Number of trees to be planted	2925	2687
4.	Per plant cost including maintenance	852	852
Total Cost (in Lakhs)		**24.92**	**22.89**

g) Solid Waste Disposal

Solid waste generated from the Depots which includes hazardous waste will be taken away by the cleaning contractor weekly and recycled/treated and disposed of at designated waste disposal sites.

h) Top soil preservation, reuse and 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).*

9.5. 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[14] 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.
   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.

9.6. TRAINING

The training for engineers, managers and workers 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 7.4 Lakh for PCMC - Range Hill; and Rs. 5.60 Lakh

[14]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

each for Range Hill - Swargate, Vanaz - Civil Court, and Civil Court - Ramwadi Corridors as the details are listed in Table 9.6. The curriculum for all reaches of the corridors will be same and the cost is distributed equally among all reaches. One extension officer for each corridor (ie N-S and E-W corridor) is considered and cost is distributed equally among the reaches.

Table 9.8. Cost for Training Program

<table>
<tr><th rowspan="2">S. No</th><th rowspan="2">Item</th><th colspan="4">Cost (Rs)</th></tr>
<tr><th>PCMC - Range Hill</th><th>Range Hill - Swargate</th><th>Vanaz - Civil Court</th><th>Civil Court - Ramwadi</th></tr>
<tr><td>1</td><td>Curriculum Development and course preparation</td><td colspan="4">1,20,000</td></tr>
<tr><td>2</td><td>2 Extension Officers (1 officer for 2 reachs) Rs. 30,000/month</td><td colspan="2">3,60,000</td><td colspan="2">3,60,000</td></tr>
<tr><td>3</td><td>Instructor @ 20000/- per sessions. One session in Two months, each of duration 3 days</td><td>1,20,000</td><td>1,20,000</td><td>1,20,000</td><td>1,20,000</td></tr>
<tr><td>4</td><td>Leaflet, Material etc</td><td>3,60,000</td><td>1,80,000</td><td>1,80,000</td><td>1,80,000</td></tr>
<tr><td>5</td><td>Demonstration/Presentation Aids</td><td>50,000</td><td>50,000</td><td>50,000</td><td>50,000</td></tr>
<tr><td colspan="2">Total</td><td>7,40,000</td><td>5,60,000</td><td>5,60,000</td><td>5,60,000</td></tr>
</table>

Chapter 10 : Environmental Monitoring Plan and Environmental Management System

10.1. ENVIRONMENT MONITORING PLAN

10.1.1. 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.

10.1.2. Construction Phase

Monitoring schedule for the entire period of construction (4 Years) is summarized in Table 10.1. 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 10.1.Construction Stage Monitoring Schedule

Parameter	Frequency	Reference/Standard	Implementation by / Approval by
Air	Once (24 hours) in Two weeks at four locations for each reach for entire construction period.	• 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.	• Protocol for Ambient Level Noise Monitoring, CPCB, May 2015 • ISO/ TC 108 (vibration)	Contractor/ Maha-Metro, Pune
Vibration	Once in a month for a Year for Elevated section. One day continuous monitoring at 2 locations vertically above TBM operation for entire UG section and at sensitive receptors near the TBM.		

Parameter	Frequency	Reference/Standard	Implementation by / Approval by
Water (surface and ground water) and waste water	Once in a season, four seasons in a year for entire construction period.	• Guide Manual – Water and waste water analysis, CPCB • Drinking water - Specifications IS 10500: 2012 and CPHEEO Manual 2012	Contractor/ Maha-Metro, Pune
Soil	Once in a season, four season in a year for entire construction period. UG section: 3 samples per km for the UG section	US EPA test protocols	Contractor/ Maha-Metro, Pune
Ecology	Once in a season, four season in a year	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 environmental monitoring cost during construction phase is Rs 50.64 Lakh for PCMC - Range Hill; Rs 512.24 Lakh for Range Hill - Swargate; Rs. 46.80 Lakh for Vanaz - Civil Court; and Rs. 48.00 Lakh for Civil Court - Ramwadi Corridors. The estimated cost towards environmental monitoring during construction will be part of civil contract and details are given in Table 10.2.

Table 10.2.Environmental Monitoring Cost during Construction

S No	ITEM	QUANTITY	TOTAL COST (Rs in Lakh)
PCMC - Range Hill			
i.	Air Quality Monitoring	4 Samples X 24 times in a year X 4 Years	19.47
ii.	Noise Quality Monitoring	4 Samples X 24 times in a year X 4 Years	3.89
iii.	Soil Quality Monitoring	4 Samples X 4 times in a year X 4 Years	5.76
iv.	Water Quality Monitoring	6 Samples X 4 times in a year X 4 Years	11.52
v.	Vibration Monitoring	1 Sample X 12 times in a year X 1 Year	6.00

S No	ITEM	QUANTITY	TOTAL COST (Rs in Lakh)
vi.	Ecological Monitoring	4 times in a year X 4 Years	4.00
		Env. Monitoring Cost for PCMC - Swargate	**50.64**
Range Hill – Swargate			
i.	Air Quality Monitoring	4 Samples X 24 times in a year X 1 Year	4.87
ii.	Noise Quality Monitoring	4 Samples X 24 times in a year X 1 Year	0.97
iii.	Soil Quality Monitoring	3 Samples X 4 times in a year X 1 Year	1.08
iv.	Soil Quality Monitoring for Muck	3 muck samples per km for the UG section	1.36
v.	Water Quality Monitoring	2 Samples X 4 times in a year X 1 Year	0.96
vi.	Vibration Monitoring	1006 Sample X 1 Year [2 locations X 5.019 km/(2 TBMs X 5m/day) + 2 ASI/Temples]	503.00
		Env. Monitoring Cost for Range Hill - Swargate	**512.24**
Vanaz - Civil Court			
i.	Air Quality Monitoring	4 Samples X 24 times in a year X 4 Years	19.47
ii.	Noise Quality Monitoring	4 Samples X 24 times in a year X 4 Years	3.89
iii.	Soil Quality Monitoring	4 Samples X 4 times in a year X 4 Years	5.76
iv.	Water Quality Monitoring	4 Samples X 4 times in a year X 4 Years	7.68
v.	Vibration Monitoring	1 Sample X 12 times in a year X 1 Year	6.00
vi.	Ecological Monitoring	4 times in a year X 4 Years	4.00
		Env. Monitoring Cost for Vanaz - Civil Court	**46.80**
Civil Court – Ramwadi			
i.	Air Quality Monitoring	4 Samples X 24 times in a year X 4 Years	19.47
ii.	Noise Quality Monitoring	4 Samples X 24 times in a year X 4 Years	3.89
iii.	Soil Quality Monitoring	2 Samples X 4 times in a year X 4 Years	2.88
iv.	Water Quality Monitoring	3 Samples X 4 times in a year X 4 Years	5.76
v.	Vibration Monitoring	2 Sample X 12 times in a year X 1 Year	12.00
vi.	Ecological Monitoring	4 times in a year X 4 Years	4.00
		Env. Monitoring Cost for Civil Court - Ramwadi	**48.00**

10.1.3. Operation Phase

The environmental monitoring schedule during operation phase for 3 years is presented in Table 10.3. The results of air quality, water quality, waste water, vibration will be submitted to management bi-annually during operation phase.

Table 10.3.Operation Stage Monitoring Schedule

Parameter	Frequency	Reference/Standard	Implementation by / Approval by	Period (years)
Air	2x24 hours in a week for each season, Three seasons in a year at all metro stations and Depot	• Guidelines for Ambient Air Quality Monitoring , CPCB, 2003 • National Ambient Air Quality Standards 2009	Maha-Metro, Pune	3
Noise	2x24 hours in a week for each season, Three seasons in a year at all metro stations and Depot	Metro Rail Transit System, Guidelines for Noise and Vibrations, RDSO, Ministry of Railways, September 2015	Maha-Metro, Pune	3
Vibration	24 hours, once in two months at Sensitive locations			
Water (surface and ground water)	Once in a season, Four seasons in a year at pre construction 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, Four seasons in a year at all stations and Depot			
Solid Waste	Once in a season, Four seasons in a year at Depot	• Solid Waste Management Rules 2016	Maha-Metro, Pune	3
Soil	Once in a season, four season in a year	US EPA test protocols	Maha-Metro, Pune	3
Ecology	Once in a season, four season in a year at Afforestation Sites	As per Forest authorities	Maha-Metro, Pune /& Parks and garden Department of PMC	3

The environmental monitoring cost during Operation phase is Rs 51.36 Lakh for PCMC - Range Hill; Rs 63.72 Lakh for Range Hill - Swargate; Rs. 45.96 Lakh for Vanaz - Civil Court; and Rs. 45.12 Lakh for Civil Court - Ramwadi Corridors. The estimated cost towards environmental monitoring during construction will be the responsibility of PIU and details are given in Table 10.4.

Table 10.4.Environmental Monitoring Cost during Operation

S No	ITEM	QUANTITY	TOTAL COST (Rs in Lakh)
PCMC - Range Hill			
i.	Air Quality Monitoring	10 Samples X 2 days X 3 times in a year for 3 Years	9.00
ii.	Noise Quality Monitoring	10 Samples X 2 days X 3 times in a year for 3 Years	1.80
iii.	Soil Quality Monitoring	4 Samples X 4 times in a year X 3 Years	4.32
iv.	Water Quality Monitoring	6 Samples X 4 times in a year X 3 Years	8.64
v.	Vibration Monitoring	1 Sample X 6 times in a year X 3 Year	9.00
vi.	Quality of Waste Water	10 Samples X 4 times in a year for 3 Years	14.4
vii.	Ecological Monitoring	4 times in a year X 3 Years	3.00
viii.	Solid Waste Characteristics at Depot	1 Sample X 4 times in a year X 3 Year	1.20
		Env. Monitoring Cost for PCMC - Swargate	**51.36**
Range Hill – Swargate			
i.	Air Quality Monitoring	5 Samples X 2 days X 3 times in a year for 3 Years	4.50
ii.	Noise Quality Monitoring	5 Samples X 2 days X 3 times in a year for 3 Years	0.90
iii.	Soil Quality Monitoring	3 Samples X 4 times in a year X 3 Years	3.24
iv.	Water Quality Monitoring	2 Samples X 4 times in a year X 3 Years	2.88
v.	Vibration Monitoring	5 Sample X 6 times in a year X 3 Year	45.00
vi.	Quality of Waste Water	5 Samples X 4 times in a year for 3 Years	7.20
		Env. Monitoring Cost for Range Hill - Swargate	**63.72**
Vanaz - Civil Court			
i.	Air Quality Monitoring	9 Samples X 2 days X 3 times in a year for 3 Years	8.10
ii.	Noise Quality Monitoring	9 Samples X 2 days X 3 times in a year for 3 Years	1.62
iii.	Soil Quality Monitoring	4 Samples X 4 times in a year X 3 Years	4.32
iv.	Water Quality Monitoring	4 Samples X 4 times in a year X 3 Years	5.76
v.	Vibration Monitoring	1 Sample X 6 times in a year X 3 Year	9.00
vi.	Quality of Waste Water	9 Samples X 4 times in a year for 3 Years	12.96
vii.	Ecological Monitoring	4 times in a year X 3 Years	3.00
viii.	Solid Waste Characteristics at Depot	1 Sample X 4 times in a year X 3 Year	1.20
		Env. Monitoring Cost for Vanaz - Civil Court	**45.96**

S No	ITEM	QUANTITY	TOTAL COST (Rs in Lakh)
Civil Court – Ramwadi			
i.	Air Quality Monitoring	7 Samples X 2 days X 3 times in a year for 3 Years	6.30
ii.	Noise Quality Monitoring	7 Samples X 2 days X 3 times in a year for 3 Years	1.26
iii.	Soil Quality Monitoring	2 Samples X 4 times in a year X 3 Years	2.16
iv.	Water Quality Monitoring	3 Samples X 4 times in a year X 3 Years	4.32
v.	Vibration Monitoring	2 Sample X 6 times in a year X 3 Year	18.00
vi.	Quality of Waste Water	7 Samples X 4 times in a year for 3 Years	10.08
vii.	Ecological Monitoring	4 times in a year X 3 Years	3.00
		Env. Monitoring Cost for Civil Court - Ramwadi	**45.12**

10.2. ESTABLISHMENT OF ENVIRONMENTAL DIVISION

Environment Management Division at Maha-Metro,Pune is already in place and also to support the division activities one Senior Environmental Expert and one R&R expert is posted at GC side. The GC Environmental Expert is monitoring the implementation of environmental mitigation measures at site through inspections and audits and reporting to Project director/ED/CPM in sync with Maha-Metro environmental and social management unit Similarly R&R expert is responsible for monitoring of the R&R aspects.. Cost for the first ten years (including 10% annual increase) is given in Table 10.5. The estimated cost for 10 years is Rs 100.08 Lakh each for PCMC - RangeHill, Range Hill - Swargate, Vanaz - Civil Court, and Civil Court - Ramwadi. The division will be setu up at one location for all reaches of the corridors and capital & recurring costs are distributed equally among all reaches.

Table 10.5.Environmental Division Cost

S. No	Head	Cost (Rs Lakh)			
		PCMC - RangeHill	RangeHill - Swargate	Vanaz - Civil Court	Civil Court - Ramwadi
A	**Capital Cost**				
	Office Furnishings (Computer, furniture etc) LS	2.00			
B	**Recurring Cost**				
	Man Power Cost (For 12 months)				
	One Environmental Engineer @ Rs. 75,000/month for all corridors	9.00			
	Two Environmental Assistant @40000/month. One Assistant for each corridor i.e N-S and E-W	4.80		4.80	
	Office Maintenance @ Rs. 20,000/month	2.40			
C	**Sub Total (A+B)**	**5.75**	**5.75**	**5.75**	**5.75**

S. No	Head	Cost (Rs Lakh)			
		PCMC - RangeHill	RangeHill - Swargate	Vanaz - Civil Court	Civil Court - Ramwadi
	Miscellaneous expenses, LS (10 % of C)	0.58	0.58	0.58	0.58
	Total cost for 1 Year	**6.33**	**6.33**	**6.33**	**6.33**
	Total cost for 10 years @ 10% annual increase	**100.80**	**100.80**	**100.80**	**100.80**

10.3. ENVIRONMENT MANAGEMENT SYSTEM (EMS)

Environment Management System is intended to facilitate implementation, tracking and reporting on Environment Management Plan and Environment Monitoring Plan proposed for the project. Clearances/permissions required for the proposed metro corridors are given in Table 10.6 and Roles and responsibilities for preparation and Implementation of Environmental Management Plan (EMP) and Environmental Monitoring Plan (EMoP) are summarized in Table 10.7.

Table 10.6.Clearances/Permissions for Proposed Metro Corridors

S. No	Clearance/Permission	Act/ Rules/ Notifications	Authority
1.	Building Permissions	EIA Notification 2006 with Amendment for Integration of environmental Conditions in local building byelaws.	Building permission from PMC/PCMC for stations and depots.
2.	Prior Environmental Clearance Metro Railway is not listed among activities requiring prior Environmental Clearance in EIA Notification 2006. March 2016 in case of Nagpur Metro, MoEFCC Clarified that construction of building for commercial purposes having built area equal to or more than 20,000 sqm shall require prior EC from SEIAA.	EIA Notification 2006 and its amendments – in case for commercial purpose having built-up area more than 20,000 sqm.	SEIAA
3.	Land Use Change	Master Plan, Town Planning Department, Pune Municipal Corporation; Maharastra Regional and Town Planning Act, 1966	PMC/PCMC
4.	Consent to establish and Consent to operate construction yards, labour	Water (Prevention and Control of Pollution) Act 1974,	State Pollution Control Board

S. No	Clearance/Permission	Act/ Rules/ Notifications	Authority
	camps, stations and depots (*since non-residential)*	Air (Prevention and Control of Pollution) Act 1981	(Checklist of information to be submitted along with Application is given in at Annexure 9.1)
5.	Sites to establish labour camps, pre-casting and material yards	Land use Master Plan and DC&PR	PMC/PCMC
6.	Permission for disposal of Construction and Demolition Waste	Construction and Demolition Waste Management Rules, 2016	SPCB; PMC/PCMC for sites
7.	Permission for Disposal of Hazardous Waste	Hazardous and Other Wastes (Management, and Trans boundary Movement) Rules, 2016	SPCB; PMC/PCMC for sites
8.	Permission for muck disposal	Rules of PMC/PCMC	PMC/PCMC for sites
9.	Permission to excavate land and near utilities	Rules/norms of PMC/PCMC and utility agencies	PMC/PCMC and utility agencies
10.	Permissions for energy, water supply, sewage and solid waste disposal etc		
11.	Permission for felling of trees	Tree Authority Department, Pune Municipal Corporation	PMC/PCMC (Form enclosed at Annexure 9.2)
12.	License and NOC in connection with blasting during construction	The Explosives Act 2008	DGMS and District Collector
13.	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 9.3)
14.	Proceedings to deal with chance finds	Indian Treasure Trove Act, 1878, modified upto the 1st September, 1949.	District Collector
15.	Consent for construction near Heritage Structures	Conservation of Heritage Buildings/ Precincts/ Natural Features, DCPR-2017 for Pune Municipal Corporation	Municipal Commissioner, Pune
16.	Forest Clearance	Forest (Conservation) Act 1980	Not required

S. No	Clearance/Permission	Act/ Rules/ Notifications	Authority
17.	Wildlife Clearance	The Wildlife (Protection) Act, 1972	Not required
18.	CRZ Clearance	Coastal Regulation Zone Notification, 2011	Not required

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.

Table 10.7.Roles and Responsibilities –Preparation and Implementation EMP and EMoP

S No	Environmental Impact	Mitigation Measure				Implementing Entity	Responsible Entity
		PCMC – Range Hill	Range Hill - Swargate	Vanaz – Civil Court	Civil Court - Ramwadi		
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	Alignment design to avoid or minimize impact.				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 structures of viaduct and stations on elevated sections.				DPR and design consultant	PIU
4	Archaeological monuments	-	Alignment design to avoid or minimize impact.	-	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	Compensatory afforestation in the ratio of 1:3 will be		Compensatory afforestation in the ratio of 1:3 will be implemented along	Implement compensatory afforestation in the	PMC	PMC

<table>
<tr><th rowspan="2">S No</th><th rowspan="2">Environmental Impact</th><th colspan="4">Mitigation Measure</th><th rowspan="2">Implementing Entity</th><th rowspan="2">Responsible Entity</th></tr>
<tr><th>PCMC – Range Hill</th><th>Range Hill - Swargate</th><th>Vanaz – Civil Court</th><th>Civil Court - Ramwadi</th></tr>
<tr><td></td><td></td><td>implemented along corridor and at Depot.</td><td></td><td>the corridor and Depot.</td><td>ratio of 1:3 along the corridor.</td><td></td><td></td></tr>
<tr><td>4</td><td>Site measures</td><td colspan="4">Prepare Safety, Health and Environment (SH&E) Manual and secure approval.</td><td>Contractor</td><td>PIU</td></tr>
<tr><td>5</td><td>Environmental Management and Monitoring</td><td colspan="4">Implement institutional requirements for implementation of EMP and EMoP.</td><td>Contractor</td><td>PIU</td></tr>
<tr><td colspan="8">EMP during Construction Phase</td></tr>
<tr><td>1</td><td>Soil erosion, fugitive dust generation, muck disposal and C&D waste management</td><td colspan="4">Implement suitable construction methods and as per SH&E Manual
• Careful planning, timing of cut and fill operations and re-vegetation shall reduce the Soil Erosion and dust generation
• 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 be provided at exit gate from where soil disposal shall be carried.
• Sufficient staff shall be made available at site to control the disposal of muck/soil from site such as a supervisor, labors for wheel cleaning, brooms for wheel cleaning and concrete pad where wheels 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/tunnelling works does not get contaminated with hydrocarbons or any other contaminant.
• The onsite muck shall be monitored 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.</td><td>Contractor</td><td>PIU</td></tr>
</table>

S No	Environmental Impact	Mitigation Measure				Implementing Entity	Responsible Entity
		PCMC – Range Hill	Range Hill - Swargate	Vanaz – Civil Court	Civil Court - Ramwadi		
		• 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; periodic check of machinery and vehicles; dust collectors and physical barriers at bulk loading and un-loading areas; machinery noise muffles etc and personal protective gear to workers.				Contractor	PIU
		The monitoring cost for Air and Noise monitoring will be Rs. 10.80 Lakh	The monitoring cost for Air and Noise monitoring will be Rs. 5.40 Lakh	The monitoring cost for Air and Noise monitoring will be Rs. 9.72 Lakh	The monitoring cost for Air and Noise monitoring will be Rs. 7.56 Lakh		
3	Vibration	Implement vibration monitoring and building condition surveys at sensitive structures.				Contractor	PIU
		Monitoring at One location and cost will be Rs. 6.00 Lakh	One day continuous monitoring at 2 locations vertically above TBM operation for entire UG section and at sensitive receptors near the TBM. Monitoring cost will be Rs. 503.00 Lakh	Monitoring at One location and cost will be Rs. 6.00 Lakh	Monitoring at Two locations and cost will be Rs. 12.00 Lakh		
4	Water pollution	• Implement measures such as precipitation tanks on site for Batching Plants • 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

<table>
<tr><th rowspan="2">S No</th><th rowspan="2">Environmental Impact</th><th colspan="4">Mitigation Measure</th><th rowspan="2">Implementing Entity</th><th rowspan="2">Responsible Entity</th></tr>
<tr><th>PCMC – Range Hill</th><th>Range Hill - Swargate</th><th>Vanaz – Civil Court</th><th>Civil Court - Ramwadi</th></tr>
<tr><td></td><td></td><td>Monitoring will be at 6 locations and cost will be Rs. 11.52 Lakh</td><td>Monitoring will be at 2 locations and cost will be Rs. 0.96 Lakh</td><td>Monitoring will be at 4 locations and cost will be Rs. 7.68 Lakh</td><td>Monitoring will be at 3 locations and cost will be Rs. 5.76 Lakh</td><td></td><td></td></tr>
<tr><td>5</td><td>Soil pollution</td><td colspan="4">• Implement measures to prevent ingress of toxic / heavy metals. Suitable storage area for such materials shall be prepared and equipment shall be made available for 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</td><td>Contractor</td><td>PIU</td></tr>
<tr><td></td><td></td><td>Monitoring will be at 4 locations and cost will be Rs. 5.76 Lakh</td><td>Monitoring will be at 3 locations & 3 muck samples per km of UG section and cost will be Rs. 1.36 Lakh</td><td>Monitoring will be at 4 locations and cost will be Rs. 5.76 Lakh</td><td>Monitoring will be at 2 locations and cost will be Rs. 2.88 Lakh</td><td></td><td></td></tr>
<tr><td>6</td><td>Water supply; waste water and solid waste disposal from construction activities</td><td colspan="4">• 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-off hazardous wastes as per the provisions of SHE manual for Pune Metro.
• Contractor shall dispose-off nonhazardous solid wastes, nonhazardous liquid wastes, biomedical wastes as per the provisions of SHE manual for Pune Metro.</td><td>Contractor</td><td>PIU</td></tr>
<tr><td>7</td><td>Labour camp: water supply; sewage and solid waste disposal; healthcare</td><td colspan="4">Implement measures as per SH&E Manual</td><td>Contractor</td><td>PIU</td></tr>
</table>

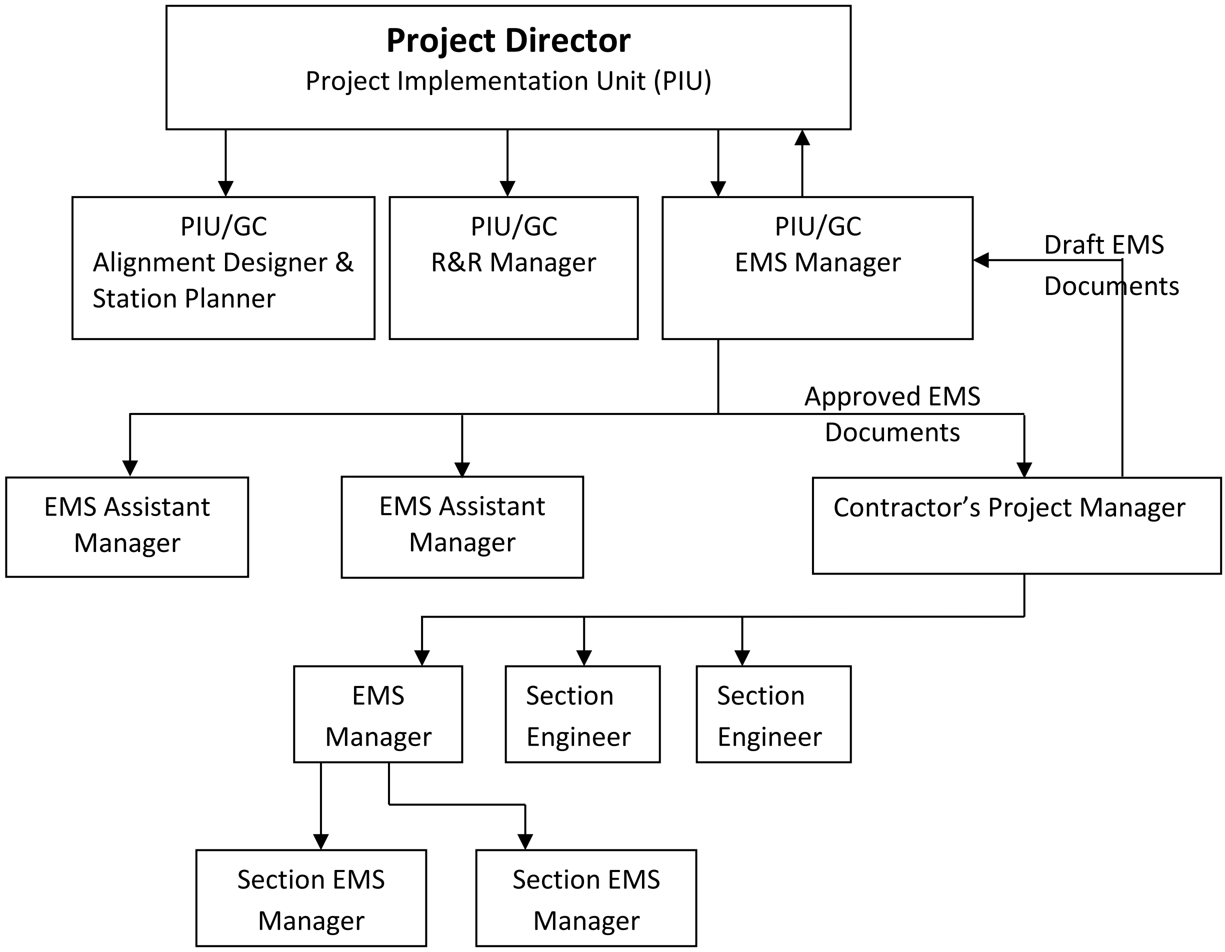
S No	Environmental Impact	Mitigation Measure				Implementing Entity	Responsible Entity
		PCMC – Range Hill	Range Hill - Swargate	Vanaz – Civil Court	Civil Court - Ramwadi		
8	Facilities on site and workplace safety	Implement measures as per SH&E Manual				Contractor	PIU
9	Incident Management	Prepare Incident Management Plan with reporting formats.				Contractor	PIU
10	Environmental Monitoring	Preparation of Environmental Monitoring Plan for Air, Noise, Soil, Water, Vibration and Ecological				Contractor	PIU
		The environmental monitoring cost will be Rs. 50.64 Lakh	The environmental monitoring cost will be Rs. 512.24 Lakh	The environmental monitoring cost will be Rs. 46.80 Lakh	The environmental monitoring cost will be Rs. 48.00 Lakh		
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 2267 trees) and trees proposed to be planted (about 6801 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 Tree etc. • 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

S No	Environmental Impact	Mitigation Measure				Implementing Entity	Responsible Entity
		PCMC – Range Hill	Range Hill - Swargate	Vanaz – Civil Court	Civil Court - Ramwadi		
		Monitoring will be at all metro stations and Depot and cost will be Rs. 1.80 Lakh. Noise Barrier proposed for a length of 723 m and the cost will be Rs. 108.00 Lakh.	Monitoring will be at all metro stations and cost will be Rs. 0.90 Lakh.	Monitoring will be at all metro stations and Depot and cost will be Rs. 1.62 Lakh. Noise Barrier proposed for a length of 682 m and the cost will be Rs. 102.00 Lakh.	Monitoring will be at all metro stations and cost will be Rs. 1.26 Lakh. Noise Barrier proposed for a length of 802 m and the cost will be Rs. 120.00 Lakh.		
2	Vibration	Implement vibration monitoring and building condition surveys at sensitive structures, if required				PIU	PIU
		Monitoring will be at one location and cost will be Rs. 9.00 Lakh.	Monitoring will be at 5 locations and cost will be Rs. 45.00 Lakh.	Monitoring will be at one location and cost will be Rs. 9.00 Lakh.	Monitoring will be at 2 locations and cost will be Rs. 18.00 Lakh.		
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
		Monitoring cost will be Rs. 24.24 Lakh water, waste water and solid waste.	Monitoring cost will be Rs. 10.08 Lakh water and waste water.	Monitoring cost will be Rs. 19.92 Lakh water, waste water and solid waste.	Monitoring cost will be Rs. 14.40 Lakh water and waste water.		
4	Incident Management	Implement Incident Management Plan.				PIU	PIU
5		Implement Environmental Monitoring Plan as mentioned in Section 9.1 of EIA report.				PIU	PIU

S No	Environmental Impact	Mitigation Measure				Implementing Entity	Responsible Entity
		PCMC – Range Hill	Range Hill - Swargate	Vanaz – Civil Court	Civil Court - Ramwadi		
	Environmental Monitoring	Environmental Monitoring cost during operation phase will be Rs. 51.36 Lakh	Environmental Monitoring cost during operation phase will be Rs. 63.72 Lakh	Environmental Monitoring cost during operation phase will be Rs. 45.96 Lakh	Environmental Monitoring cost during operation phase will be Rs. 45.12 Lakh		
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

A typical EMS organization is depicted in Figure 10.1. One indicative activity i.e, approval of EMS documents is shown in this organisation chart.

Figure 10.1.EMS Organization



* GC: General Consultant as Project Management Consultant

10.4. 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.
- 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 9.4 to Annexure 9.14.

10.4.1. 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 11 : Cost Estimate

11.1. SUMMARY OF COSTS

The total estimated environmental management and monitoring cost for the proposed project is Rs 2294.07 Lakh as indicated corridor wise in Table 11.1. The cost towards environmental 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 11.1.Cost of Environmental Management Plan

S. No	Item	Amount in Rs. Lakh				Responsibility
		PCMC - Range Hill	Range Hill - Swargate	Vanaz - Civil Court	Civil Court - Ramwadi	
1.	Noise Barriers	108.45	-	102.30	120.30	PIU
2.	Rainwater Harvesting	214.88	-	128.70	133.65	Civil Contract
3.	Environmental Monitoring					
	During Construction	50.64	512.24	46.80	48.00	Civil Contract
	During Operation	51.36	63.72	45.96	45.12	PIU
4.	Training and Extension	7.40	5.60	5.60	5.60	PIU
5.	Environment Division	100.80	100.80	100.80	100.800	PIU
6.	Waste Water Treatment through Bio Digesters	17.60	9.20	11.60	7.20	PIU
	Cost for each Reach	**551.13**	**691.56**	**441.76**	**460.67**	
	Total Cost for all Corridors	**2145.12**				
7.	**Depots**	**Range Hill Depot**		**Vanaz Depot**		
a.	Rainwater Harvesting	20.00		20.00		Civil Contract
b.	Waste Water Treatment through Bio Digesters	1.60		1.60		PIU
c.	I	24.92		22.89		PIU
	Cost for Each Depot	**46.52**		**44.49**		

S. No	Item	Amount in Rs. Lakh				Responsibility
		PCMC - Range Hill	Range Hill - Swargate	Vanaz - Civil Court	Civil Court - Ramwadi	
Total Cost for both Depot		**91.01**				
Compensatory Afforestation for both Corridors and Depots		**2267 x 3 x 852 = 57.94**				
Total Environmental Cost for all Corridors and Depot		**2294.07**				

Details of the Green Belt Development cost :

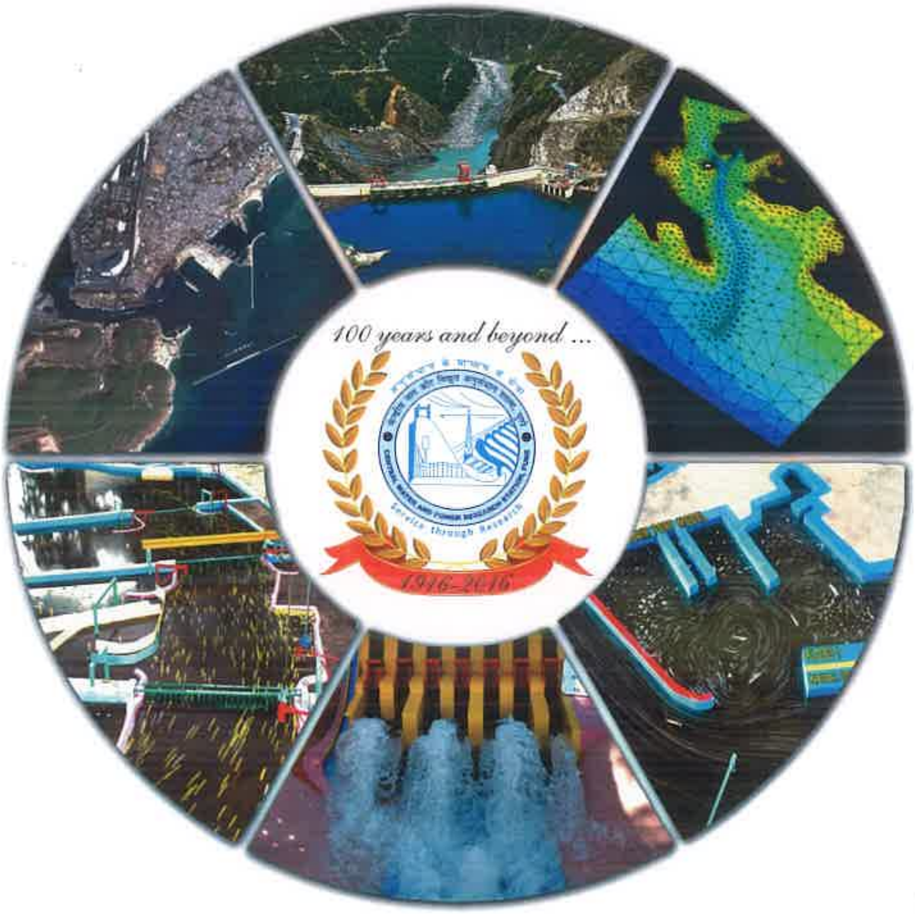
Sr. No.	Particulars	Range Hill Depot	Vanaz Depot
1.	Area of Depots (in ha)	13.3	11.9
2.	Considering 20% area for plantation (in ha)	2.7	2.4
3.	Number of trees to be planted	2925	2687
4.	Per plant cost including maintenance	852	852
Total Cost (in Lakhs)		**24.92**	**22.89**

Annexure-1

Government of India
Ministry of Jal Shakti
Department of Water Resources,
River Development and
Ganga Rejuvenation

सत्यमेव जयते

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास
और गंगा संरक्षण विभाग



TECHNICAL REPORT NO.5886
JANUARY, 2021

MATHEMATICAL MODEL STUDIES OF RIVER MUTHA FOR MAHA – METRO RAIL CORPORATION LTD. PUNE

केन्द्रीय जल और विद्युत अनुसंधान शाला, पुणे

CENTRAL WATER AND POWER RESEARCH STATION, PUNE

A. K. Agrawal
Director

VISION

To be a world-class centre of excellence in hydraulic engineering research and allied areas; which is responsive to changing global scenario, and need for sustaining and enhancing excellence in providing technological solutions for optimal and safe design of water resources structures.

MISSION

- To meet the country's need for basic & applied research in water resources, power sector and coastal engineering with world-class standards
- To develop competence in deployment of latest technologies by networking with the top institutions globally, to meet the future needs for development of water resources projects in the country effectively
- To disseminate information, build skills and knowledge for capacity-building and mass awareness for optimization of available water resources

MAJOR FUNCTIONS

- Undertaking specific research studies relating to development of water resources, power and coastal projects
- Consultancy and advisory services to Central and State Governments, private sector and other countries
- Disseminating research findings and promoting/assisting research activities in other organizations concerned with water resources projects
- Contributions to Bureau of Indian Standards and International Standards Organization
- Carrying out basic and applied research to support the specific studies
- Contribution towards advancements in technology through participation in various committees at National and State Levels

The Director,

Central Water and Power Research Station

Khadakwasala, Sinhgad Road, Pune 411 024. Maharashtra

Telephone : +91-20-24103400/ 24103500

Fax : +91-20-24381004

Web : www.cwprs.gov.in

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास और
गंगा संरक्षण विभाग
केन्द्रीय जल और विद्युत अनुसंधान शाला
खड़कवासला, पुणे-411 024

सत्यमेव जयते

Government of India
Ministry of Jal Shakti
Department of Water Resources
River Development and Ganga Rejuvenation
CENTRAL WATER & POWER RESEARCH STATION
Khadakwasla, Pune – 411 024

संख्या: ज.वि.आ.प./ महा मेट्रो/ 2021- 46 |23 दिनांक: 11.01.2021

22 JAN 2021

श्री रत्नाकर पांडे
उप महाप्रबंधक (पर्यावरण)
महाराष्ट्र मेट्रो रेल कोर्प लि।
प्रथम तल, द ओरियन बिल्डिंग, अर्जुन मनसुखानी मार्ग,
पुणे -411001

विषय : महा-मेट्रो रेल कॉर्पोरेशन लिमिटेड, पुणे के लिए मुठा नदी के गणितीय प्रतिमान का अध्ययन ।

महोदय,

"महा-मेट्रो रेल कॉर्पोरेशन लिमिटेड, पुणे के लिए मुठा नदी का गणितीय प्रतिमान अध्ययन के लिए" शीर्षक की तकनिकी रिपोर्ट संख्या 5886, जनवरी 2021 की दो प्रतियाँ आपकी जानकारी और अभिलेख हेतु संलग्न है ।

कृपया तकनिकी रिपोर्ट के प्राप्ति की सूचना दे।

धन्यवाद,

भवदीया,

Neena Isaac
11/01/2021

डॉ.(श्रीमती) नीना आयझॅक
वैज्ञानिक- ई

संलग्न: तकनिकी रिपोर्ट की दो प्रतियाँ।

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास और
गंगा संरक्षण विभाग
केन्द्रीय जल और विद्युत अनुसंधान शाला
खड़कवासला, पुणे-411 024

सत्यमेव जयते

Government of India
Ministry of Jal Shakti
Department of Water Resources
River Development and Ganga Rejuvenation
CENTRAL WATER & POWER RESEARCH STATION
Khadakwasla, Pune – 411 024

No.HAPT/Maha-Metro/2021 - 46|23

Date : 11.01.2021
22 JAN 2021

Shri Ratnakar Pandey
Deputy General Manager (Environment)
Maharashtra Metro Rail Corporation Ltd.
1st floor, The Orion Building, Arjun Mansukhani Marg,
Pune-411001

Sub : Mathematical Model Studies of River Mutha for Maha-Metro Rail Corporation Ltd. Pune.

Sir,

A Technical Report No. 5886 of January 2021 entitled "Mathematical Model Studies of River Mutha for Maha-Metro Rail Corporation Ltd. Pune" is enclosed in duplicate, for reference and record.

Kindly acknowledge the receipt of report alongwith the feedback in the format attached herewith.

Thanking you,

Yours faithfully,

Neena Isaac
11/01/2021

(Dr. (Mrs) Neena Isaac)
Scientist 'E'

Encl: Two copies of Technical report

दूरभाष / Telephone: +91-20-24103331; फैक्स/Fax: +91-20-24381004; ईमेल / Email : neena.isaac@gov.in / n_isaac@rediffmail.com
वेबसाइट/ Website : http://jalshakti-mowr.gov.in, www.cwprs.gov.in

भारत सरकार
जल शक्ति मंत्रालय
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केन्द्रीय जल और विद्युत अनुसंधान शाला
खड़कवासला, पुणे-411 024

सत्यमेव जयते

Government of India
Ministry of Jal Shakti
Department of Water Resources
River Development and Ganga Rejuvenation
CENTRAL WATER & POWER RESEARCH STATION
Khadakwasla, Pune – 411 024

No.HAPT/Maha-Metro/2021 - Date :

Shri Ratnakar Pandey
Deputy General Manager (Environment)
Maharashtra Metro Rail Corporation Ltd.
1st floor, The Orion Building, Arjun Mansukhani Marg,
Pune-411001

Sub : Corrigenda (Errata) for "Mathematical Model Studies of River Mutha for Maha-Metro Rail Corporation Ltd. Pune".

Sir,

The Corrigenda (Errata) for the technical report no. 5886 of January 2021 entitled "Mathematical Model Studies of River Mutha for Maha-Metro Rail Corporation Ltd. Pune" is enclosed , for reference and record.

Kindly acknowledge the receipt.

Thanking you,

Yours faithfully,

Neena Isaac
23/02/2021

(Dr. (Mrs) Neena Isaac)
Scientist 'E'

Encl: As above

GOVERNMENT OF INDIA
MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES, RIVER
DEVELOPMENT AND GANGA REJUVENATION
CENTRAL WATER AND POWER RESEARCH STATION
PUNE - 411 024

100 years and beyond ...

Reservoirs and Appurtenant Structures

TECHNICAL REPORT NO. 5886
JANUARY 2021

MATHEMATICAL MODEL STUDIES OF RIVER MUTHA FOR MAHA – METRO RAIL CORPORATION LTD. PUNE

A.K. Agrawal
Director

REPORT DOCUMENTATION SHEET

Technical Report No. 5886 | **Month: January 2021**

TITLE: MATHEMATICAL MODEL STUDIES OF RIVER MUTHA FOR MAHA – METRO RAIL CORPORATION LTD. PUNE

Officers Responsible for Conducting the Studies
Shri P. S. Kunjeer, Scientist 'C', Mrs. H. P. Chaudhary, Shri P. D. Patil, Scientist 'B', Mrs. S. B. Tayade, Assistant Research Officer, Mrs. S. A. Shinde, Shri V. R. Medhe Research Assistants, Shri U. K. Kanthali, Shri P. M. Mehatar Lab Assistants-II under the supervision of Dr. (Mrs) Neena Isaac, Scientist 'E'

Name and Address of Organization Conducting the Studies
Reservoirs and Appurtenant Structures
Central Water and Power Research Station, Khadakwasla, Pune-411 024

Name and Address of the Authority Sponsoring the Studies
Shri Ratnakar Pandey, Deputy General Manager (Environment), Maharashtra Metro Rail Corporation Ltd. 1st floor, The Orion Building, Arjun Mansukhani Marg, Pune-411001

Synopsis:
Maharashtra Metro Rail Corporation Limited (MMRCL) is a joint venture company of Govt. of India and Govt. of Maharashtra, established for the purpose of implementation of Pune Metro Rail Project. The total length of Pune Metro Rail Project is 31.25 km of which a stretch of 1.45 km passes along the left bank of Mutha River. As per the design, 61 Piers of Metro Rail line will be constructed along the left bank of Mutha River. MMRCL approached Central Water and Power Research Station (CWPRS) to conduct hydrodynamic model studies to estimate the afflux in Mutha River due to the construction of metro pier and allied structures. One dimensional mathematical model studies for river Mutha were carried out. The numerical model of river Mutha covering a reach of about 15.0 km from Khadakwasla dam to Sangam near confluence of Mutha River with Mula River was developed using HEC-RAS software. Simulations were carried out for Mutha River in the study reach considering the existing bridges without Metro piers and then including Metro piers to find out the afflux for the discharges of 60,000 ft^3/s and 1,00,000 ft^3/s. Further, same set of experiments were carried out using Aerial Survey data. The maximum afflux for the discharge of 1,00,000 ft^3/s in the reach near Sambhaji bridge reduces to 216 from 380 mm when the extended cross sections from the Aerial survey the afflux in same reach are taken into account. For discharge of 60,000 ft^3/s reduces to 193 mm from 290 mm. Inundation depths and the extent of inundation were also computed considering SRTM DEM. Subsequently the inundation depths were computed based on the DEM data collected by aerial survey for limited reach of 2.5 Km. Flood extent was overlaid on Google image.

Key words: Afflux, Bridges, Piers, Mutha River, One dimensional model, HEC-RAS, RAS Mapper

TABLE OF CONTENTS

NUMERICAL MODEL STUDIES FOR RIVER MUTHA FOR MAHA METRO RAIL CORPORTION LTD. (MMRCL), PUNE

Technical Report No.: 5886 **Month: January 2021**

1.0 INTRODUCTION

Maharashtra Metro Rail Corporation Limited (MMRCL) is a joint venture company of Govt. of India and Govt. of Maharashtra, established for the purpose of implementation of Pune Metro Rail Project. The total length of Pune Metro Rail Project is 31.25 km of which a stretch of 1.45 km passes along the left bank of Mutha river. As per the design, 61 Piers will be constructed along the left bank of Mutha river. MMRCL approached Central Water and Power Research Station (CWPRS) to conduct hydrodynamic model studies to estimate the afflux in Mutha river due to the construction of Metro Pier and allied structures. This technical report describes the numerical model studies conducted to determine the afflux along Mutha river due to the construction of Metro Piers. Numerical model simulations were conducted for various discharge conditions.

2.0 STUDY AREA

The study area is a reach of Mutha river passing through Pune city. The Mutha river is a part of Bhima basin which is a sub-basin of river Krishna. The Mutha river originates from the Sahyadri ranges and flows in the South-East direction. The flows in the Mutha river is controlled by the releases from the Khadakwasla dam located about 10 km upstream of Pune city area. River Mutha is flowing through the heart of Pune city and have confluence with river Mula about 15 km downstream of Khadakwasla dam. The river is known as Mula-Mutha downstream of this confluence. The river Mula-Mutha continues to flow in South-East direction and have confluence with river Bhima near village Pargaon at about 80 km downstream of Khadakwasla dam. The 15 km reach of Mutha river from Khadakwasla dam to its confluence with Mula river in Pune city is considered in the present study (Figure 1a). Pune city is spread along both the banks of Mutha river and there are about 16 bridges across the river in the study reach. MMRCL proposes to construct Pune Metro Rail Project for a length of about 31.25 km out of which a stretch of about 1.45 km length is passing along the left bank flood plain of Mutha river in the city area (Figure 1b).

3.0 TERMS OF REFERENCE

1. Estimation of afflux at each bridge for two river discharges of 60,000 ft^3/s and 1,00,000 ft^3/s.
2. Inundation of riverbanks caused by afflux

4.0 DATA REQUIRED FOR THE STUDIES

The basic data required for the studies include

(i) Topographic data in the form of river plan and cross sections

(ii) Hydraulic data in the form of discharge and water level/rating curve

(iii) Structural data of the bridges, causeways and Metro Piers in the form of plan, elevation and sections

The data received from the project were reviewed and observations along with data used in the studies are given below.

4.1 Topographic Data

Geometric data of the river in the form of river plan, cross sections and L-section were provided by MMRCL. The cross sections of river Mutha covering a reach of about 15.0 km from Khadakwasla dam to Sangam near confluence of Mutha river with Mula river were made available. The cross sections of the river were taken at an interval of 30 m in the study reach. The representative cross sections in the study reach are shown in Figure 2.

4.2 Hydraulic Data

The MMRCL provided the water surface profiles for Mutha river published by Water Resource Department, Government of Maharashtra in the study reach for the two river discharges of 60,000 ft^3/s (Blue line) and 1,00,000 ft^3/s (Red line).

4.3 Structural Data

The MMRCL provided the details of the bridges across the Mutha river in the study reach. Project Authorities also provided the structural details of Metro Pier and pier cap along with the alignment of Metro line passing through the Mutha river flood plain.

5.0 MATHEMATICAL MODEL

A number of commercial or free numerical models are available which can simulate hydrodynamic flow routing along with the structural operations. The selection of the model depends on the objectives of the study, availability of data and computational resources. HEC-RAS 5.0.7 developed by the U.S. Army Corps of Engineers at the Army's Hydrologic Engineering Centre is extensively used all over world for simulating hydrodynamic flow routing. Hence, the same software was selected for hydrodynamic simulations in the present studies. The main input data required for HEC-RAS model include cross-sections of the river reach, gauge-discharge data, structural data etc.

The numerical model of river Mutha covering a reach of about 15.0 km from Khadakwasla dam to Sangam near confluence of Mutha river with Mula river was developed using HEC-RAS software. The river geometry was reproduced in the model using the cross section data supplied by the Project Authorities (Figure 3). The steady state simulations were performed by imposing the discharge as the upstream boundary and water levels obtained from the Irrigation data as the downstream boundary. The Manning 'n' of 0.021 was used in simulations studies based on the existing river condition. Details of the simulations performed along with the results are described in the following paragraphs.

5.1 Simulation studies without Metro Piers

Initial simulation studies were conducted to obtain water surface elevations without the Metro Piers. The existing bridges in the river Mutha were incorporated in the model. The studies were conducted for two river discharges of 60,000 ft^3/s and 1,00,000 ft^3/s corresponding to blue and red line respectively. The results presented in the report are restricted to the study reach of river Mutha between Garware bridge and Shivaji bridge covering the Metro Piers and infrastructure. The computed water surface elevations were compared with blue line and red line provided by the Irrigation department. The results are plotted in the Figure 4. The simulated water surface elevations are above the red line in the reach between Sambhaji bridge and Shivaji bridge for the discharge of 1,00,000 ft^3/s. This may be attributed to the restricted cross section data. The cross sections may not be covering the entire flood plain where the water is likely to spread for larger area along both the banks thereby reducing the flood levels in actual site conditions. The representation of some of the bridge data in the model may also be incorrect. It was observed that the computed water surface elevation is about 0.74 m above the red line near/in the vicinity of Shinde bridge. The results obtained were also compared with the blue line. Similar trend as described above is observed for this condition also, wherein simulated water surface elevations are above the blue line provided by the Irrigation Department. The computed water surface profile is about 1.5 m above the blue line near/in the vicinity of Shinde Bridge.

5.2 Simulation studies with Metro Piers

The Metro Pier and related infrastructure works were also incorporated in the model. These simulations indicate the afflux induced due to construction of the Metro Piers. Figure 5 shows the Metro Pier near the Sambhaji Bridge and Figure 6 shows Metro Pier with the cap protruding above the ground surface near Gadgil (Z) Bridge incorporated in the model. The simulations were conducted for two river discharges of 60,000 and 1,00,000 ft^3/s. The computed water surfaces from these simulations were compared with the previously simulated water surface elevations.

The results are plotted in the Figure 7(a) and (b) for the discharge of 1,00,000 ft^3/s. The water surface elevations and afflux are given in Table 1. It was observed that in the study reach, afflux varies from 50 to 100 mm in the reach between Shivaji and Shinde bridges. Further in the upstream reach between Shinde bridge and Metro Pier DE 8, afflux varies between 150 to 250 mm. The afflux upstream of the Baba Bhide bridge is in the range of 340 to 350 mm with the maximum afflux of 380 mm observed at pier No. P152.

The results for the discharge of 60,000 ft^3/s are also plotted in the Figure 8(a) and (b). The water surface elevations and afflux are given in Table 2. It was observed that in the study reach, afflux is the range of 60 to 100 mm in the reach between Shivaji and Shinde bridges. Further in the upstream reach between Shinde bridge and Metro Pier DE 8 afflux varies between 150 to 240 mm. The afflux upstream of the Baba Bhide bridge is in the range of 200 to 250 mm with the maximum afflux of 290 mm observed at pier No. P153.

5.3 Additional simulations with aerial survey data

The results of the initial simulations with available data were discussed in the meeting held at Divisional Commissioner Office on 24.09.2020. The issue of the restricted cross sections was discussed during the meeting. The cross section data used in the studies were cross verified with the Irrigation Department to check the width of cross sections. It was found that the data used in the model is in agreement with the Irrigation data. It was decided to conduct additional survey covering both the banks of river Mutha to overcome the problem of restricted cross section data. Owing to time restriction, aerial survey using the drone was conducted by MMRCL. This data was provided to CWPRS to utilize in further studies. The data was provided in the cross section (Figure 9) and Digital Elevation Model (DEM) format.

5.3.1 Simulation studies using aerial survey data and existing bridges

The cross sections obtained from the aerial survey was incorporated in the model. The old cross sections provided by the Irrigation Department in the reach between the chainage 11430 m to 13800 m were replaced with cross sections obtained from the aerial survey. The simulations were performed for the discharges of 60000 ft^3/s and 1,00,000 ft^3/s corresponding to blue and red line respectively. The results are plotted in Figure 10 and given in Table 3 and Table 4. The water level in the Metro Pier reach varies from 546.13 m to 547.50 m for the discharge of 60000 ft^3/s and from 548.67 m to 549.68 m for the discharge of 1,00,000 ft^3/s.

5.3.2 Simulation studies using aerial survey data along with Metro Piers

The cross sections obtained from the aerial survey was incorporated in the model. The old cross section data provided by the Irrigation Department in the reach between the chainage 11430 m to 13800 m was replaced with cross sections obtained from the aerial survey. The simulations were performed for the discharges of 60000 ft^3/s and 1,00,000 ft^3/s corresponding to blue and red line respectively. The results are plotted in Figure 11 and given in Table 3 and Table 4. The water level in the Metro Pier reach varies from 546.13 m to 547.70 m for the discharge of 60000 ft^3/s and from 548.67 m to 549.90 m for the discharge of 1,00,000 ft^3/s.

The water surface profiles for the discharge of 1,00,000 ft^3/s with and without the Metro Piers are plotted in the Figure 11(a) and Figure 11(b). The water surface elevations and afflux at bridges and Metro Piers are given in Table 5. The results indicate that there is reduction in the afflux in the study reach because of the extended cross sections obtained from aerial survey. The afflux is lowered by an average of about 50 mm in the reach between Shivaji and Shinde bridge and the afflux at present with extended cross sections is in the range of 0 to 30 mm. In the reach between Shinde bridge and Metro Pier DE 8, the afflux is reduced by an average of about 80 mm and afflux at present is in the range of 30 to 180 mm. The afflux is reduced by about 120 mm in the reach upstream of Baba Bhide bridge. The afflux observed at P152 with extended cross sections is 216 mm which is less than previously computed value of 380 mm.

The water surface profiles for the discharge of 60,000 ft^3/s with and without the Metro Piers are plotted in the Figure 12(a) and Figure 12(b). The water surface elevations and afflux at bridges and Metro Piers are given in Table 6. The results indicate that there is reduction in the afflux in the study reach because of the extended cross sections obtained from aerial survey. The afflux is lowered by an average of about 60 mm in the reach between Shivaji and Shinde bridge and the afflux at present with extended cross sections is in the range of 0 to 23 mm. In the reach between Shinde bridge and Metro Pier DE 8, the afflux is reduced by an average of about 50 mm and afflux at present is in the range of 23 to 202 mm. The afflux is reduced by about 40 mm in the reach upstream of Baba Bhide bridge. The afflux observed at P152 with extended cross sections is 193 mm which is less than previously computed value of 270 mm.

5.4 Flood inundation mapping

Water surface profiles were computed for the discharges of 60,000 ft^3/s (Blue line) and 1,00,000 ft^3/s (Red line) using the numerical model. The inundation depths were computed based on the STRM DEM (30 m grid) downloaded from the USGS website. The inundation map generated is presented in Figure 13 to Figure 24. The inundation map overlaid on Google Map covering the entire study reach and for different stretches are presented in Figure 13 to Figure 18. The inundation map overlaid on SRTM terrain map covering the entire study reach and for different stretches are presented in Figure 19 to Figure 24.

Subsequently, the inundation depths were computed based on the DEM generated from the aerial survey data. The aerial survey data were provided for a reach of about 2.5 km covering the reach between S M Joshi bridge and Shivaji bridge (reach where Metro Piers are located along the river flood plain).

The inundation area for the flood discharge of 1,00,000 ft^3/s with and without the Metro Piers are plotted in the Figure 25. The inundation area at bridges and Metro Piers are given in Table 7. The results indicate that the inundation area in the reach between Shivaji and Shinde bridge in the range of 0 to 0.02 m. In the reach between Shinde bridge and Metro Pier DE 8, the inundation area varies from 0.02 m to 10.01 m. The inundation area in the reach between Metro Pier DE 8 and Baba Bhide bridge is in the range of 3.06 m to 10.94 m. The inundation area in the reach upstream of Baba Bhide bridge varies from 10.94 m to 2.66 m. In the reach near the Metro Piers P159, P160 and Z bridge, inundation area is higher and is in the range of 20 m to 30 m.

The inundation area for the flood discharge of 60,000 ft^3/s with and without the Metro Piers are plotted in the Figure 26. The inundation area at bridges and Metro Piers are given in Table 8. The results indicate that the inundation area in the reach between Shivaji and Shinde bridge in the range of 0 to 0.01 m. In the reach between Shinde bridge and Metro Pier DE 8, the inundation area varies from 0.01 m to 2.27 m. The inundation area in the reach between Metro Pier DE 8 and Baba Bhide bridge is in the range of 2.27 m to 11.44 m. The inundation area in the reach upstream of Baba Bhide bridge varies from 11.44 m to 0.79 m. In the reach near Bhide bridge and Metro Piers P162 and P163 inundation area is higher and is in the range of about 10 m to 12 m.

The extent of inundation and its accuracy is dependent on the underlying DEM data. Hence, the extent of inundation may vary depending on the underlying DEM.

6.0 CONCLUSIONS

The numerical model of river Mutha covering a reach of about 15.0 km from Khadakwasla dam to Sangam near confluence of Mutha river with Mula river was developed using HEC-RAS 5.0.7. Simulations were carried out for the discharges of 60,000 ft^3/s and 1,00,000 ft^3/s to compute the water surface profiles under existing conditions and also by incorporating the Metro Piers to estimate the afflux.

- It was observed that the maximum afflux for the discharge of 1,00,000 ft^3/s is about 380 mm in the reach near Sambhaji bridge. This afflux is reduced to 216 mm when the extended cross sections are taken into account.
- It was observed that the maximum afflux for the discharge of 60,000 ft^3/s is about 290 mm in the reach upstream of Sambhaji bridge near pier number P153. This afflux is reduced to ~~198~~ 201 mm when the extended cross sections are taken into account.
- The inundation depths were computed based on the STRM DEM (30 m grid) downloaded from the USGS website and inundation maps were prepared for the entire study reach. The extent of inundation and its accuracy is dependent on the underlying DEM data. Hence, the extent of inundation may vary depending on the underlying DEM.
- Subsequently the inundation depths were computed based on the DEM data collected by aerial survey for limited reach of 2.5 Km. Flood extent was overlaid on Google image.

ACKNOWLEDGEMENTS

Central Water and Power Research Station, Pune (CWPRS) is thankful to M/s MMRCL, Pune for referring the studies. We wish to express our sincere gratitude to Shri A.K. Agrawal, Director CWPRS, Pune for his constant encouragement and continuous guidance during execution of studies. The help and efforts of Shri S.A Kamble, Scientist B, Shri S D. Pingale, Research Assistant and other staff members are acknowledged with thanks. Shri Ratnakar Pandey, Deputy General Manager (Environment), Ms Renu Gera, Consultant visited CWPRS during the studies and discussed various aspects of model studies in details. Their valuable contribution and support during the course of studies is gratefully acknowledged.

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Table 1: Water Surface Elevations for the discharge of 1,00,000 ft^3/s

Brigde and Peir Names	Water Surface Elevation before Metro Pier	Water Surface Elevation after Metro Pier	Afflux
	(m)	(m)	(mm)
Nanded Shivne	559.90	559.90	0
NH 4 Vadgaon	555.23	555.27	40
Rajaram	553.10	553.21	110
Mhatre	551.13	551.38	250
SM Joshi	550.56	550.93	370
YB Chavan	550.47	550.83	360
P152	550.36	550.74	380
P153	550.39	550.70	310
P154	550.16	550.49	330
P155	550.14	550.47	330
Sambhaji/ Lakadi	550.12	550.45	330
P156	550.12	550.45	330
P157	550.06	550.39	330
P158	550.02	550.35	330
P159	549.99	550.33	340
P160	550.00	550.33	330
Z bridge	549.97	550.30	330
P161	549.93	550.27	340
P162	549.91	550.24	330
P163	549.80	550.14	340
Bhide	549.79	550.13	340
DE1	549.78	550.13	350
DE2	549.78	550.12	340
DE3	549.75	550.08	330
DE4	549.76	550.09	330
DE5	549.71	550.04	330
DE6	549.77	550.08	310

DE7	549.79	550.04	250
DE8	549.65	549.90	250
DE9	549.67	549.90	230
DE10	549.62	549.86	240
P164	549.67	549.89	220
P165	549.65	549.88	230
P166	549.42	549.67	250
P167	549.43	549.68	250
P168	549.46	549.70	240
P169	549.29	549.55	260
P170	549.27	549.53	260
P171	549.38	549.61	230
P172	549.16	549.39	230
P173	549.02	549.26	240
P174	549.10	549.32	220
P175	549.13	549.35	220
P176	549.06	549.28	220
SP1	549.11	549.31	200
SP2	549.10	549.30	200
SP3	548.99	549.19	200
SP4	549.06	549.24	180
SP5	549.07	549.24	170
SP6	549.03	549.19	160
SP7	549.08	549.23	150
SP8	549.10	549.24	140
SP9	549.11	549.25	140
SP10	548.98	549.12	140
P177	549.03	549.15	120
P178	548.96	549.08	120
P179	548.97	549.08	110
P180	549.01	549.12	110
P181	548.82	548.93	110
P182	548.84	548.96	120

Shinde	548.81	548.91	100
P183	548.74	548.85	110
P184	548.63	548.74	110
P185	548.52	548.63	110
P186	548.54	548.63	90
P186a	548.53	548.61	80
Causeway	548.60	548.67	70
P187	548.62	548.68	60
P188	548.30	548.35	50
P189	548.53	548.55	20
P190	548.48	548.49	10
P191	548.33	548.34	10
Shivaji	548.34	548.34	0
Dengale	547.91	547.91	0
Wellesely	547.07	547.07	0
Railway	547.02	547.02	0
Sangam/RTO	546.86	546.86	0

Table 2: Water Surface Elevations for the discharge of 60,000 ft^3/s

Bridge and Pier Names	Water Surface Elevation before Metro Pier	Water Surface Elevation after Metro Pier	Afflux
	(m)	(m)	(mm)
Nanded Shivne	558.18	558.18	0
NH 4 Vadgaon	553.35	553.35	0
Rajaram	550.70	550.75	50
Mhatre	549.19	549.31	120
SM Joshi	548.48	548.71	230
YB Chavan	548.41	548.67	260
P152	548.31	548.58	270
P153	548.29	548.58	290
P154	548.33	548.55	220
P155	548.12	548.36	240
Sambhaji/ Lakadi	548.11	548.35	240
P156	548.08	548.32	240
P157	548.06	548.31	250
P158	548.03	548.28	250
P159	548.00	548.25	250
P160	547.98	548.23	250
Z bridge	547.99	548.23	240
P161	547.97	548.22	250
P162	547.93	548.18	250
P163	547.91	548.16	250
Bhide	547.85	548.10	250
DE1	547.83	548.09	260
DE2	547.80	548.06	260
DE3	547.78	548.04	260
DE4	547.77	548.02	250
DE5	547.77	548.02	250
DE6	547.73	547.98	250
DE7	547.74	547.99	250

DE8	547.77	547.97	200
DE9	547.66	547.87	210
DE10	547.68	547.88	200
P164	547.66	547.86	200
P165	547.67	547.86	190
P166	547.64	547.84	200
P167	547.43	547.66	230
P168	547.46	547.67	210
P169	547.49	547.69	200
P170	547.26	547.50	240
P171	547.23	547.46	230
P172	547.34	547.54	200
P173	547.23	547.42	190
P174	547.07	547.27	200
P175	547.12	547.31	190
P176	547.16	547.34	180
SP1	547.15	547.32	170
SP2	547.17	547.33	160
SP3	547.17	547.32	150
SP4	547.09	547.24	150
SP5	547.05	547.21	160
SP6	547.10	547.25	150
SP7	547.05	547.19	140
SP8	547.11	547.24	130
SP9	547.10	547.23	130
SP10	547.11	547.24	130
P177	546.98	547.09	110
P178	547.03	547.14	110
P179	546.98	547.09	110
P180	546.99	547.09	100
P181	547.00	547.09	90
P182	546.89	546.98	90
Shinde	546.88	546.97	90

P183	546.86	546.94	80
P184	546.78	546.87	90
P185	546.72	546.81	90
P186	546.62	546.72	100
P186a	546.64	546.73	90
Causeway	546.63	546.71	80
P187	546.68	546.74	60
P188	546.67	546.73	60
P189	546.28	546.35	70
P190	546.54	546.54	0
P191	546.37	546.37	0
Shivaji	546.24	546.24	0
Dengale	545.74	545.74	0
Wellesely	544.57	544.57	0
Railway	544.56	544.56	0
Sangam/RTO	544.33	544.33	0

Table 3: Water Surface Elevations for the discharge of 1,00,000 ft^3/s EXTENDED CS

Bridge and Pier Names	Water Surface Elevation before Metro Pier	Water Surface Elevation after Metro Pier	Afflux
	(m)	(m)	(mm)
Nanded shivne bridge	559.936	559.936	0
NH4 1	555.268	555.279	11
Rajaram	553.206	553.243	37
Mhatre	550.514	550.654	140
SM Joshi	549.924	550.132	208
YB Chavan	549.840	550.045	205
P152	549.683	549.899	216
P153	549.613	549.831	218
P154	549.585	549.802	217
P155	549.583	549.795	212
Sambhaji/ Lakadi	549.471	549.691	220
P156	549.458	549.677	219
P157	549.466	549.683	217
P158	549.457	549.672	215
P159	549.470	549.681	211
P160	549.464	549.671	207
Z bridge	549.408	549.624	216
P161	549.423	549.635	212
P162	549.432	549.641	209
P163	549.423	549.634	211
Bhide	549.419	549.629	210
DE1	549.347	549.562	215
DE2	549.345	549.557	212
DE3	549.343	549.550	207
DE4	549.270	549.466	196
DE5	549.283	549.476	193
DE6	549.278	549.468	190

DE7	549.281	549.467	186
DE8	549.269	549.452	183
DE9	549.265	549.445	180
DE10	549.237	549.418	181
P164	549.229	549.407	178
P165	549.195	549.372	177
P166	549.186	549.360	174
P167	549.164	549.340	176
P168	549.138	549.307	169
P169	549.052	549.208	156
P170	549.053	549.201	148
P171	549.046	549.191	145
P172	549.031	549.173	142
P173	549.021	549.160	139
P174	549.014	549.142	128
P175	548.993	549.116	123
P176	548.964	549.081	117
SP1	548.94	549.053	113
SP2	548.943	549.044	101
SP3	548.933	549.030	97
SP4	548.940	549.031	91
SP5	548.936	549.017	81
SP6	548.893	548.97	77
SP7	548.883	548.957	74
SP8	548.885	548.953	68
SP9	548.875	548.939	64
SP10	548.918	548.973	55
P177	548.912	548.963	51
P178	548.909	548.958	49
P179	548.900	548.946	46
P180	548.822	548.865	43
P181	548.844	548.882	38
P182	548.808	548.842	34

Shinde	548.804	548.834	30
P183	548.755	548.785	30
P184	548.751	548.777	26
P185	548.778	548.798	20
P186	548.762	548.779	17
P186a	548.756	548.77	14
Causeway	548.722	548.735	13
P187	548.693	548.707	14
P188	548.636	548.647	11
P189	548.675	548.682	7
P190	548.670	548.673	3
P191	548.665	548.666	1
Tilak	548.560	548.560	0
Shivaji	548.076	548.076	0
Dengle/ Kumbharwada new	547.598	547.598	0
Wellesely	547.190	547.190	0
Railway	547.054	547.054	0
Sangam/RTO	546.956	546.956	0

Table 4: Water Surface Elevations for the discharge of 60,000 ft^3/s EXTENDED CS

Bridge and Pier Names	Water Surface Elevation before Metro Pier	Water Surface Elevation after Metro Pier	Afflux
	(m)	(m)	(mm)
Nanded shivne bridge	558.278	558.278	0
NH4 1	553.330	553.331	1
Rajaram	550.764	550.778	14
Mhatre	548.548	548.615	67
SM Joshi	547.791	547.947	156
YB Chavan	547.677	547.849	172
P152	547.504	547.697	193
P153	547.434	547.635	201
P154	547.407	547.609	202
P155	547.405	547.603	198
Sambhaji/ Lakadi	547.319	547.529	210
P156	547.287	547.500	213
P157	547.253	547.468	215
P158	547.254	547.464	210
P159	547.256	547.462	206
P160	547.250	547.452	202
Z bridge	547.183	547.395	212
P161	547.160	547.377	217
P162	547.129	547.354	225
P163	547.115	547.341	226
Bhide	547.107	547.332	225
DE1	547.031	547.272	241
DE2	547.028	547.266	238
DE3	547.023	547.255	232
DE4	547.006	547.215	209
DE5	547.008	547.214	206

DE6	547.002	547.204	202
DE7	547.002	547.201	199
DE8	546.958	547.160	202
DE9	546.950	547.150	200
DE10	546.935	547.129	194
P164	546.926	547.117	191
P165	546.845	547.036	191
P166	546.833	547.020	187
P167	546.837	547.015	178
P168	546.819	546.985	166
P169	546.763	546.915	152
P170	546.752	546.901	149
P171	546.705	546.855	150
P172	546.676	546.824	148
P173	546.662	546.808	146
P174	546.587	546.739	152
P175	546.597	546.741	144
P176	546.601	546.737	136
SP1	546.524	546.657	133
SP2	546.520	546.633	113
SP3	546.507	546.617	110
SP4	546.500	546.599	99
SP5	546.500	546.581	81
SP6	546.387	546.467	80
SP7	546.371	546.448	77
SP8	546.375	546.446	71
SP9	546.356	546.422	66
SP10	546.424	546.475	51
P177	546.410	546.456	46
P178	546.406	546.450	44
P179	546.409	546.448	39
P180	546.394	546.430	36
P181	546.396	546.428	32

P182	546.358	546.386	28
Shinde	546.352	546.375	23
P183	546.291	546.316	25
P184	546.285	546.305	20
P185	546.303	546.315	12
P186	546.288	546.296	8
P186a	546.281	546.286	5
Causeway	546.200	546.205	5
P187	546.133	546.140	7
P188	546.104	546.111	7
P189	546.124	546.128	4
P190	546.138	546.140	2
P191	546.131	546.131	0
Tilak	546.066	546.066	0
Shivaji	545.984	545.984	0
Dengle/ Kumbharwada new	545.370	545.370	0
Wellesely	544.685	544.685	0
Railway	544.585	544.585	0
Sangam/RTO	544.396	544.396	0

Table 5: Water Surface Elevations and comparison of afflux for the discharge of 1,00,000 ft^3/s

Bridge and Pier Names	Water Surface Elevation and Afflux for old survey			Water Surface Elevation and Afflux for New (aerial) survey		
	Before Metro Pier	After Metro Pier	Afflux	Before Metro Pier	After Metro Pier	Afflux
	(m)	(m)	(mm)	(m)	(m)	(mm)
Nanded shivne bridge	559.90	559.90	0	559.936	559.936	0
NH4 1	555.23	555.27	40	555.268	555.279	11
Rajaram	553.10	553.21	110	553.206	553.243	37
Mhatre	551.13	551.38	250	550.514	550.654	140
SM Joshi	550.56	550.93	370	549.924	550.132	208
YB Chavan	550.47	550.83	360	549.840	550.045	205
P152	550.36	550.74	380	549.683	549.899	216
P153	550.39	550.70	310	549.613	549.831	218
P154	550.16	550.49	330	549.585	549.802	217
P155	550.14	550.47	330	549.583	549.795	212
Sambhaji/ Lakadi	550.12	550.45	330	549.471	549.691	220
P156	550.12	550.45	330	549.458	549.677	219
P157	550.06	550.39	330	549.466	549.683	217
P158	550.02	550.35	330	549.457	549.672	215
P159	549.99	550.33	340	549.470	549.681	211
P160	550.00	550.33	330	549.464	549.671	207
Z bridge	549.97	550.30	330	549.408	549.624	216
P161	549.93	550.27	340	549.423	549.635	212
P162	549.91	550.24	330	549.432	549.641	209
P163	549.80	550.14	340	549.423	549.634	211
Bhide	549.79	550.13	340	549.419	549.629	210
DE1	549.78	550.13	350	549.347	549.562	215
DE2	549.78	550.12	340	549.345	549.557	212
DE3	549.75	550.08	330	549.343	549.550	207

DE4	549.76	550.09	330	549.270	549.466	196
DE5	549.71	550.04	330	549.283	549.476	193
DE6	549.77	550.08	310	549.278	549.468	190
DE7	549.79	550.04	250	549.281	549.467	186
DE8	549.65	549.90	250	549.269	549.452	183
DE9	549.67	549.90	230	549.265	549.445	180
DE10	549.62	549.86	240	549.237	549.418	181
P164	549.67	549.89	220	549.229	549.407	178
P165	549.65	549.88	230	549.195	549.372	177
P166	549.42	549.67	250	549.186	549.360	174
P167	549.43	549.68	250	549.164	549.340	176
P168	549.46	549.70	240	549.138	549.307	169
P169	549.29	549.55	260	549.052	549.208	156
P170	549.27	549.53	260	549.053	549.201	148
P171	549.38	549.61	230	549.046	549.191	145
P172	549.16	549.39	230	549.031	549.173	142
P173	549.02	549.26	240	549.021	549.160	139
P174	549.10	549.32	220	549.014	549.142	128
P175	549.13	549.35	220	548.993	549.116	123
P176	549.06	549.28	220	548.964	549.081	117
SP1	549.11	549.31	200	548.940	549.053	113
SP2	549.10	549.30	200	548.943	549.044	101
SP3	548.99	549.19	200	548.933	549.030	97
SP4	549.06	549.24	180	548.940	549.031	91
SP5	549.07	549.24	170	548.936	549.017	81
SP6	549.03	549.19	160	548.893	548.970	77
SP7	549.08	549.23	150	548.883	548.957	74
SP8	549.10	549.24	140	548.885	548.953	68
SP9	549.11	549.25	140	548.875	548.939	64
SP10	548.98	549.12	140	548.918	548.973	55
P177	549.03	549.15	120	548.912	548.963	51
P178	548.96	549.08	120	548.909	548.958	49
P179	548.97	549.08	110	548.900	548.946	46

P180	549.01	549.12	110	548.822	548.865	43
P181	548.82	548.93	110	548.844	548.882	38
P182	548.84	548.96	120	548.808	548.842	34
Shinde	548.81	548.91	100	548.804	548.834	30
P183	548.74	548.85	110	548.755	548.785	30
P184	548.63	548.74	110	548.751	548.777	26
P185	548.52	548.63	110	548.778	548.798	20
P186	548.54	548.63	90	548.762	548.779	17
P186a	548.53	548.61	80	548.756	548.770	14
Causeway	548.60	548.67	70	548.722	548.735	13
P187	548.62	548.68	60	548.693	548.707	14
P188	548.30	548.35	50	548.636	548.647	11
P189	548.53	548.55	20	548.675	548.682	7
P190	548.48	548.49	10	548.67	548.673	3
P191	548.33	548.34	10	548.665	548.666	1
Tilak				548.560	548.560	0
Shivaji	548.34	548.34	0	548.076	548.076	0
Dengle/ Kumbharwada new	547.91	547.91	0	547.598	547.598	0
Wellesely	547.07	547.07	0	547.190	547.190	0
Railway	547.02	547.02	0	547.054	547.054	0
Sangam/RTO	546.86	546.86	0	546.956	546.956	0

Table 6: Water Surface Elevations and comparison of afflux for the discharge of 60,000 ft^3/s

Bridge and Pier Names	Water Surface Elevation and Afflux for old survey			Water Surface Elevation and Afflux for New (aerial) survey		
	Before Metro Pier	After Metro Pier	Afflux	Before Metro Pier	After Metro Pier	Afflux
	(m)	(m)	(mm)	(m)	(m)	(mm)
Nanded shivne bridge	558.18	558.18	0	558.278	558.278	0
NH4 1	553.35	553.35	0	553.33	553.331	1
Rajaram	550.70	550.75	50	550.764	550.778	14
Mhatre	549.19	549.31	120	548.548	548.615	67
SM Joshi	548.48	548.71	230	547.791	547.947	156
YB Chavan	548.41	548.67	260	547.677	547.849	172
P152	548.31	548.58	270	547.504	547.697	193
P153	548.29	548.58	290	547.434	547.635	201
P154	548.33	548.55	220	547.407	547.609	202
P155	548.12	548.36	240	547.405	547.603	198
Sambhaji/ Lakadi	548.11	548.35	240	547.319	547.529	210
P156	548.08	548.32	240	547.287	547.500	213
P157	548.06	548.31	250	547.253	547.468	215
P158	548.03	548.28	250	547.254	547.464	210
P159	548.00	548.25	250	547.256	547.462	206
P160	547.98	548.23	250	547.25	547.452	202
Z bridge	547.99	548.23	240	547.183	547.395	212
P161	547.97	548.22	250	547.16	547.377	217
P162	547.93	548.18	250	547.129	547.354	225
P163	547.91	548.16	250	547.115	547.341	226
Bhide	547.85	548.10	250	547.107	547.332	225
DE1	547.83	548.09	260	547.031	547.272	241
DE2	547.80	548.06	260	547.028	547.266	238
DE3	547.78	548.04	260	547.023	547.255	232

DE4	547.77	548.02	250	547.006	547.215	209
DE5	547.77	548.02	250	547.008	547.214	206
DE6	547.73	547.98	250	547.002	547.204	202
DE7	547.74	547.99	250	547.002	547.201	199
DE8	547.77	547.97	200	546.958	547.160	202
DE9	547.66	547.87	210	546.950	547.150	200
DE10	547.68	547.88	200	546.935	547.129	194
P164	547.66	547.86	200	546.926	547.117	191
P165	547.67	547.86	190	546.845	547.036	191
P166	547.64	547.84	200	546.833	547.020	187
P167	547.43	547.66	230	546.837	547.015	178
P168	547.46	547.67	210	546.819	546.985	166
P169	547.49	547.69	200	546.763	546.915	152
P170	547.26	547.5	240	546.752	546.901	149
P171	547.23	547.46	230	546.705	546.855	150
P172	547.34	547.54	200	546.676	546.824	148
P173	547.23	547.42	190	546.662	546.808	146
P174	547.07	547.27	200	546.587	546.739	152
P175	547.12	547.31	190	546.597	546.741	144
P176	547.16	547.34	180	546.601	546.737	136
SP1	547.15	547.32	170	546.524	546.657	133
SP2	547.17	547.33	160	546.520	546.633	113
SP3	547.17	547.32	150	546.507	546.617	110
SP4	547.09	547.24	150	546.500	546.599	99
SP5	547.05	547.21	160	546.5	546.581	81
SP6	547.10	547.25	150	546.387	546.467	80
SP7	547.05	547.19	140	546.371	546.448	77
SP8	547.11	547.24	130	546.375	546.446	71
SP9	547.10	547.23	130	546.356	546.422	66
SP10	547.11	547.24	130	546.424	546.475	51
P177	546.98	547.09	110	546.410	546.456	46
P178	547.03	547.14	110	546.406	546.450	44
P179	546.98	547.09	110	546.409	546.448	39

P180	546.99	547.09	100	546.394	546.430	36
P181	547.00	547.09	90	546.396	546.428	32
P182	546.89	546.98	90	546.358	546.386	28
Shinde	546.88	546.97	90	546.352	546.375	23
P183	546.86	546.94	80	546.291	546.316	25
P184	546.78	546.87	90	546.285	546.305	20
P185	546.72	546.81	90	546.303	546.315	12
P186	546.62	546.72	100	546.288	546.296	8
P186a	546.64	546.73	90	546.281	546.286	5
Causeway	546.63	546.71	80	546.200	546.205	5
P187	546.68	546.74	60	546.133	546.140	7
P188	546.67	546.73	60	546.104	546.111	7
P189	546.28	546.35	70	546.124	546.128	4
P190	546.54	546.54	0	546.138	546.140	2
P191	546.37	546.37	0	546.131	546.131	0
Tilak				546.066	546.066	0
Shivaji	546.24	546.24	0	545.984	545.984	0
Dengle/ Kumbharwada new	545.74	545.74	0	545.370	545.370	0
Wellesely	544.57	544.57	0	544.685	544.685	0
Railway	544.56	544.56	0	544.585	544.585	0
Sangam/RTO	544.33	544.33	0	544.396	544.396	0

Table :7 Flood inundation extent for the discharge of 1,00,000 ft^3/s

Bridge and Pier Names	Water Surface Elevation after Metro Pier	Water Surface Elevation before Metro Pier	Water spread
	(m)	(m)	(m)
Nanded shivne bridge	462.49	462.49	0.00
NH4 1	186.43	186.29	0.14
NH4 2	185.18	185.03	0.15
Rajaram	306.00	304.95	1.05
Mhatre	159.77	158.42	1.35
SM Joshi	206.82	206.63	0.19
YB Chavan	214.08	206.82	7.26
P152	205.34	202.68	2.66
P153	180.12	180.05	0.07
P154	174.26	174.16	0.10
P155	174.26	174.16	0.10
Sambhaji/ Lakadi	161.72	161.44	0.28
P156	167.20	166.77	0.43
P157	204.24	203.97	0.27
P158	196.30	194.76	1.54
P159	285.24	263.04	22.20
P160	283.31	262.70	20.61
Z bridge	325.40	295.56	29.84
P161	340.00	330.37	9.63
P162	364.56	354.80	9.76
P163	364.38	353.79	10.59
Bhide	364.25	353.31	10.94
DE1	283.27	280.68	2.59
DE2	283.21	280.66	2.55
DE3	283.13	280.63	2.50
DE4	213.90	211.13	2.77
DE5	256.41	250.16	6.25
DE6	256.31	250.01	6.30

DE7	254.78	249.61	5.17
DE8	252.16	249.10	3.06
DE9	252.05	249.03	3.02
DE10	264.80	261.69	3.11
P164	264.65	261.54	3.11
P165	230.42	227.18	3.24
P166	230.21	227.05	3.16
P167	278.39	222.63	55.76
P168	260.85	259.62	1.23
P169	223.19	218.10	5.09
P170	211.00	208.03	2.97
P171	230.95	230.48	0.47
P172	251.21	245.52	5.69
P173	250.60	245.21	5.39
P174	240.65	239.33	1.32
P175	225.95	224.23	1.72
P176	191.05	189.55	1.50
SP1	249.56	242.07	7.49
SP2	268.92	258.91	10.01
SP3	267.31	258.00	9.31
SP4	266.18	263.51	2.67
SP5	265.88	263.39	2.49
SP6	261.90	257.24	4.66
SP7	261.59	255.58	6.01
SP8	258.62	254.65	3.97
SP9	257.78	254.28	3.50
SP10	249.73	249.70	0.03
P177	249.73	249.70	0.03
P178	248.82	248.39	0.43
P179	243.08	242.56	0.52
P180	168.39	168.38	0.01
P181	183.53	183.51	0.02
P182	174.06	174.04	0.02

Shinde	174.06	174.04	0.02
P183	172.40	172.36	0.04
P184	172.39	172.36	0.03
P185	211.42	210.62	0.80
P186	184.98	184.85	0.13
P186a	184.92	184.82	0.10
Causeway	247.44	247.00	0.44
P187	246.59	246.14	0.45
P188	195.94	195.62	0.32
P189	225.04	224.87	0.17
P190	198.59	198.37	0.22
P191	175.54	175.53	0.01
Tilak	203.36	203.36	0.00
Shivaji	209.62	209.62	0.00
Dengle/ Kumbharwada new	164.18	164.18	0.00
Wellesely	196.25	196.25	0.00
Railway	164.63	164.63	0.00
Sangam/RTO	174.98	174.98	0.00

Table :8 Flood inundation extent for the discharge of 60,000 ft^3/s

Bridge and Pier Names	Water Surface Elevation after Metro Pier	Water Surface Elevation before Metro Pier	Water spread
	(m)	(m)	(m)
Nanded shivne bridge	201.66	201.66	0.00
NH4 1	155.83	155.82	0.01
NH4 2	155.48	155.47	0.01
Rajaram	172.42	172.31	0.11
Mhatre	144.11	143.62	0.49
SM Joshi	204.90	204.76	0.14
YB Chavan	202.63	202.50	0.13
P152	190.75	189.96	0.79
P153	179.42	179.36	0.06
P154	172.19	171.49	0.70
P155	172.17	171.48	0.69
Sambhaji/ Lakadi	158.08	157.76	0.32
P156	163.14	162.99	0.15
P157	160.50	160.40	0.10
P158	162.76	161.98	0.78
P159	160.74	160.63	0.11
P160	160.74	160.63	0.11
Z bridge	164.67	164.36	0.31
P161	189.08	184.14	4.94
P162	209.98	199.57	10.41
P163	209.42	198.90	10.52
Bhide	209.00	197.56	11.44
DE1	192.63	187.43	5.20
DE2	192.46	187.36	5.10
DE3	192.19	187.27	4.92
DE4	170.58	168.38	2.20
DE5	175.23	173.16	2.07
DE6	175.13	173.10	2.03

DE7	180.25	178.73	1.52
DE8	184.39	182.12	2.27
DE9	184.29	182.03	2.26
DE10	169.12	166.41	2.71
P164	168.94	166.28	2.66
P165	174.08	173.43	0.65
P166	174.03	173.39	0.64
P167	169.89	169.12	0.77
P168	161.30	159.86	1.44
P169	150.13	149.41	0.72
P170	160.05	159.31	0.74
P171	158.23	157.60	0.63
P172	158.16	156.38	1.78
P173	157.93	156.23	1.70
P174	158.13	153.52	4.61
P175	157.97	156.36	1.61
P176	160.19	159.82	0.37
SP1	146.80	143.96	2.84
SP2	147.87	146.09	1.78
SP3	147.63	145.90	1.73
SP4	150.41	147.54	2.87
SP5	149.87	147.56	2.31
SP6	149.22	148.56	0.66
SP7	149.06	148.42	0.64
SP8	163.86	163.30	0.56
SP9	163.67	163.14	0.53
SP10	195.45	195.30	0.15
P177	195.39	195.26	0.13
P178	190.83	190.82	0.01
P179	183.24	183.21	0.03
P180	163.47	163.08	0.39
P181	182.45	182.44	0.01
P182	172.99	172.98	0.01

Shinde	172.98	172.97	0.01
P183	169.83	169.81	0.02
P184	169.82	169.80	0.02
P185	177.33	177.31	0.02
P186	162.95	162.94	0.01
P186a	162.94	162.94	0.00
Causeway	150.08	150.08	0.00
P187	150.02	150.02	0.00
P188	147.50	147.47	0.03
P189	165.21	165.20	0.01
P190	167.83	167.83	0.00
P191	167.42	167.42	0.00
Tilak	159.83	159.83	0.00
Shivaji	172.83	172.83	0.00
Dengle/ Kumbharwada new	157.44	157.44	0.00
Wellesely	175.69	175.69	0.00
Railway	156.63	156.63	0.00
Sangam/RTO	165.41	165.41	0.00

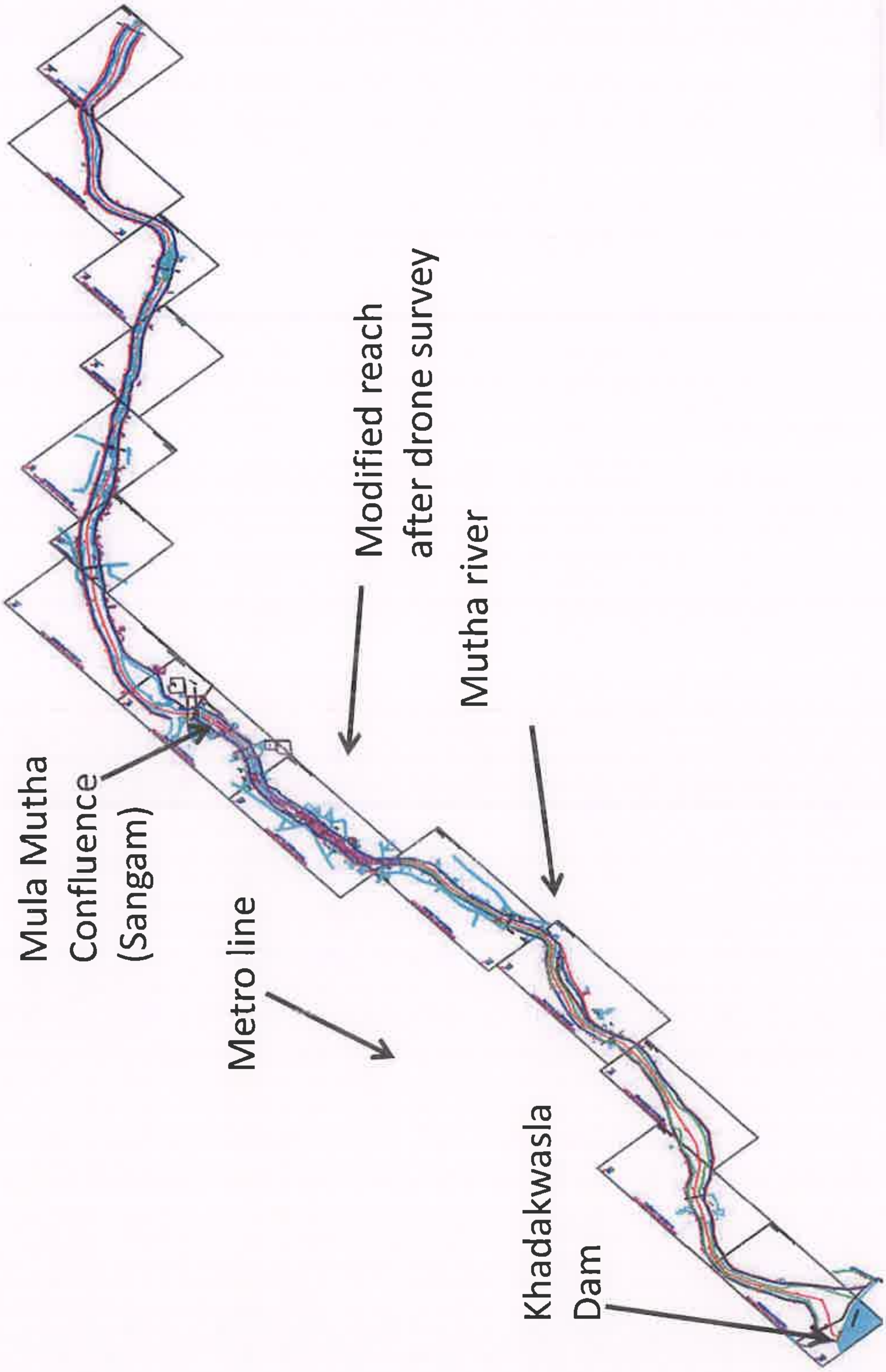


Figure 1(a): Study Reach

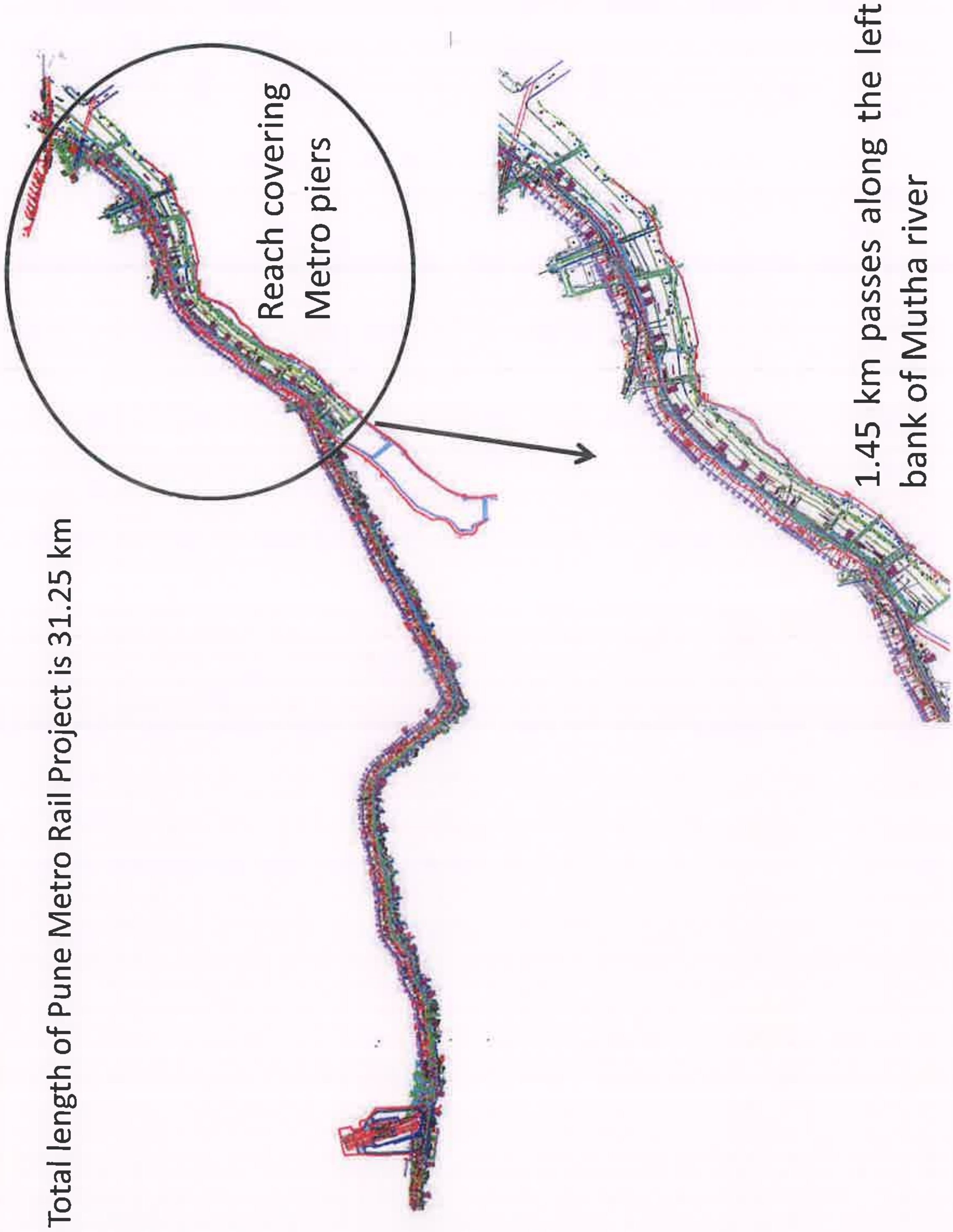


Figure 1(b): Study Reach highlighting area of metro pier in river flood plain

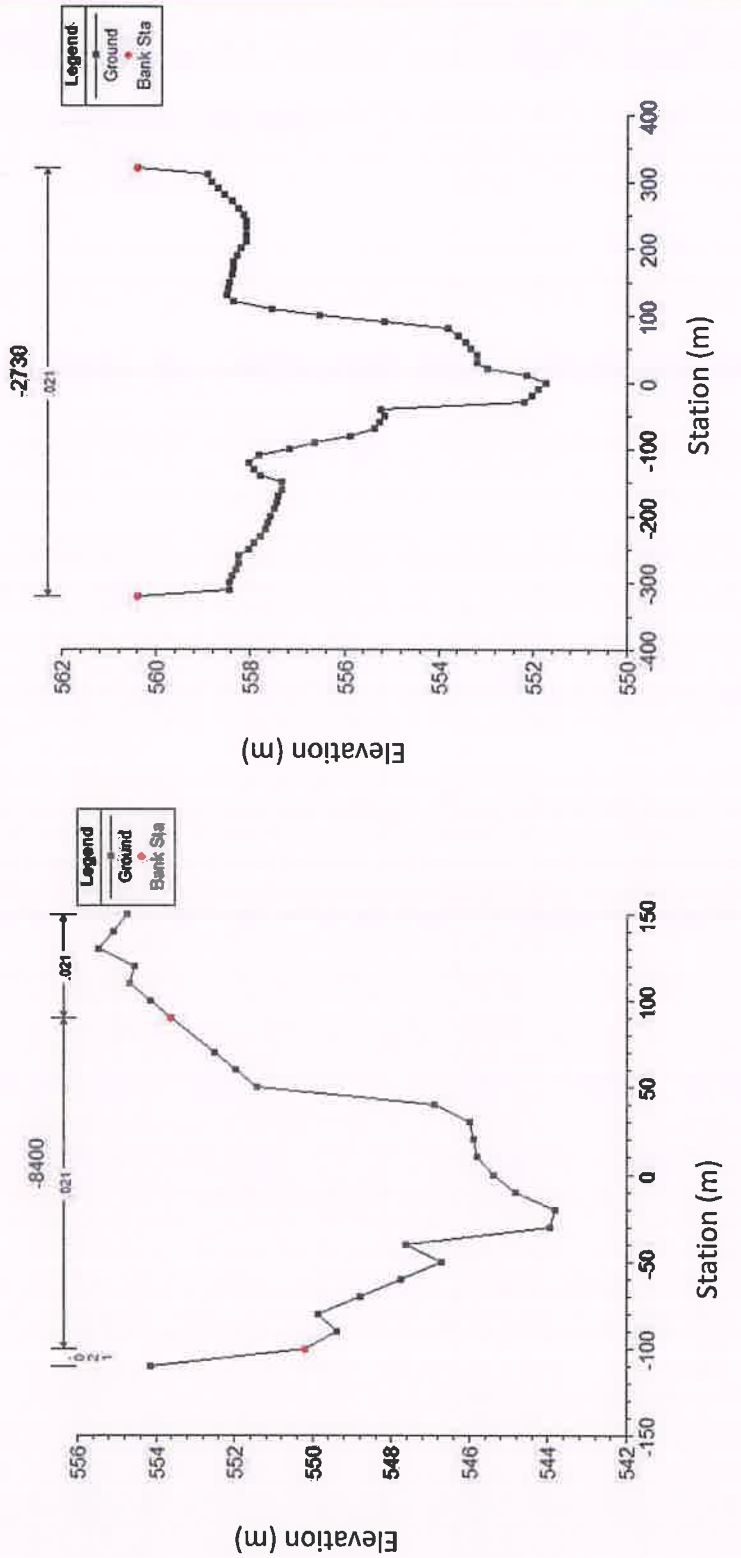


Figure 2: Representative cross sections of Mutha river in the study reach

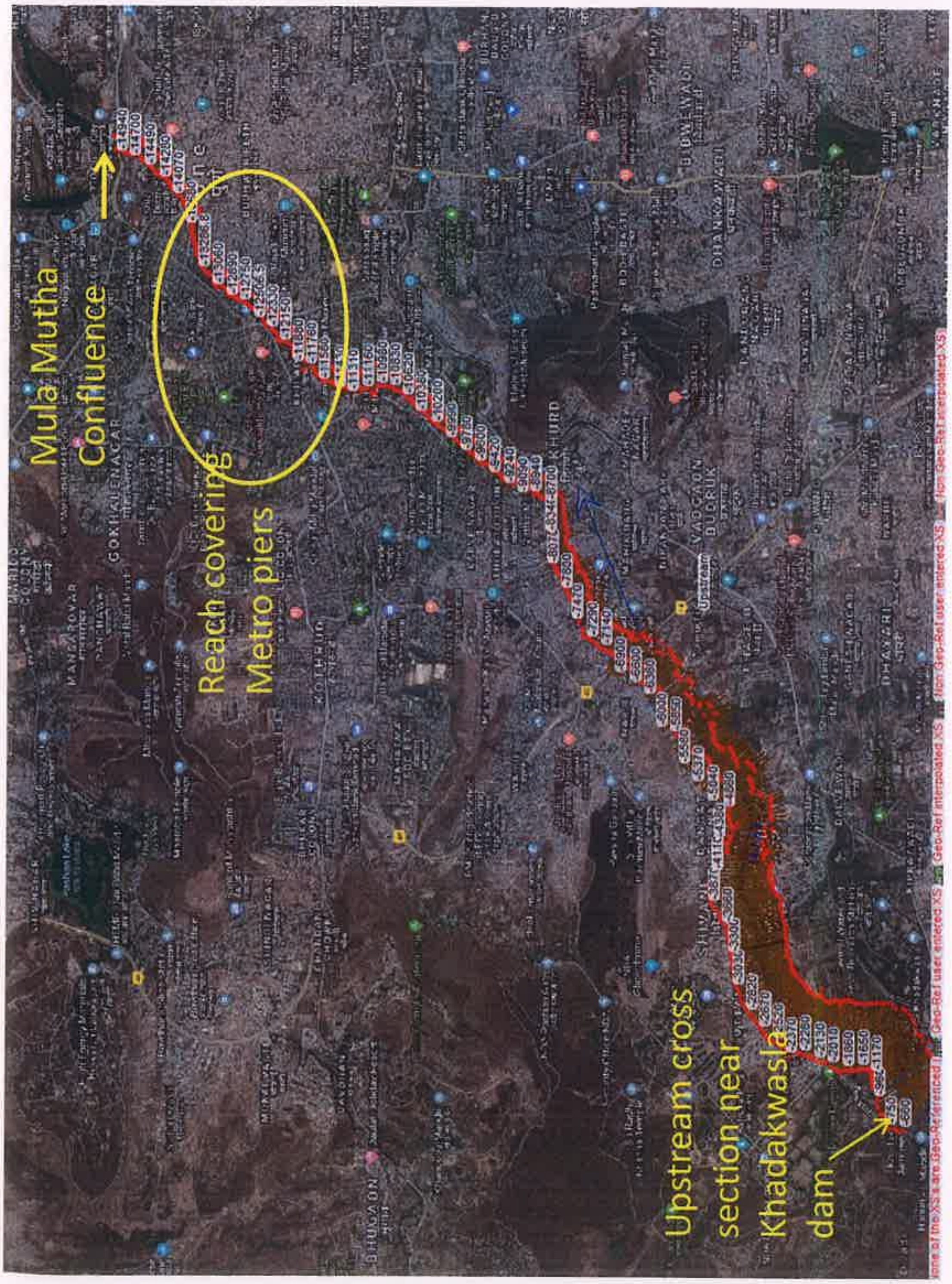


Figure 3: River schematic in HEC-RAS

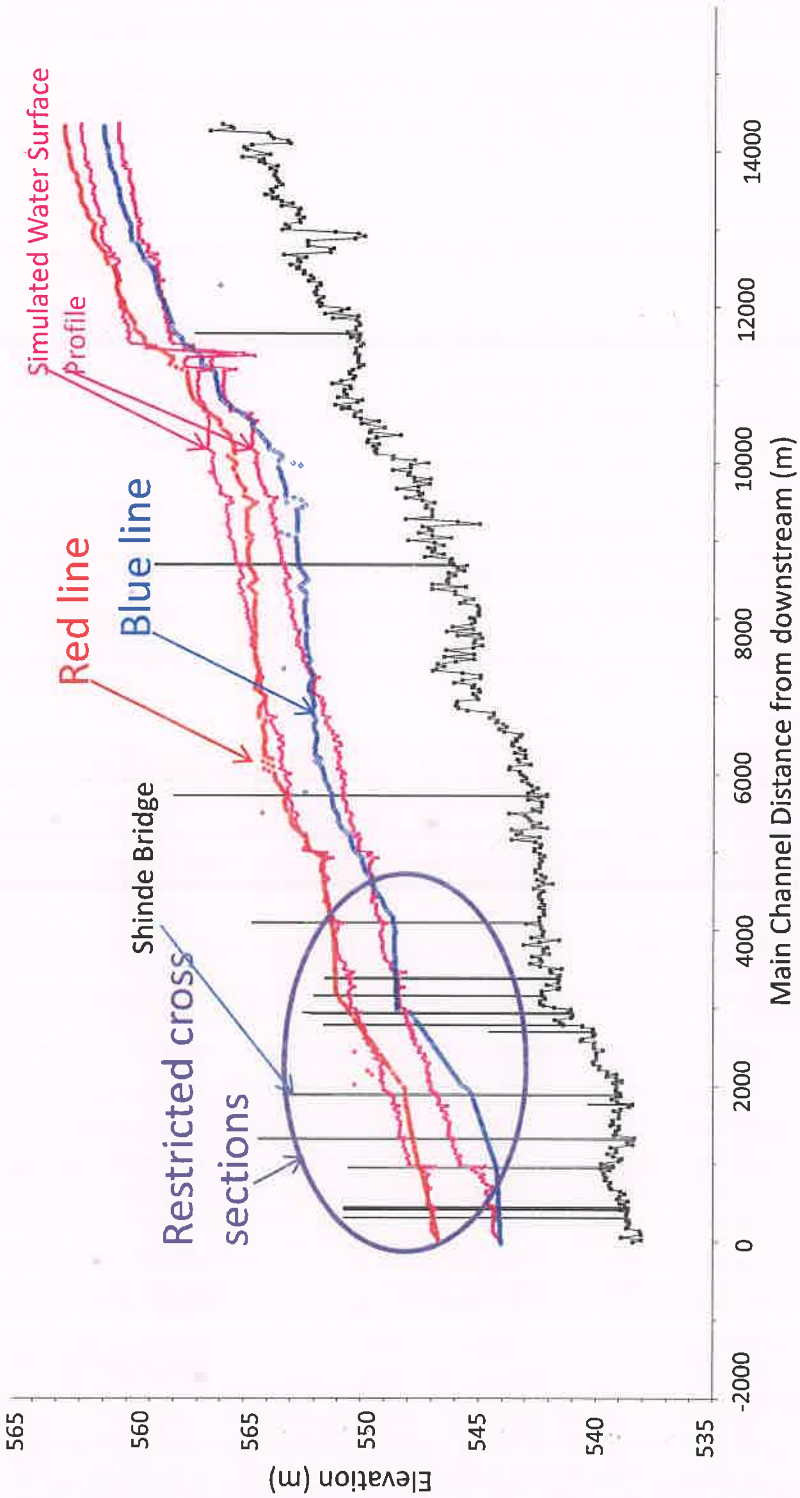


Figure 4: Water surface profiles incorporating existing bridges without metro piers alongwith blue line (60,000 ft^3/s) and red line (1,00,000 ft^3/s)

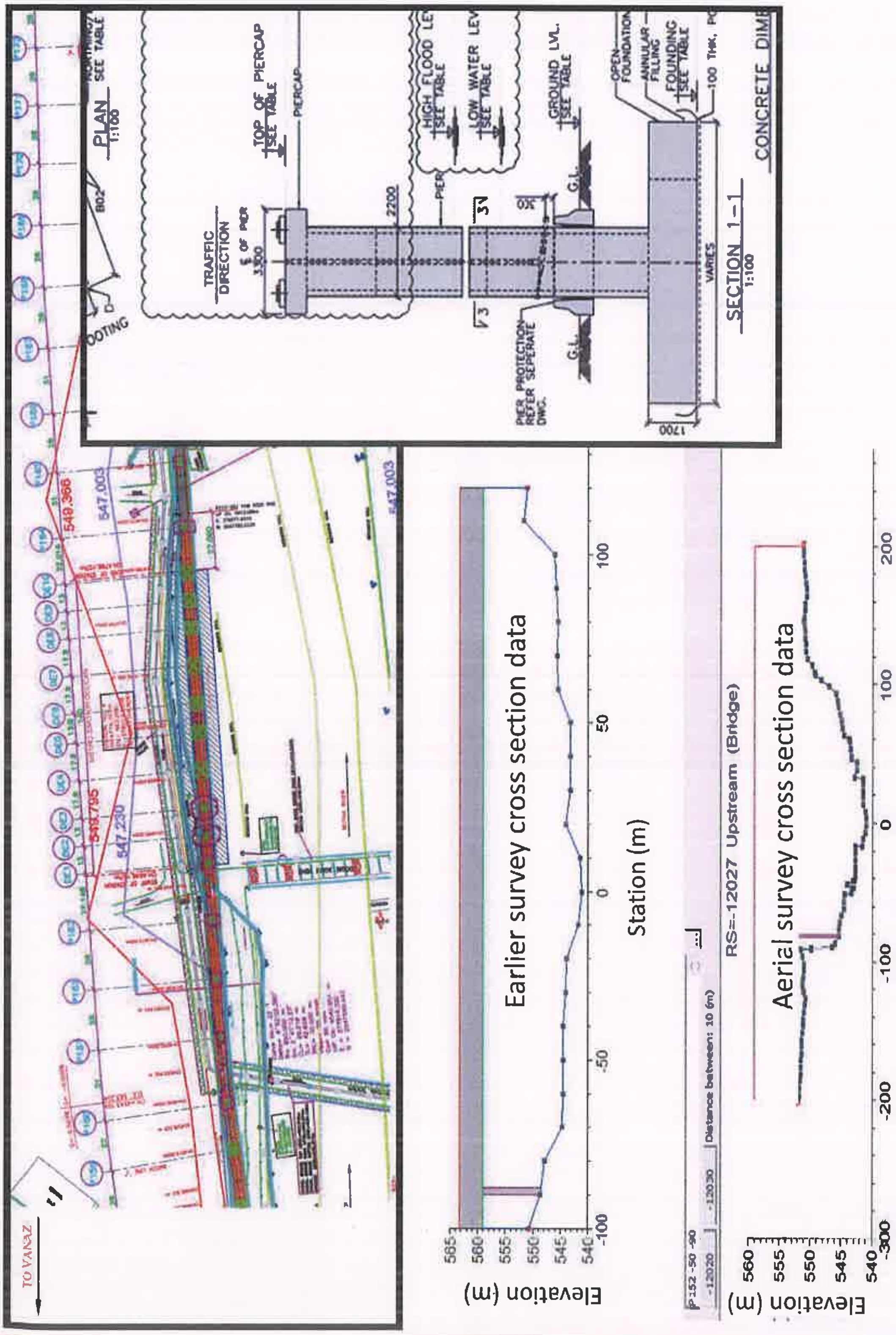


Figure 5: Sample Data Metro pier (P152) near Sambhaji Bridge

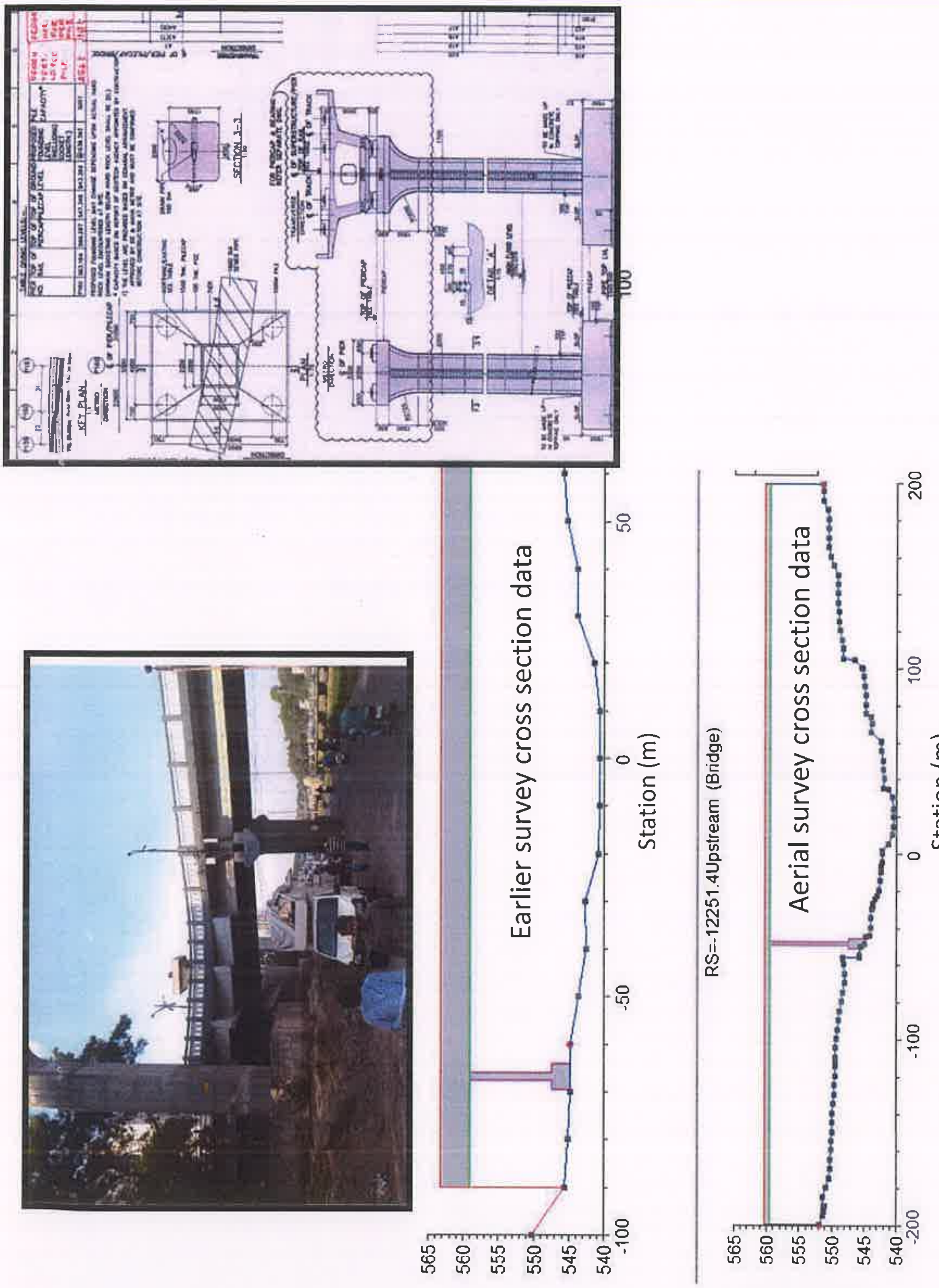


Figure 6: Sample Data Metro pier (P160) near Gadgil (Z) Bridge

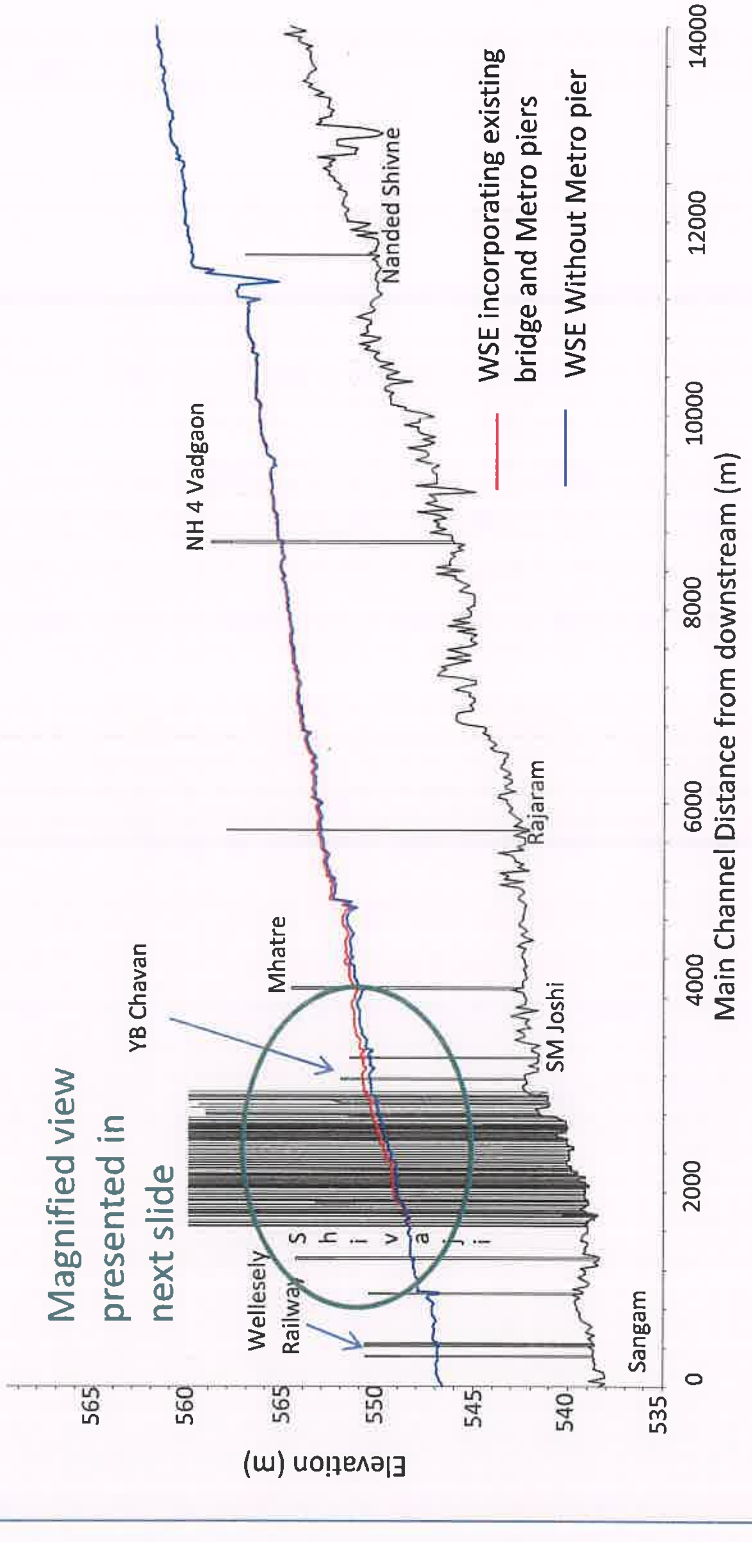


Figure 7(a): Water surface elevation for the discharge of 1,00,000 ft^3/s (incorporating existing bridge and Metro piers)

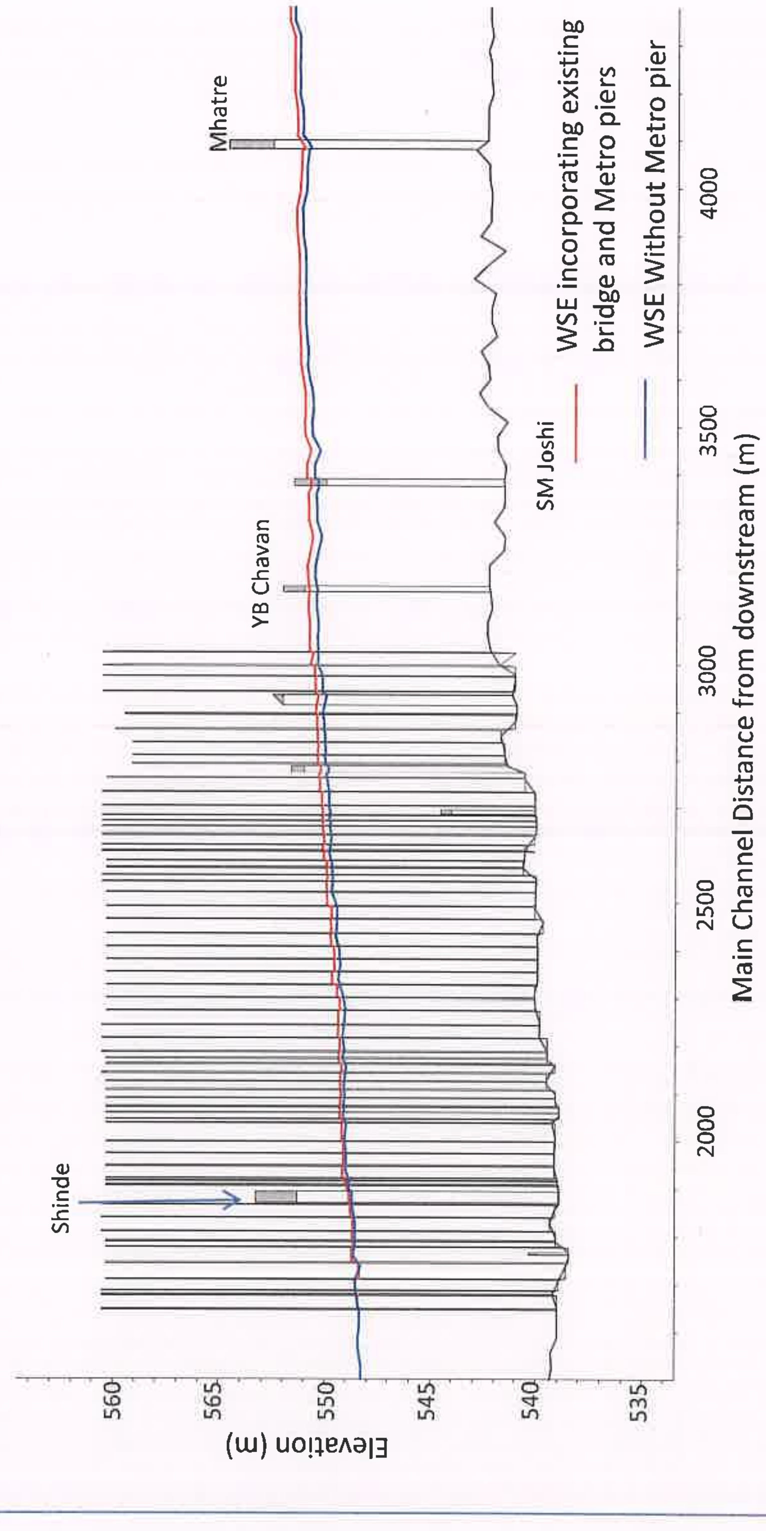


Figure 7(b) : Zoomed view of
Water Surface Elevations for the discharge of 1,00,000 ft^3/s

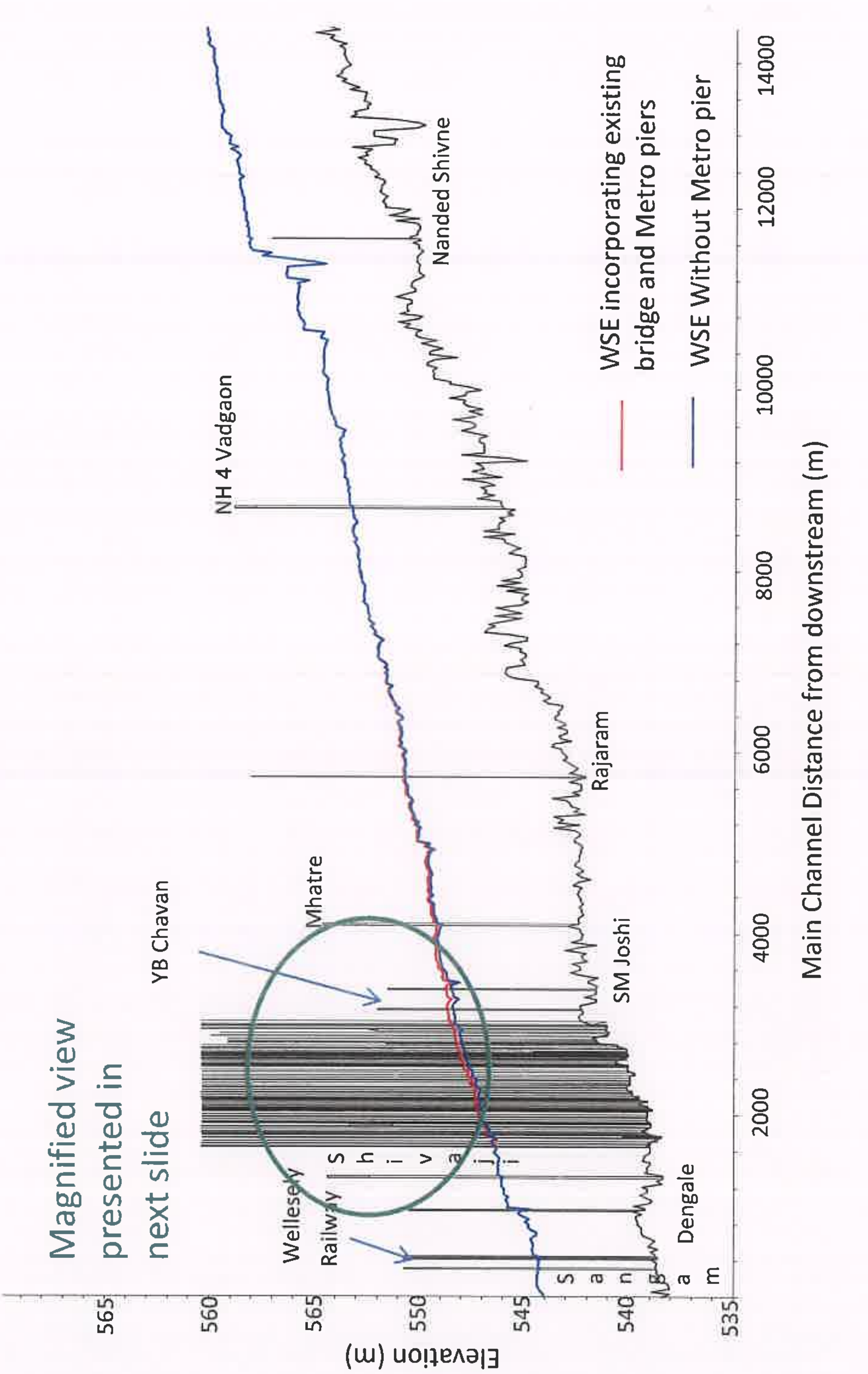


Figure 8(a): Water surface elevation for the discharge of 60,000 ft^3/s (incorporating existing bridge and Metro piers)

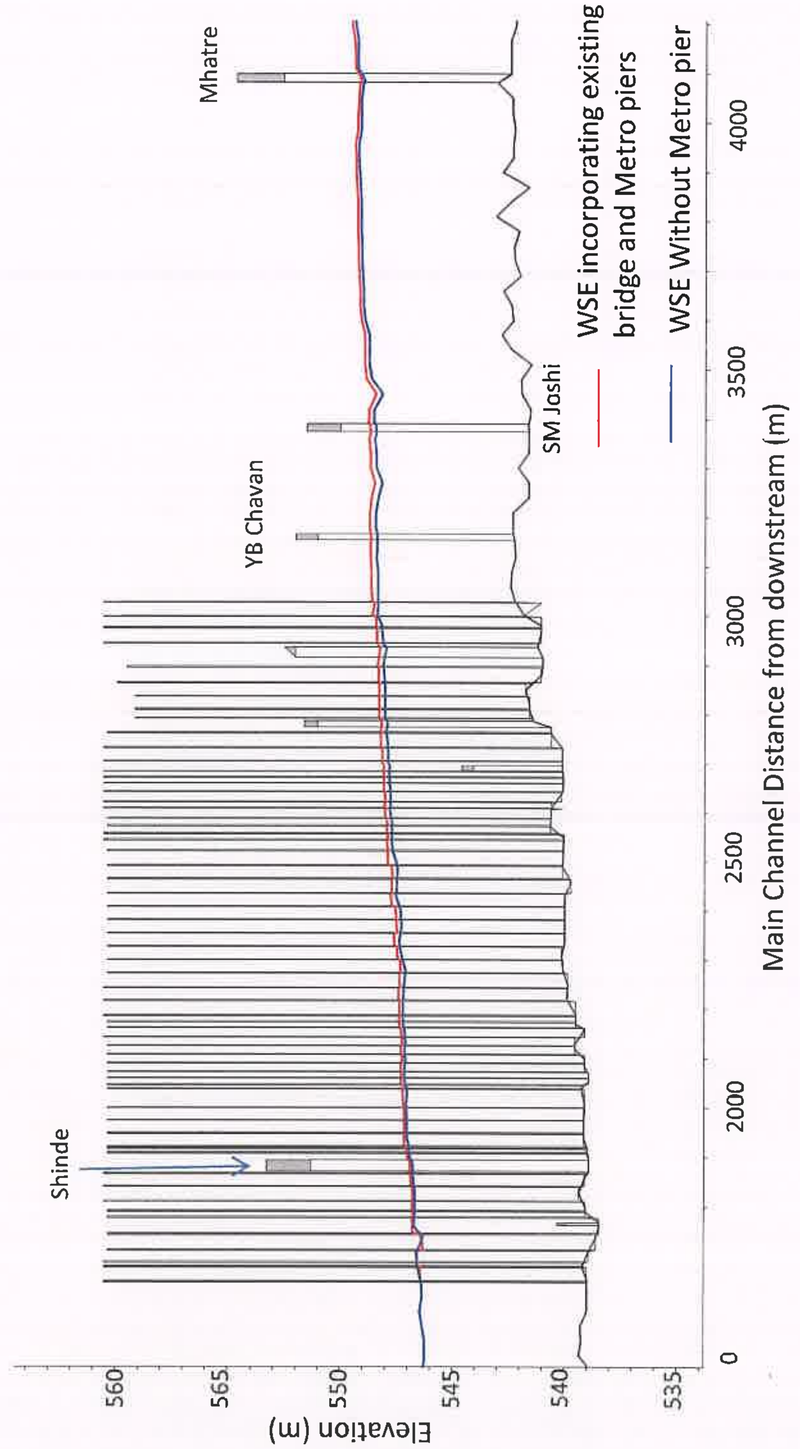
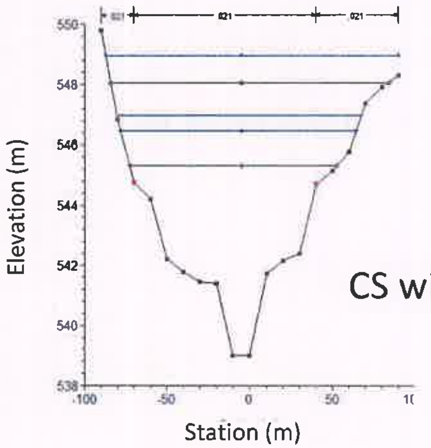
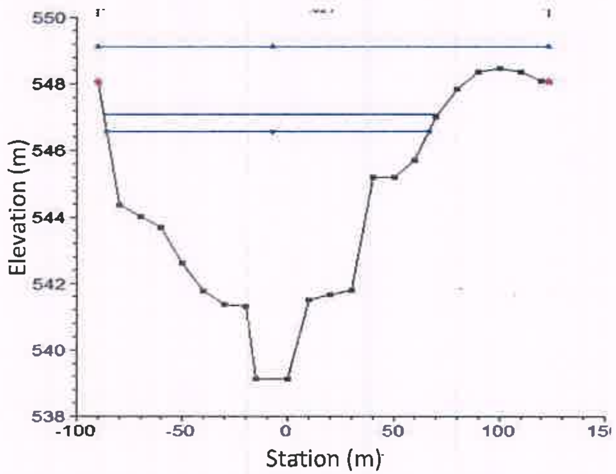


Figure 8(b) : Zoomed view of
Water Surface Elevations for the discharge of 60,000 ft^3/s

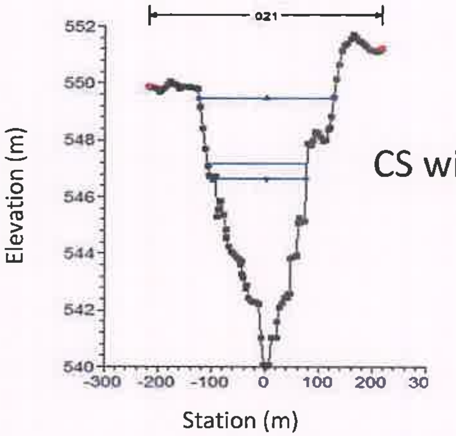
Restricted cross sections between Sambhaji bridge and Shinde bridge



CS width 200 m



Extended cross sections between Sambhaji bridge and Shinde bridge



CS width 450 m

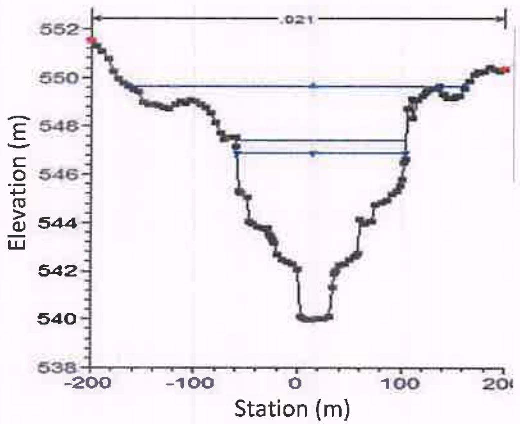


Figure 9: Restricted and extended cross section near Sambhaji bridge

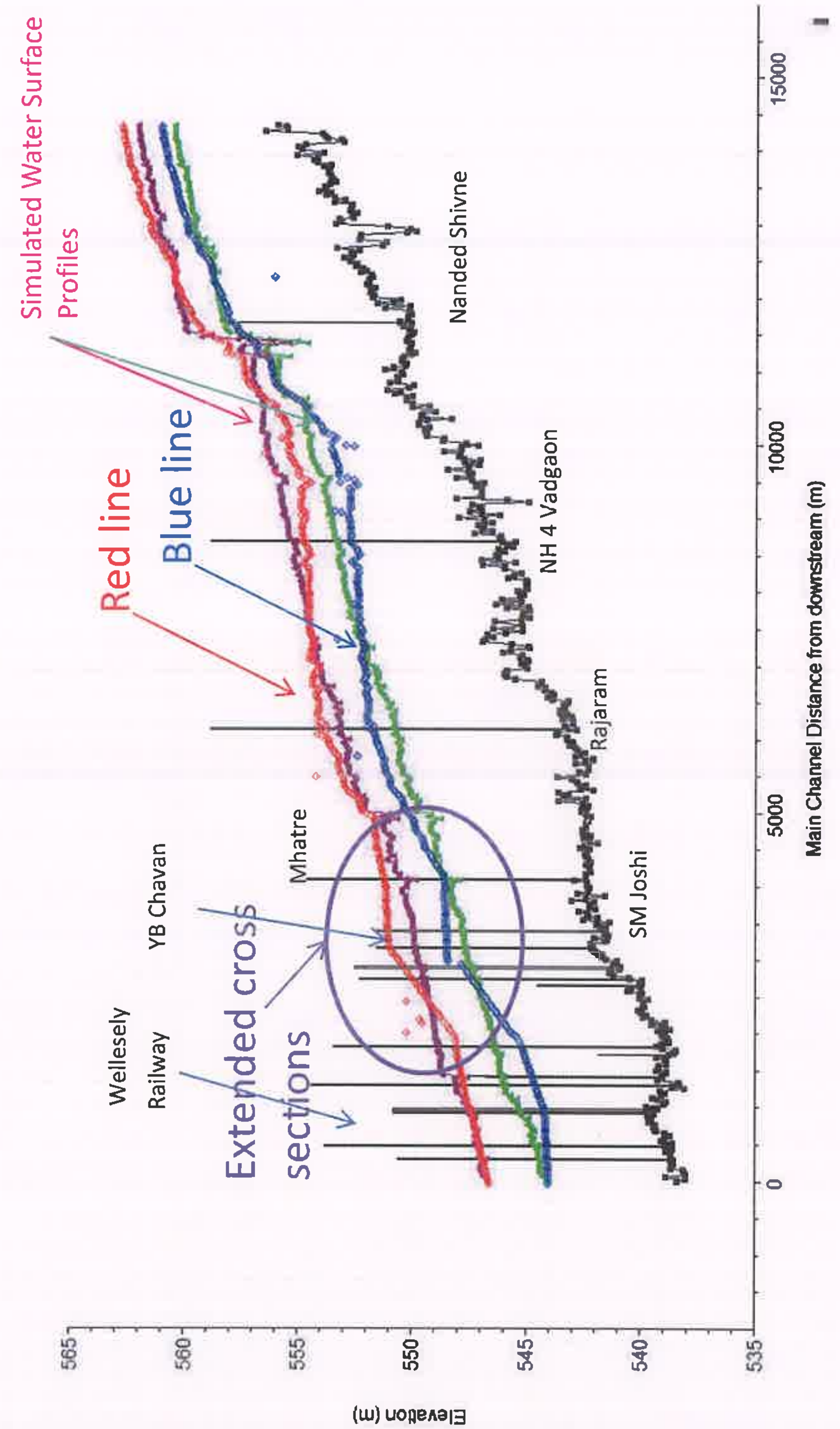


Figure 10: Water surface profiles using aerial survey data incorporating existing bridges alongwith blue line (60,000 ft^3/s) and red line (1,00,000 ft^3/s)

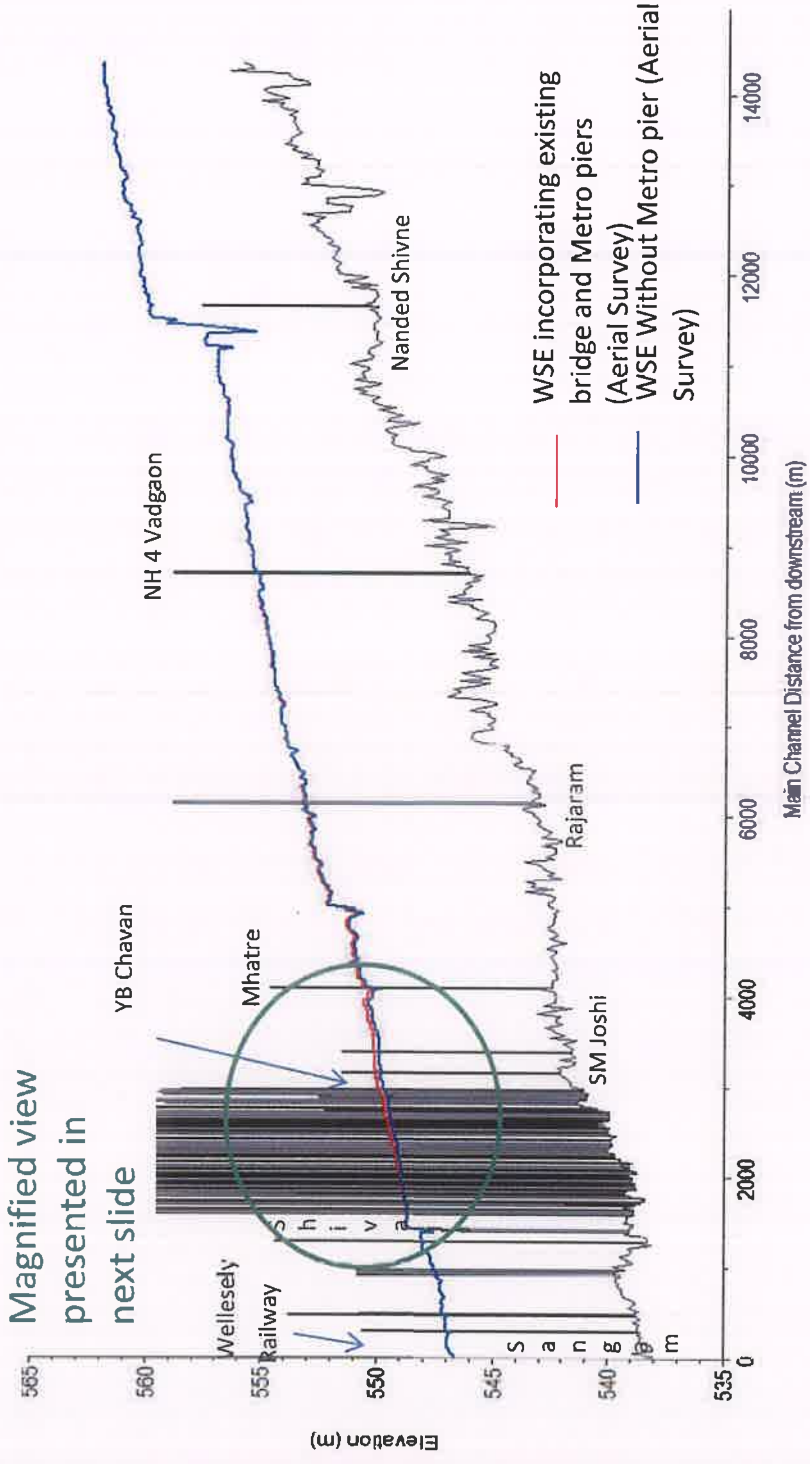


Figure 11(a): Water surface profiles using aerial survey data incorporating existing bridges and Metro piers for discharge of $1,00,000\ ft^3/s$

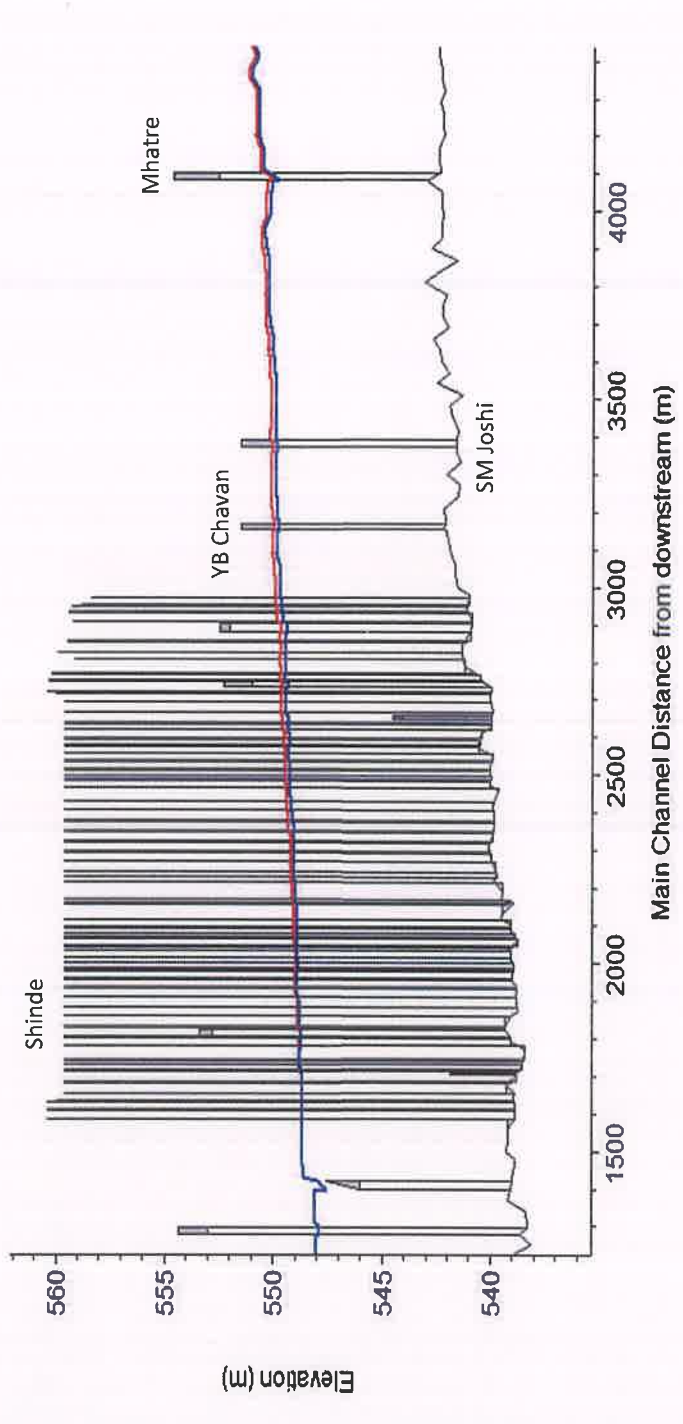


Figure 11(b): Zoomed view of water surface profiles using aerial survey data incorporating existing bridges and Metro piers for discharge of 1,00,000 ft^3/s

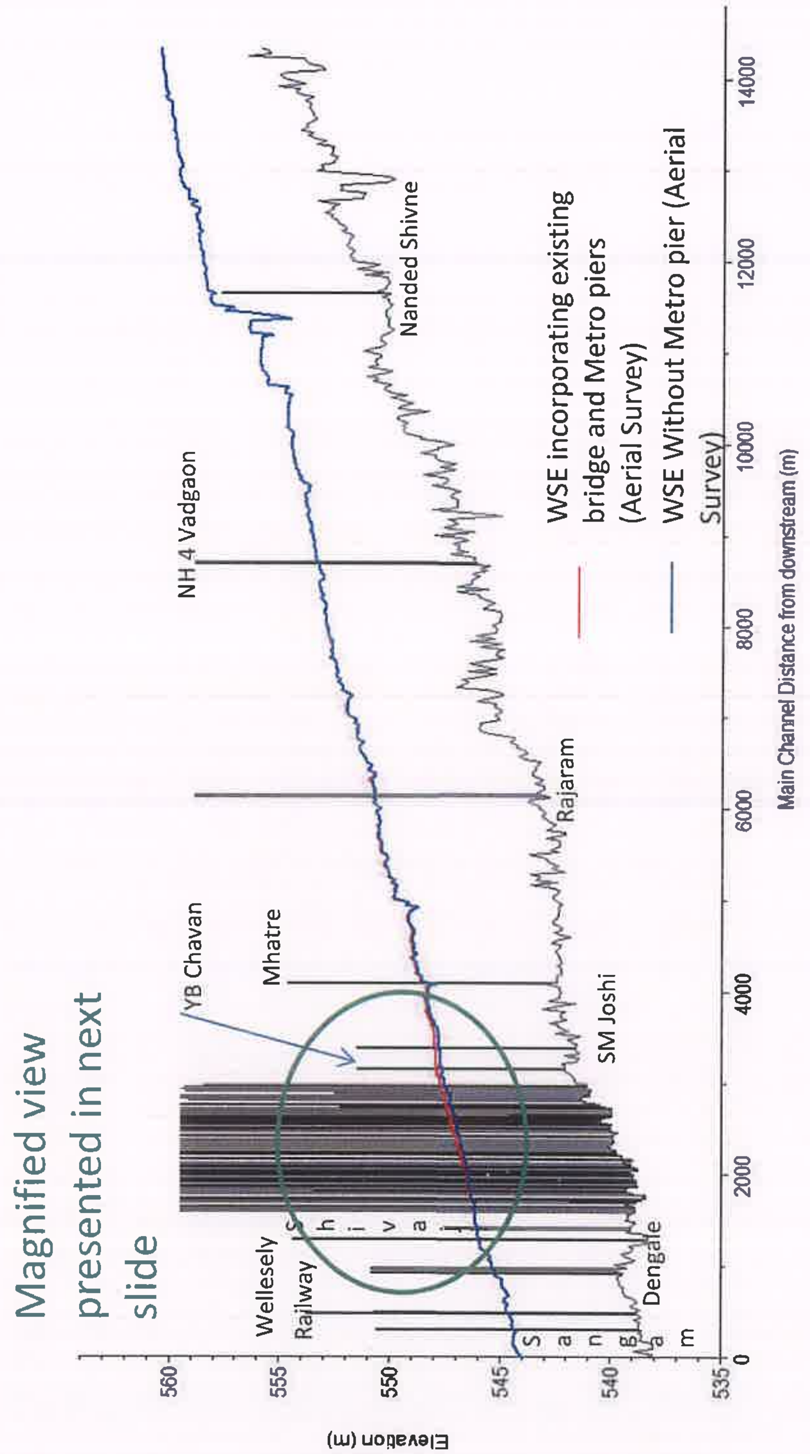


Figure 12(a): Water surface profiles using aerial survey data incorporating existing bridges and Metro piers for discharge of 60,000 ft^3/s

Figure 13: Flood inundation map overlaid on Google map for the discharge of 1,00,000 ft^3/s covering the entire study reach

Figure 14: Flood inundation map overlaid on Google map for the discharge of 1,00,000 ft^3/s covering reach from Khadakwasla dam to Nanded city

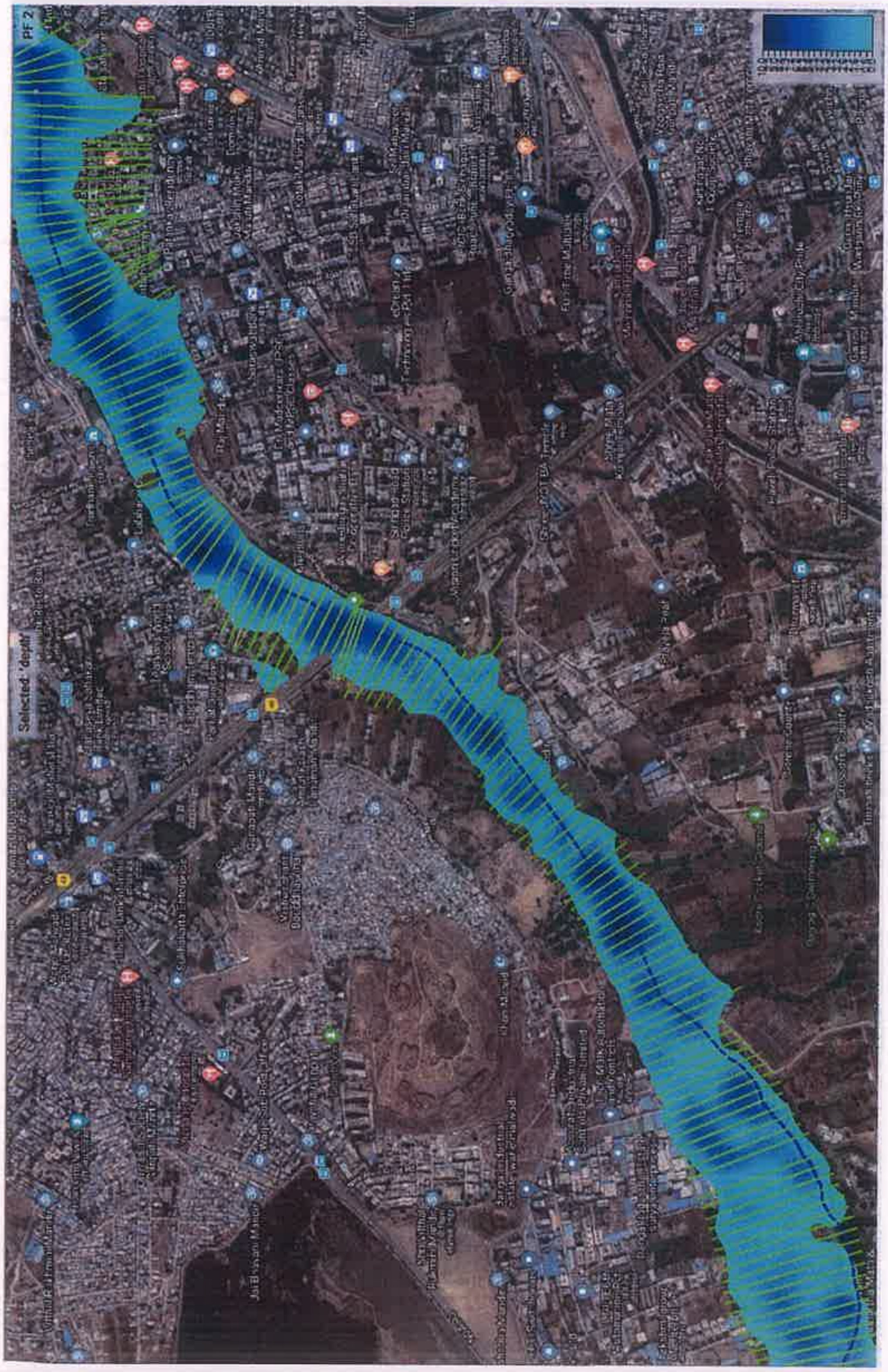


Figure 15: Flood inundation map overlaid on Google map for the discharge of 1,00,000 ft^3/s covering reach from Nanded city to Anand nagar

Figure 16: Flood inundation map overlaid on Google map for the discharge of 1,00,000 ft^3/s covering reach from Anand nagar to Mhatre bridge

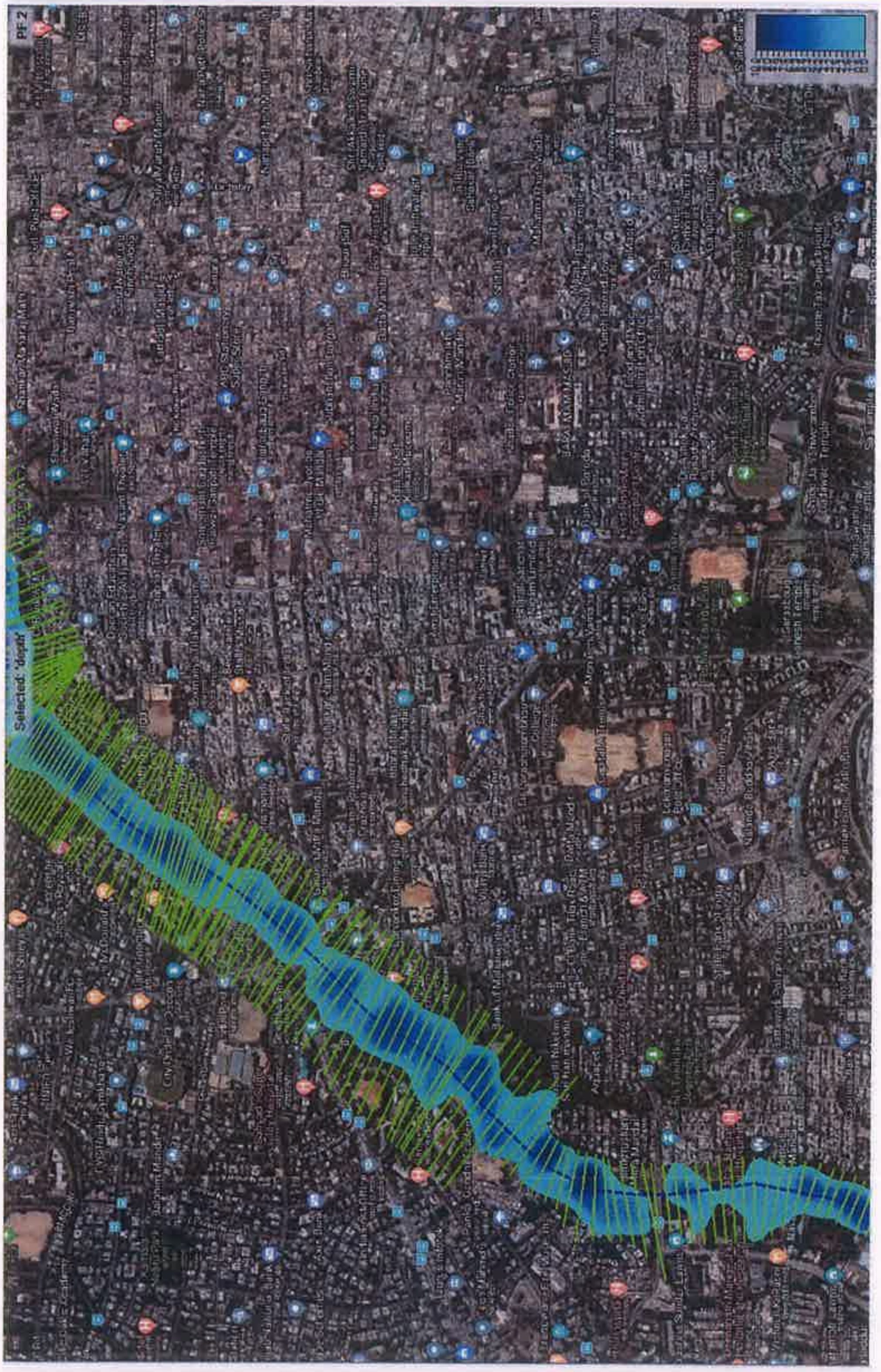


Figure 17: Flood inundation map overlaid on Google map for the discharge of 1,00,000 ft^3/s covering reach from Mhatre bridge to Tilak bridge

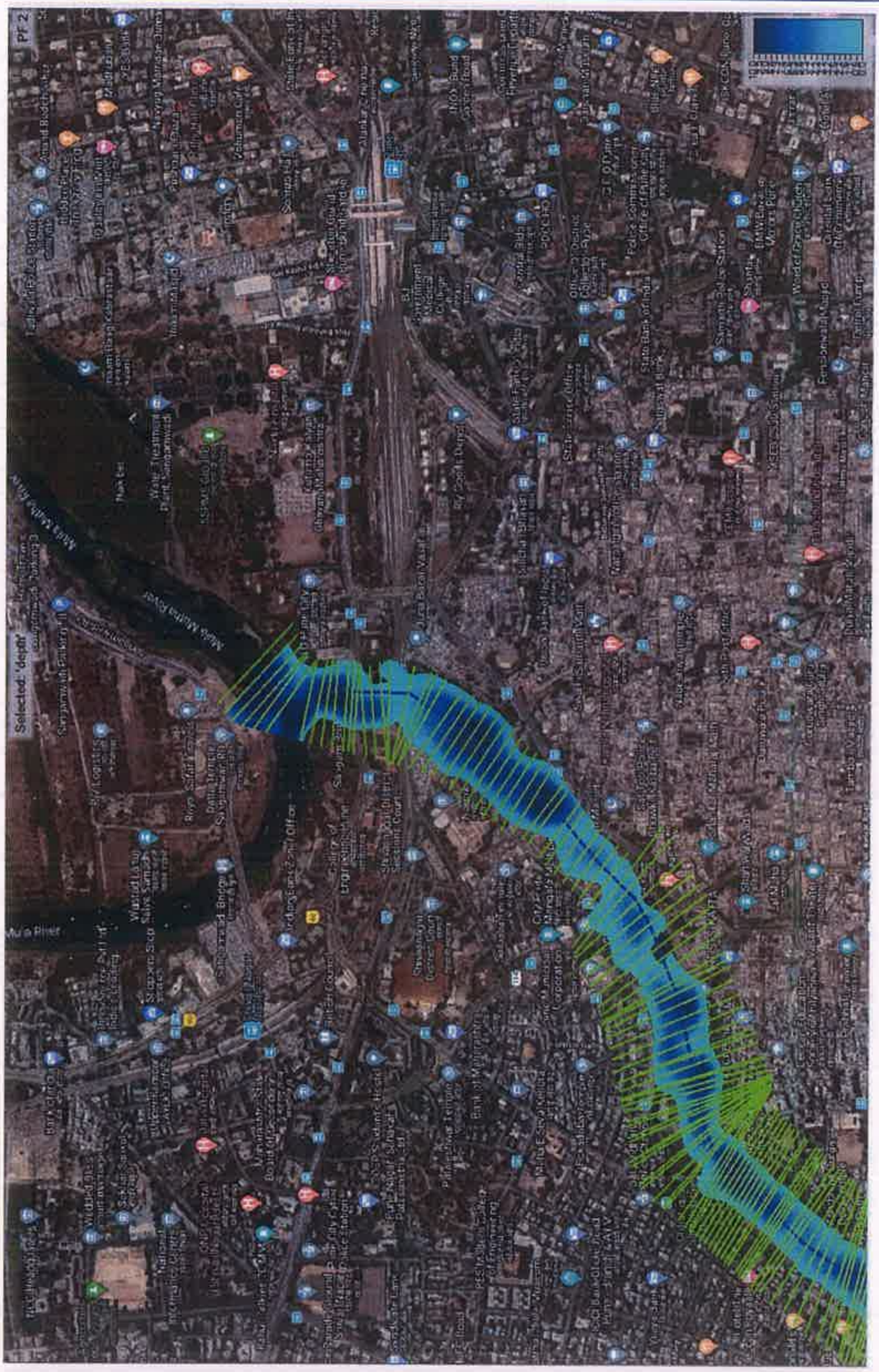


Figure 18: Flood inundation map overlaid on Google map for the discharge of 1,00,000 ft^3/s covering reach from Tilak bridge to Sangam

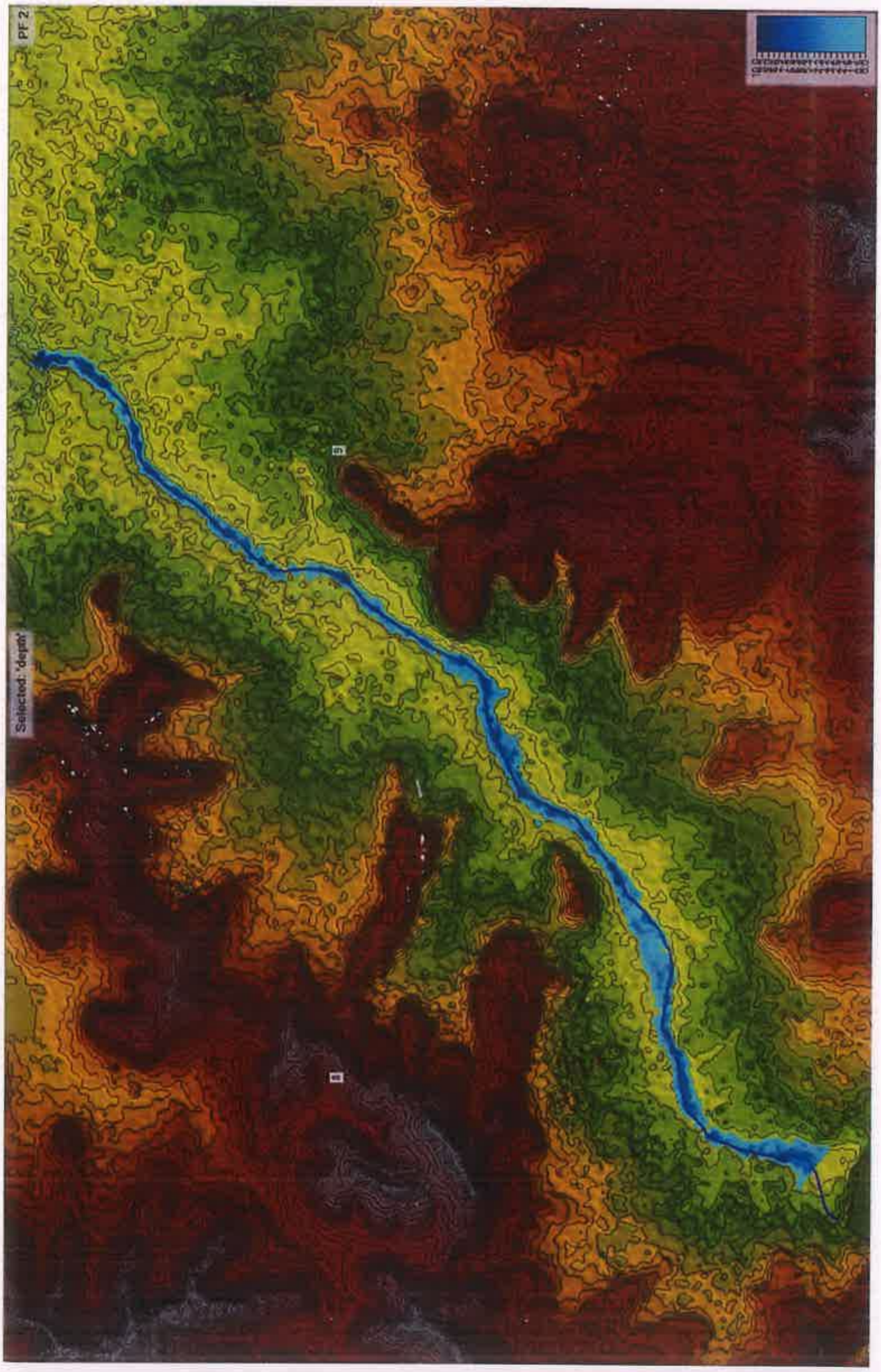


Figure 19: Flood inundation map overlaid on SRTM terrain map for the discharge of 1,00,000 ft^3/s covering the entire study reach

Figure 20: Flood inundation map overlaid SRTM terrain map for the discharge of 1,00,000 ft^3/s covering reach from Khadakwasla dam to Nanded city

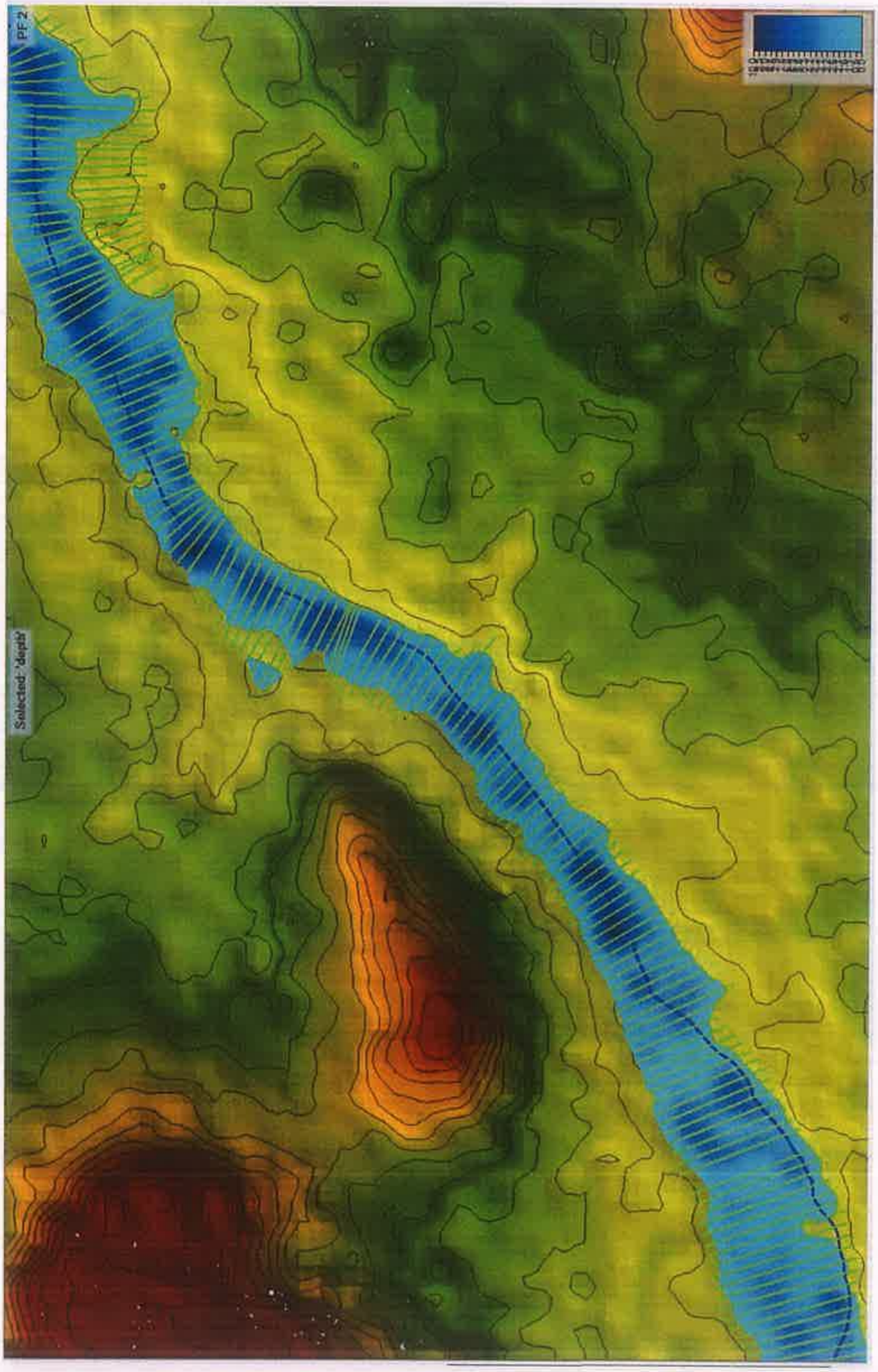


Figure 21: Flood inundation map overlaid SRTM terrain map for the discharge of 1,00,000 ft^3/s covering reach from Nanded city to Anand nagar

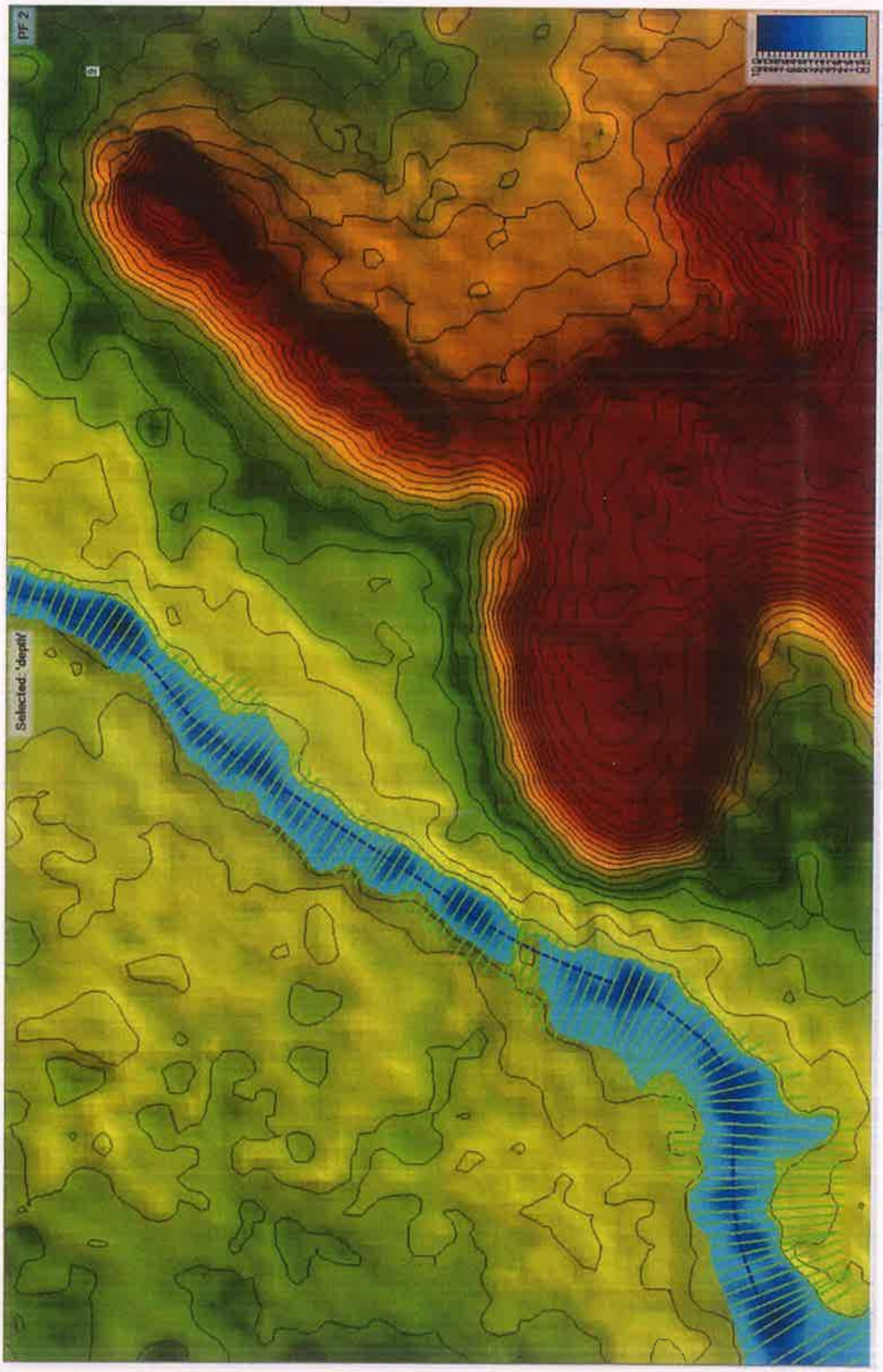


Figure 22: Flood inundation map overlaid on SRTM terrain map for the discharge of 1,00,000 ft^3/s covering reach from Anand nagar to Mhatre bridge

Figure 23: Flood inundation map overlaid on SRTM terrain map for the discharge of 1,00,000 ft^3/s covering reach from Mhatre bridge to Tilak bridge

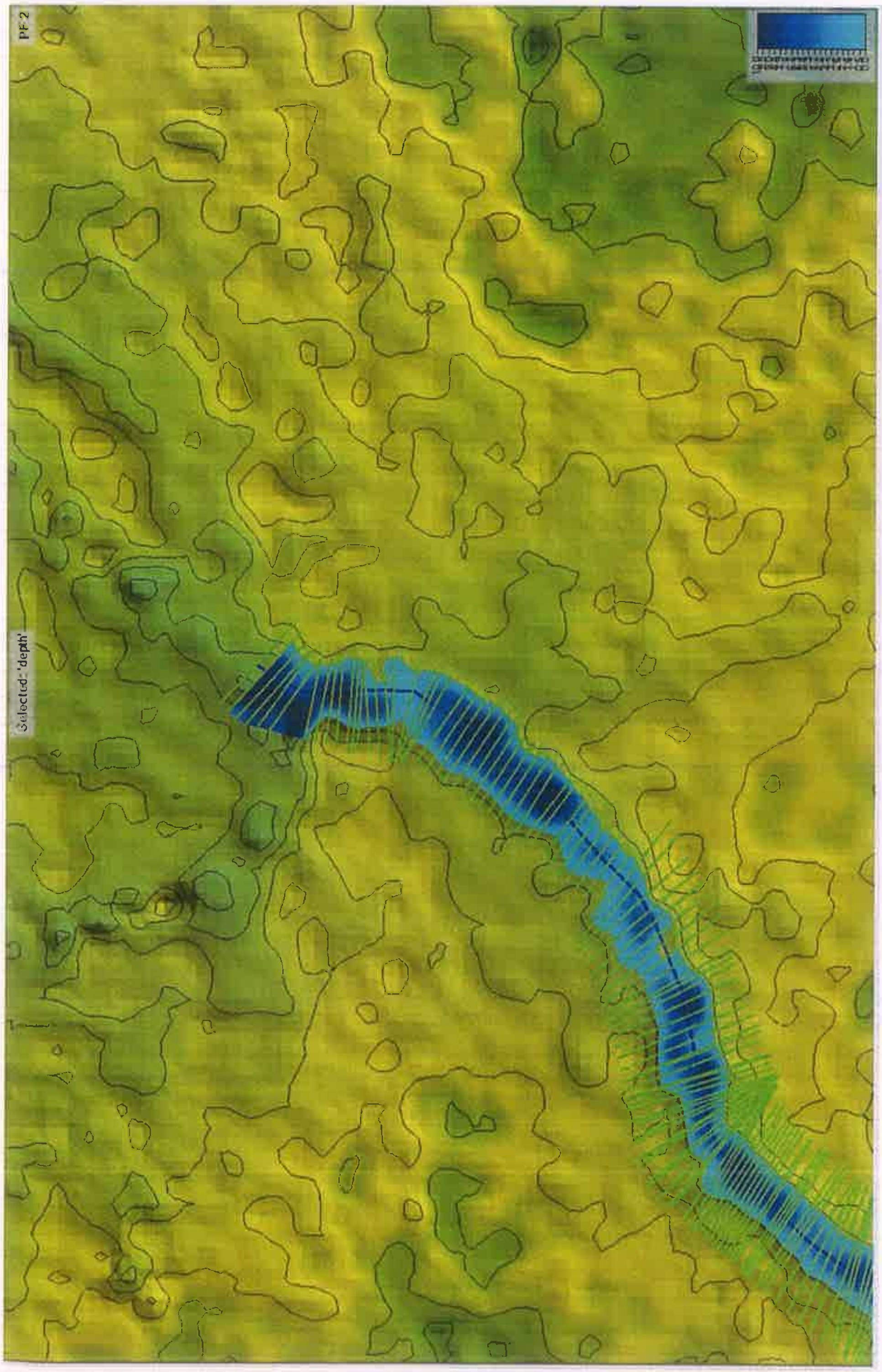


Figure 24: Flood inundation map overlaid on SRTM terrain map for the discharge of 1,00,000 ft^3/s covering reach from Tilak bridge to Sangam

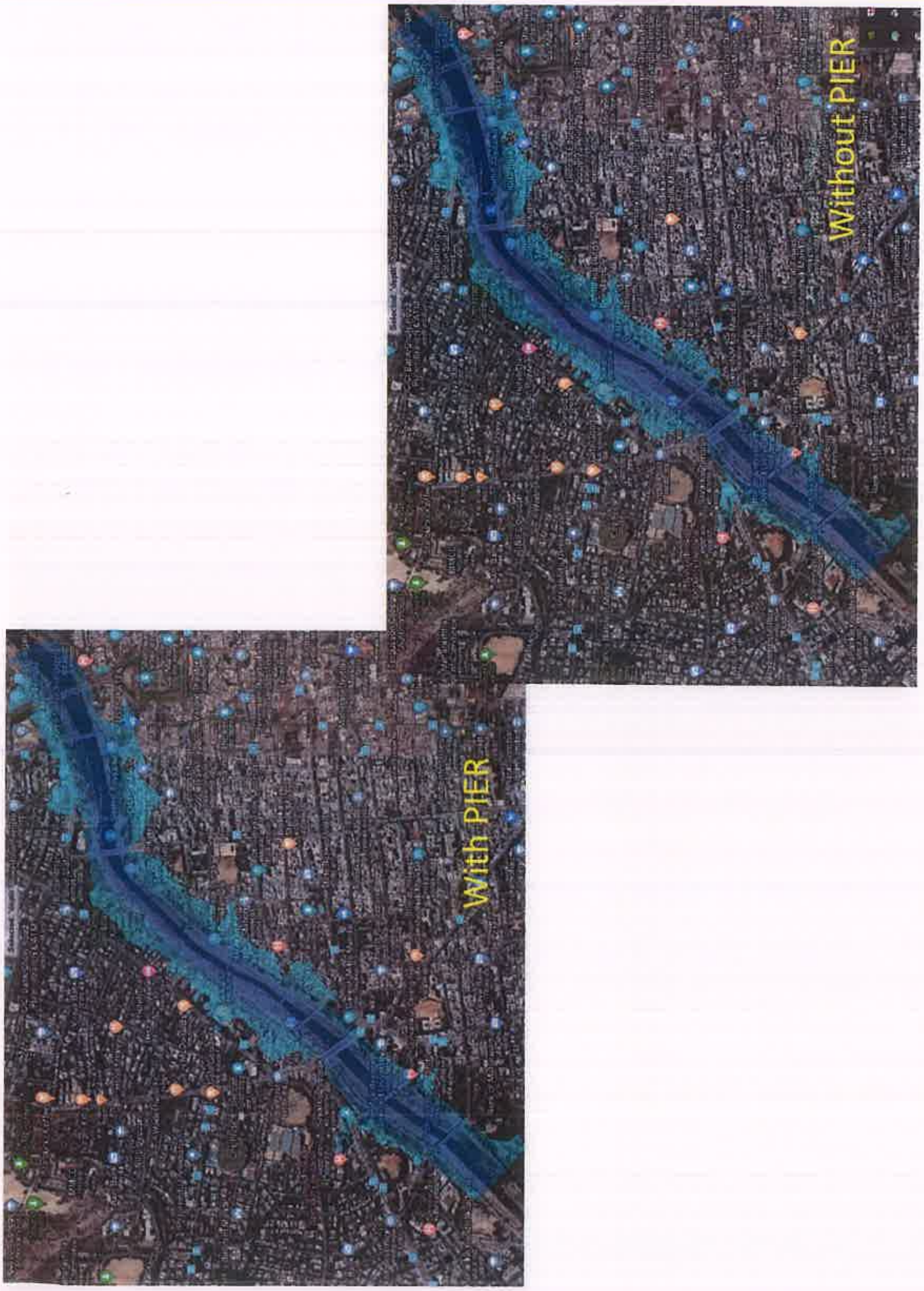


Figure 25: The inundation area for the flood discharge of 1,00,000 ft^3/s with and without the Metro piers between Joshi and Shivaji bridge

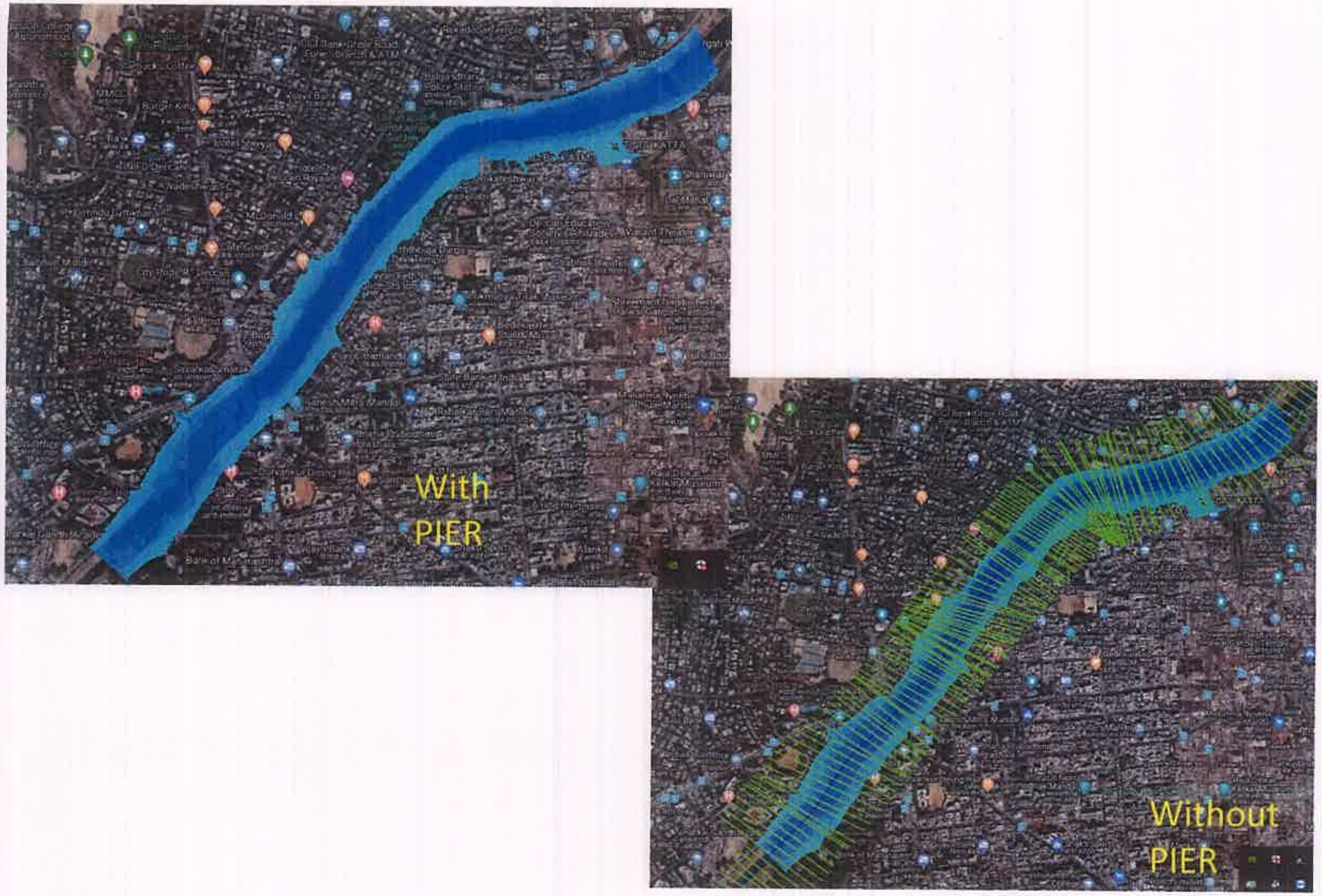


Figure 26: The inundation area for the flood discharge of 60,000 ft^3/s with and without the Metro piers between Joshi and Shivaji bridge

Annexure-1

HEC-RAS: Model Capabilities

HEC-RAS is designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels. The following is a description of the major capabilities of HEC-RAS.

- User interface
- Hydraulic Analysis Components
- Data Storage and Management
- Graphics and Reporting
- RAS Mapper

User Interface

The user interacts with HEC-RAS through a graphical user interface (GUI). The interface provides for the following functions:

File Management
Data Entry and Editing
Hydraulic Analyses
Tabulation and Graphical Displays of Input and Output Data
Reporting Facilities
Context Sensitive Help

Hydraulic Analysis Components

The HEC-RAS system contains four one-dimensional river analysis components for: (1) steady flow water surface profile computations; (2) unsteady flow simulation; (3) movable boundary sediment transport computations; and (4) water quality analysis. A key element is that all four components use a common geometric data representation and common geometric and hydraulic computation routines. In addition to the four river analysis components, the system contains several hydraulic design features that can be invoked once the basic water surface profiles are computed.

Steady Flow Water Surface Profiles

This component of the modeling system is intended for calculating water surface profiles for steady gradually varied flow. The system can handle a full network of channels, a dendritic system, or a single river reach. The steady flow component is capable of modeling subcritical, supercritical, and mixed flow regimes water surface profiles.

The basic computational procedure is based on the solution of the one-dimensional energy equation. Energy losses are evaluated by friction (Manning's equation) and contraction/expansion (coefficient multiplied by the change in velocity head). The momentum equation may be used in situations where the water surface profile is rapidly varied. These situations include mixed flow regime calculations (i.e. hydraulic jumps), hydraulics of bridges, and evaluating profiles at river confluences (stream junctions).

The effects of various obstructions such as bridges, culverts, weirs, etc. in the flood plain may be considered in the computations. The steady flow system is designed for application in flood plain management and flood insurance studies to evaluate floodway encroachments. Also, capabilities are available for assessing the change in water surface profiles due to channel improvements, and levees.

Special features of the steady flow component include: multiple plan analyses; multiple profile computations; multiple bridge and/or culvert opening analyses; and split flow optimization.

Unsteady Flow Simulation.

This component of the HEC-RAS modeling system is capable of simulating one-dimensional unsteady flow through a full network of open channels. The unsteady flow equation solver was adapted from Dr. Robert L. Barkau's UNET model (Barkau, 1992 and HEC, 1997). The unsteady flow component was developed primarily for subcritical flow regime calculations. However, with the release of further Versions, the model can now performed mixed flow regime (subcritical, supercritical, hydraulic jumps, and draw downs) calculations in the unsteady flow computations module.

The hydraulic calculations for cross-sections, bridges, culverts, and other hydraulic structures that were developed for the steady flow component were incorporated into the unsteady flow module.
Special features of the unsteady flow component include: Dam break analysis; levee breaching and overtopping; Pumping stations; navigation dam operations; and pressurized pipe systems.

Sediment Transport/Movable Boundary Computations

This component of the modeling system is intended for the simulation of one-dimensional sediment transport/movable boundary calculations resulting from scour and deposition over moderate time periods (typically years, although applications to single flood events are possible).

The sediment transport potential is computed by grain size fraction, thereby allowing the simulation of hydraulic sorting and armoring. Major features include the ability to model a full network of streams, channel dredging, various levee and encroachment alternatives, and the use of several different equations for the computation of sediment transport. The model is designed to simulate long-term trends of scour and deposition in a stream channel that might result from modifying the frequency and duration of the water discharge and stage, or modifying the channel geometry. This system can be used to evaluate deposition in reservoirs, design channel contractions required to maintain navigation depths, predict the influence of dredging on the rate of deposition, estimate maximum possible scour during large flood events, and evaluate sedimentation in fixed channels.

Water Quality Analysis

This component of the modeling system is intended to allow the user to perform riverine water quality analyses. An advection-dispersion module is included with this version of HEC–RAS, adding the capability to model water temperature. This new module uses the QUICKEST-ULTIMATE explicit numerical scheme to solve the one-dimensional advection-dispersion equation using a control volume approach with a fully implemented heat energy budget. Transport and Fate of a limited set of water quality constituents is now also available in HEC-RAS. The currently available water quality constituents are: Dissolved Nitrogen (NO3-N, NO2-N, NH4-N, and Org-N); Dissolved Phosphorus (PO4-P and Org-P); Algae; Dissolved Oxygen (DO); and Carbonaceous Biological Oxygen Demand (CBOD).

Data Storage and Management

Data Storage is accomplished through the use of "flat" files (ASCII and binary), as well as the HEC-DSS. User input data are stored in flow files under separate categories of project, plan, geometry, steady flow, unsteady flow, and sediment data. Output data is predominantly stored in separate binary files. Data can be transferred between HEC-RAS and other programs by utilizing the HEC-DSS. Data management is accomplished through the user interface. The modeler is required to enter a single filename for the project being developed. Once the project filename is entered, all other files are automatically created and named by the interface as needed. The interface provides for renaming, mobbing, and deletion of files on a project-by-project basis.

Graphics and Reporting

Graphics include X-Y plots of the river system schematic, cross-sections, profiles, rating curves, hydrographs, and many other hydraulic variables. A three-dimensional plot of multiple cross-sections is also provided. Tabular output is available. Users can select from pre-defined tables or develop their own customized tables. All graphical and tabular output can be displayed on the screen, sent directly to a printer (or plotter), or passed through the Windows Clipboard to other software, as a word-processor or spreadsheet.

Reporting facilities allow for printed output of input data as well as output data. Reports can be customized as to the amount and type of information desired.

RAS Mapper

HEC-RAS has the capability to perform inundation mapping of water surface profile results directly from HEC-RAS. Using the HEC-RAS geometry and computed water surface profiles, inundation depth and floodplain boundary datasets are created through the RAS Mapper. Additional geospatial data can be generated for analysis of velocity, shear stress, stream power, ice thickness, and floodway encroachment data. In order to use the RAS Mapper for for analysis, you must have a terrain model in the binary raster floating-point format (.flt). The resultant depth grid is stored in the .flt format while the boundary dataset is store in ESRI's Shapefile format for use with geospatial software.

ANNEXURE 1 A: LIST OF TRANSPLANTED AND NEW PLANTED TREES

A: Trees Transplanted and felled since inception

Sr. No.	Project site including Stations	Trees Felled	Trees Transplanted	Transplantation Site
1.	Reach -1 (PCMC- Range Hill)	0	443	Kasarwadi STP
2.	Reach -2 (Vanaz-Civil Court) i.e.	7	158	Forest Area ARAI
3.	Reach- 3 (Civil court-Ramwadi) i.e.	17	427	Dr.Salim Ali Bird Sanctuary, Bund Garden. Nagar Road
4.	(Reach-4) – Swargate,Civil Court,Shivajinagar,Mandai ,Budhwar Peth and Are Dairy	164	569	Arey Dairy Bus Stand, Range Hill & Taljai Forest Area, Alandi MSRTC Bus Depot, Survey No.01Taljai & Survey No. 69, Dhanori & Range Hill/Command Hospital
5.	Range Hill Depot	0	506	Agriculture College, Range Hill-KCB
6.	Vanaz Depot	0	161	Vanaz Kachara Depot, ARAI
Grand Total		**188 +**	**2264**	**= 2452**

B. New Plantations since inception

Year	Sr. No.	Place	PMC	PCMC
2017 (A)	**1**	Vanvihar Taljai	3000	-
	2	Akurdi Metro Eco Park	-	100
	3	Sahyog Kendra	-	40
		Total (A)	**3000**	**140**
2018 (B)	**1**	I.T.I Aundh	1200	-
	2	Vanvihar Taljai	1000	-
	3	Range Hill Campus	1700	-
	4	Gref Centre, Dighi	2000	-
	5	Akurdi Railway Line	-	-
	6	Akurdi Metro Eco-Park	-	500
	7	Ordnance Factory Khadki	200	
		Total (B)	**6100**	**500**

Year	Sr. No.	Place	PMC	PCMC
2019 (C)	**1**	Kharadi Forest Survey No. 74	100	-
	2	Army Campus Pimple Nilakh		4700
	3	Deccan College Campus	270	
		Total (C)	**370**	**4700**
		Total A+B+C	**9470**	**5340**
2020 (D)	**1**	Deccan College Campus	**25**	**-**
	2	Agriculture College Campus	**115**	**-**
	3	National Institute of Naturopathy Yewalewadi, Pune.	**200**	**-**
	4	Tarkeshwar Tekdi, Yerwada	**270**	**-**
	5	Dhanori Forest Survey No. 69	**275**	**-**
	6	Wagholi Forest Area Gat No. 864	**714**	**-**
		Total D	**1599**	
2021 (E)	**1**	Casting Yard-Nashik Phata	**-**	**17**
	2	Pimple Nilakh	**-**	**10**
	3	Casting Yard – Kiwale	**-**	**5**
	4	College of Agriculture	**55**	**-**
	5	River Bed Deccan	**15**	**-**
	6	Yerwada J.Kumar Office	**15**	**-**
	7	Casting Yard –Wagholi	**25**	**-**
	8	Khadki Cantonment Area	**1416**	**-**
	9	HVPC Depot Kothrud	**9**	**-**
	10	Range Hill Office Campus	**10**	**-**
		Total E	**1545**	**32**
		Total A+B+C+D+E	**12614**	**5372**
		Total PMC & PCMC	**12614+5372= 17986**	

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	-

S. No.	Characteristic	Requirement (Acceptable Limit)	Permissible limit in the absence of alternate source	Remarks
20	Manganese (as Mn) mg/l, Max	0.1	0.3	-
21	Mineral oil, mg/l Max	0.5	No relaxation	-
22	Nitrate (as NO_3) mg/l, Max	45	No relaxation	-
23	Phenolic compounds (as C_6H_5OH) mg/l, Max	0.001	0.002	-
24	Selenium (as Se), mg/l, Max	0.01	No relaxation	-
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.	°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^{0}C), mg/l	2	3	3	-	-
Total coliform organisms, MPN/100 ml. Max.	50	500	5000	-	-
Colour Hazen units	10	300	300	-	-
Chlorides (as Cl), mg/l Max.	250	-	600	-	600
Sodium Adsorption ratio Max.	-	-	-	-	26
Boron (as B), mg/l. Max.	-	-	-	-	2
Sulphates (as SO_4), mg/ l	400	-	400	-	1000
Nitrates (as NO), mg/l Max.	20	-	50	-	-
Free Ammonia (as NH_3), mg/l	-	-	-	1.2	-
Conductivity at 25° C microhm / cm Max.	-	-	-	1000	2250
Arsenic (as As), mg/l. Max.	0.05	0.2	0.2	-	-
Iron (as Fe), mg/l	0.3	-	50	-	-
Fluorides (as F), mg/l	1.5	1.5	1.5	-	-
Lead (as Pb), mg/l. Max.	0.1	-	0.1	-	-
Copper (as Cu), mg/l	1.5	-	1.5	-	-
Zinc (as Zn) mg/l/ Max.	1.5	-	1.5	-	-
Manganese (as Mn), mg/l	0.5	-	-	-	-
Total Dissolved Solids, mg/l	500	-	1500	-	2100
Total Hardness ($CaCO_3$), mg/l	300	-	-	-	-
Magnesium (as Mg), mg/l	100	-	-	-	-
Chlorides (as Cl), mg/l	250	600	-	-	600
Cyanides (as CN), mg/l	0.05	0.05	0.05	-	-

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

*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-3.1 : LIST OF APPROVALS FOR REVISED ALIGNMENT (GUNJAN CHOWK-KALYANI NAGAR)

MoM of Board of Directors

EXTRCT OF MINUTES OF THE 17th MEETING OF THE BOARD OF DIRECTORS OF THE MAHARASHTRA METRO RAIL CORPORATION LIMITED (MAHA-METRO) HELD ON THURSDAY, 17th DAY OF JANUARY 2019 AT 12:45 PM, IN THE BOARD ROOM OF MUMBAI METRO RAIL CORPORATION LIMITED "TRANSIT OFFICE", 'A' WING, NORTH SIDE OF CITY PARK BLOCK-E, BANDRA KURLA COMPLEX, BANDRA (E), MUMBAI-400 051

Item No. 17/C1: To approve the recommendation of Project Committee for change in the Alignment of Corridor 2 (Reach 3) from Civil Court to Ramwadi of Pune Metro Rail Project.

Director (Projects) explained the necessity of change in the Alignment of Corridor 2 of Pune Metro Rail Project. He also informed that Project Committee in its 4th meeting held on 17th January 2019 reviewed in detail the merits and demerits of various possible alternate alignment options proposed and recommended option 2 i.e. deviating the present alignment from Gunjan Chowk moving along the proposed DP road joining existing Vitthalrao Vandekar Road and coming back to Pune- Ahmednagar Road via East Eve Road to terminate at Ramwadi Metro Station, which passes beyond the Regulated Area of Aga Khan Palace with a financial implication of approx. Rs.87.75 crore, to be met from the savings in the Project cost of Pune Metro Rail Project.

The Board after detailed deliberations approved the recommendations of Project Committee for change in the Alignment of Corridor 2 (Reach 3) from Civil Court to Ramwadi of Pune Metro Rail Project and passed the following resolutions.

Resolution No. 127 (17)/18-19

"**RESOLVED THAT** based on the recommendations of the Project Committee, Board accorded approval for change in the Alignment of Corridor 2 (Reach 3) from Civil Court to Ramwadi of Pune Metro Rail Project at an estimated cost of approx. Rs.87.75 crore to be met from the savings in the Project cost of Pune Metro Rail Project.

RESOLVED FURTHER THAT Managing Director of Maha-Metro be and is hereby authorize to do all acts, matters and things as deem necessary, proper or desirable in this regard".

Pune Municipal Corporation Approval

822

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OFFICE OF THE
MUNICIPAL COMMISSIONER
PUNE MUNICIPAL CORPORATION,
SHIVAJINAGAR, PUNE - 411 005.
Outward No : MCO / 13545
Date :

To,

Executive Director,
Maharashtra Metro Rail Corporation Ltd.
Pune metro Rail Project,
Pune.

Sub: "In-Principal Approval'' of revised alignment from Gunjan Chauk to Ramwadi on Ahamadnaar Road.

Ref: Your letter Maha-Metro/Pune/R-3/CPM/VIA/54, dated 28.11.2018.

Sir,

You are aware of that as per original Metro DPR, the alignment between civil court and Ramwadi was selected based on techno-economic feasibility considering the commuter traffic, availability of land, cost of construction and other parameters.

As per the above mentioned letter we are made to understand that, certain part of DPR, alignment along Nagar road is falling within the prohibited area of Agakhan Palace monument and permission for this to stretch is denied by National Monument Authority (NMA). The alternate alignment suggested by MAHA-METRO is studied by PMC. We feel that based on availability of land, commuter traffic, cost escalation due to increase in length etc. MAHA-METRO can take appropriate decision at their level.

(Saurabh Rao)
Municipal Commissioner,
Pune Municipal Corporation.

Government of Maharashtra (GoM) Approval

Government of Maharashtra

No.PRD-3314/C.R.80/UD-7
Urban Development Department,
Mantralaya, Mumbai- 400 032.
Date : 16th February, 2019.

To,
The Secretary,
Ministry of Urban Development,
Nirman Bhawan, Maulana Azad Road,
New Delhi-110011.

Sub: Notification of Alignment for the Pune Metro Rail Project under the Metro Railways (Construction of works) Act, 1978 (Act 33 of 1978) -Modification to the GoI Gazatte Notification dated 05th January, 2018.

Sir,

Kindly refer Maharashtra Metro Rail Corporation Ltd.(Maha-Metro) letter dated 26th December, 2018 and 12th February, 2019. (copies attached)

02. Pune Metro Rail Project is under implementation through Maharashtra Metro Rail Corporation Ltd. (Maha-Metro) and the project alignment was notified by Government of India on 05th January, 2018. Pune Metro rail Project consists of two corridors having total length of 31.254 Kms.

03. The alignment of Pune Metro Corridor-2 (Vanaz to Ramwadi) has been reviewed by Maha Metro as National Monument Authority (NMA) has declined to issue No Objection Certificate as the Metro Corridor is passing through the vicinity of Nationally Protected Monument, Aga Khan Palace, on Pune-Ahmednagar Highway. In this regard, GoM has approved the proposal submitted by Maha-Metro to revise alignment from Gunjan Chowk to Ramwadi on Nagar Road as per Option 2 (Increase in length of 0.92 Kms) on condition that the additional expenditure with respect to the revised alignment shall be within limit of Project Completion Cost of Rs. 11,420 Crs. Route map showing the change in alignment is enclosed with the said letter.

04. In the view of above, MoUD is requested to notify the revised alignment for Pune Metro Corridor through an appropriate notification

Yours,

Enclosure: - As above

(Dr. Nitin Kareer)
Principal Secretary,
Urban Development Department (UD-1)

Government of India (GoI) Gazette Notification

MINISTRY OF HOUSING AND URBAN AFFAIRS

NOTIFICATION

New Delhi, the 14th October, 2019

S.O. 3706(E).—Whereas, in exercise of the powers conferred by sub-section (3) of section 1 of the Metro Railways (Construction of Works) Act, 1978 (33 of 1978) (hereinafter referred to as the said Act), the Central Government had extended the application of the provisions of the said Act to the Pune Metropolitan Area in the State of Maharashtra *vide* notification of the Government of India in the erstwhile Ministry of Urban Development number S.O. 2732 (E), dated the 21st October, 2014;

And whereas, in exercise of the powers conferred by clause (a) of sub-section (1) of section 32 of the said Act, the Central Government added metro alignment of Pune Metro Rail Project, Phase-1, corridor 1 (Pimpri-Chinchwad to Swargate) and corridor 2 (Vanaz to Ramwadi) to the Schedule of the said Act vide notification of the Government of India in the Ministry of Housing and Urban Affairs Number S.O.95(E), dated the 5th January, 2018.

Now, therefore, in exercise of the powers conferred by clause (b) of sub-section (1) of section 32 of the said Act, the Central Government hereby alters the said metro alignment in respect of Corridor 2 (Vanaz to Ramwadi) of the Pune Metro Rail Corridors – Phase – 1 in the Schedule of the said Act, namely :—

"Corridor 2: Vanaz to Ramwadi	Vanaz, Anand Nagar, Ideal Colony, Nal Stop, Garware College, Deccan Gymkhana, Chahatrapati Sambhaji Udyan, Pune Municipal Corporation, Civil Court, Mangalwar Peth, Pune Railway Station, Ruby Hall Clinic, Bund Garden, Yerwada, Kalyani Nagar, Ramwadi.
Depot	Vanaz Depot (Kachara Depot Land at Kothrud)."

*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.	11370	Ganesh Temple	U/G section – No impact
4.	11500	St. Francis High School	U/G section – No impact
5.	12300	Pune Engineering College	U/G section – No impact
6.	13370	Masjid	U/G section – No impact
7.	13400	Temple	U/G section – No impact
8.	13475	Temple	U/G section – No impact
9.	13782	Kumbhare Hospital	U/G section – No impact
10.	13800	Sidhivinayak Mandir	U/G section – No impact
11.	14510	Temple	U/G section – No impact
12.	14832	Temple	U/G section – No impact
13.	14887	Temple	U/G section – No impact
14.	15405	Modern Mickies school	U/G section – No impact
15.	15473	Temple	U/G section – No impact
16.	15882	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 Ch: - 800 m to - 270 m	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 Ch: - 410 m to - 270 m	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
47.		Subabul	*Leucaena leucocephala*	40	10	C
48.		Subabul	*Leucaena leucocephala*	50	10	C
49.		Subabul	*Leucaena leucocephala*	50	10	C

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
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 Ch: - 270 m to 1693 m	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 Ch: 1693 m to 1833 m	Nil	Nil	Nil	Nil	Nil
84.	Tukaram Nagar Station to Bhosari Station Ch: 1693 m to 2480 m	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
98.		Subabul	*Leucaena leucocephala*	50	10	C

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
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 Ch: 2480 m to 2620 m	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
150.		Kadam	*Neolamarckia cadamba*	40	7	T

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (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 Ch: 2620 m to 3752 m	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 Ch: 3752 m to 3892 m	Nil	Nil	Nil	Nil	T
178.	Kasarwadi Station - Fugewadi Station Ch: 3892 m to 4780 m	Devils tree	*Alstonia scolaris*	20	2	T
179.		Shisham	*Dalbergia sissoo*	20	2	T
180.		Shisham	*Dalbergia sissoo*	20	2	T
181.	Fugewadi Station Ch: 4780 m to 4920 m	Nil	Nil	Nil	Nil	T
182.	Fugewadi Station - Dapodi Station Ch: 4920 m to 5646 m	Subabul	*Leucaena leucocephala*	80	10	C
183.		Subabul	*Leucaena leucocephala*	90	10	C
184.		Devils Tree	*Alstonia scholaris*	60	10	T
185.	Dapodi Station Ch: 5646 m to 5786 m	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 Ch: 5786 m to 7268 m	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

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (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
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 Ch: 7268 m to 7408 m	Umbar	*Ficus glomerata*	120	12	T
222.		Asoka	*Polyalthia longifolia*	50	12	T
223.		Kathahal	*Arthocarpus heterophyllus*	60	12	T
224.	Bopadi Station to Khadki Station Ch: 7408 m to 8145 m	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

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (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
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 Ch: 8145 m to 8285 m	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 Ch: 8285 m to 9542 m	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

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
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
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.		**Karanj – 8 Nos**	*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 Ch: 9542 m to 9682 m	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 Ch: 9682 m to 11138 m	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

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
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
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 - CIVIL COURT

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
1.	Start to Vanaz station Ch: -625 m to -55 m	Nil	Nil	Nil	Nil	T
2.	Vanaz station Ch: -55 m to 85 m	Saptaparni (champa)	*Plumeraia rubra*	40	03	T
3.	Vanaz station to Ananad nagar station Ch: 85 m to 1080 m	Nil	Nil	Nil	Nil	T
4.	Anand nagar station	Umbar	*Ficus glomerata*	60	10	T

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
5.	Ch: 1080 m to 1220 m	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 Ch: 1220 m to 1829 m	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 Ch: 1829 m to 1969 m	Nil	Nil	Nil	Nil	Nil
12.	Ideal colony station - Nal stop station Ch: 1969 m to 2718 m	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 Ch: 2718 m to 2858 m	Nil	Nil	Nil	Nil	Nil
21.	Nal stop to Garvare college Ch: 2858 m to 3802 m	Nil	Nil	Nil	Nil	Nil
22.	Garvare college station Ch: 3802 m to 3942 m	Nil	Nil	Nil	Nil	T
23.	Garvare college station – Deccan station Ch: 3942 m to 4655 m	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

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
	Ch: 4655 m to 4795 m					
46.	Deccan Station - Sambhaji Park Station Ch: 4795 m to 5188 m	Nil	Nil	Nil	Nil	Nil
47.	Sambhaji Park Station Ch: 5188 m to 5328 m	Nil	Nil	Nil	Nil	Nil
48.	Sambhaji Park Station - PMC Station Ch: 5328 m to 5890 m	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
60.		Shahatut	*Morus alba*	60	08	T
61.		Subabool	*Leucaena leucocephala*	80	08	T
62.	PMC Station Ch: 5890 m to 6030 m	Nil	Nil	Nil	Nil	Nil
63.	PMC Station - Civil Court Station Ch: 6030 m to 6533 m	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 Ch: 6533 m to 6673 m	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

CIVIL COURT - RAMWADI

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
1.	Civil Court Station - Mangalwar Peth Station Ch: 6673 m to 7338 m	Rain tree	*Samania saman*	40	08	T
2.		Rain tree	*Samania saman*	50	10	T
3.		Nilgiri	*Eucalyptus sp*	60	14	T
4.		Rain tree	*Samania saman*	50	08	T
5.		Rain tree	*Samania saman*	60	10	T
6.		Rain tree	*Samania saman*	50	10	T
7.	Mangalwar Peth Station Ch: 7338 m to 7478 m	Nil	Nil	Nil	Nil	Nil
8.		Peepal	*Ficus religiosa*	300	14	C

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
9.	Mangalwar Peth Station - Pune Railway Station Ch: 7478 m to 8230 m	Peepal	*Ficus religiosa*	500	14	C
10.		Chinch	*Tamarindus indica*	45	14	T
11.	Pune Railway Station Ch: 8230 m to 8370 m	Rain tree	*Samania saman*	55	14	T
12.		Peepal	*Ficus religiosa*	90	14	T
13.		Chinch	*Tamarindus indica*	08	04	T
14.		Peepal	*Ficus religiosa*	55	14	T
15.	Pune Railway Station - Ruby hall Clinic Ch: 8370 m to 9107 m	Bad	*Ficus bengalensis*	32	10	T
16.		Gulmohar	*Delonix regia*	60	08	T
17.		Arjuna	*Terminalia arjuna*	50	08	T
18.		Peepal	*Ficus religiosa*	55	14	T
19.		Mango	*Mangifera indica*	50	08	T
20.		Chinch	*Tamarindus indica*	60	10	T
21.		Rain tree	*Samania saman*	60	08	T
22.		Rain tree	*Samania saman*	60	08	T
23.	Ruby hall Clinic Ch: 9107 m to 9247 m	Nil	Nil	Nil	Nil	Nil
24.	Ruby hall Clinic - Bund Garden Ch: 9247 m to 10041 m	Nil	Nil	Nil	Nil	Nil
25.	Bund Garden Station Ch: 10041 m to 10181 m	Nil	Nil	Nil	Nil	Nil
26.	Bund Garden – Yerwada Ch: 10181 m to 10855 m	Badam	*Terminalia catapa*	40	08	T
27.		Peepal	*Ficus religiosa*	60	10	T
28.		Devils tree	*Alstonia scholaris*	60	10	T
29.		Dhavada	*Anogeissus latifolia*	80	14	T
30.		Kadam	*Neolamarckia cadamba*	40	10	T
31.		Dhavada	*Anogeissus latifolia*	30	06	T
32.		Dhavada	*Anogeissus latifolia*	20	06	T
33.		Kadam	*Neolamarckia cadamba*	40	10	T
34.		Kadam	*Neolamarckia cadamba*	40	10	T
35.		Asoka	*Polyalthia longifolia*	50	12	T
36.		kesari	*Mallotus sp*	80	10	T
37.		Babaul	*Acacia nilotica*	60	10	T
38.		Bakul	*Mimusops elengi*	40	10	T
39.		Bakul	*Mimusops elengi*	40	10	T
40.		Bakul	*Mimusops elengi*	50	10	T
41.		Dhavada	*Anogeissus latifolia*	90	10	T
42.		Rain tree	*Samania saman*	40	12	T
43.		Rain tree	*Samania saman*	50	12	T
44.		Rain tree	*Samania saman*	40	10	T
45.		Neem	*Azadirachta indica*	60	12	T
46.		Coconut	*Cocos nucifera*	80	10	C
47.		Subabool	*Leucaena leucocephala*	80	10	C
48.	Yerwada station Ch: 10855 m to 10995 m	Shisam	*Dalbergia sisoo*	80	10	T
49.		Shisam	*Dalbergia sisoo*	40	06	T
50.		Subabool	*Leucaena leucocephala*	60	08	C

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
51.		Subabool	*Leucaena leucocephala*	70	08	C
52.	Yerwada - Kalyani Nagar Ch: 10995 m to 12407 m	Rain tree	*Samania saman*	70	10	T
53.		Shisam	*Dalbergia sisoo*	40	08	T
54.		Subabool	*Leucaena leucocephala*	60	08	C
55.		Subabool	*Leucaena leucocephala*	50	08	C
56.		Sindi palm tree – 85 Nos	*Phoenix sylvestris*	50	08	T
57.	Kalyani Nagar Station Ch: 12407 m to 12547 m	Sindi palm tree – 10 Nos	*Phoenix sylvestris*	50	08	T
58.		Palmera palm	*Borassus flabellifer,*	80	06	T
59.	Kalyani Nagar - Ramavadi Ch: 12547 m to 13487 m	Nil	Nil	Nil	Nil	Nil
60.	Ramavadi Station Ch: 13487 m to 13627 m					
61.	Ramavadi - End of the alignment Ch: 13627 m to 13950 m	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	T
6.		Neem	Azadirachta indica	80	10	T
7.		Shahatut	Morus alba	50	08	T
8.		Peepal	Ficus religiosa	600	14	T
9.		Indian rain tree	Samania saman	60	10	T
10.		Babul	Acacia nilotica	60	10	T
11.		Babul	Azadirachta indica	80	12	T
12.		Mango – 16 Nos	Mangifera indica	60	03	T
13.		Guava – 90 Nos	Psidium guajava	30	02	T
14.		Coconut	Cocos nucifera	60	02	T
15.		Coconut	Cocos nucifera	60	02	T
16.		Jambhul	Syzygium cumini	60	03	T
17.		Jambhul – 18 Nos	Syzygium cumini	60	03	T
18.		Pomegranate -– 90 Nos	Punica granatum	30	02	T
19.		Subabul	Leucaena leucocephala	40	03	T
20.		Shisam	Dalbergia sisoo	40	04	T
21.		Aola – 108 Nos	Phyllanthus emblica	60	10	T
22.		Neem	Azadirachta indica	60	08	T
23.		Neem	Azadirachta indica	60	08	T
24.		Sitafal – 10 Nos	Annona reticulate	20	02	T
25.		Neem	Azadirachta indica	60	07	T

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
26.		Babaul	Azadirachta indica	40	05	T
27.		Subabool	Leucaena leucocephala	50	10	T
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	T
34.		Karanj	Pongamia pinnata	50	07	T
35.		Rain tree	Samania saman	90	10	T
36.		Subabool	Leucaena leucocephala	50	10	T
37.		Guava	Psidium guajava	30	05	T
38.		Babool	Acacia nilotica	45	08	T
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	T
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	T
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	T
60.		Shevaga	Moringa sp	45	08	T
61.		Babul	Acacia nilotica	45	08	T
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	T
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	T
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
75.		Arjun	Terminalia arjuna	40	10	T
76.		Chopadi sawar	Bombax malabarica	65	10	T
77.		Shisam	Dalbergia sisoo	40	10	T

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (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	T
83.		Subabul	Leucaena leucocephala	45	10	T
84.		Rain tree	Samania saman	50	10	T
85.		Talwar babul	Acacia auriculoformis	50	10	T
86.		Subabul	Leucaena leucocephala	70	10	T
87.		Arjuna	Terminalia arjuna	45	10	T
88.		Babul	Acacia nilotica	40	08	T
89.		Neem	Azadirachta indica	50	08	T
90.		Babul	Acacia nilotica	45	10	T
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.		Chinchbhilai – 3 Nos	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
30.		Subabool	Leucaena leucocephala	60	10	C
31.		Subabool	Leucaena leucocephala	70	10	C

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
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.		Subabool – 4 Nos	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.		Bad -– 2 Nos	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.		Subabool – 3Nos	Leucaena leucocephala	60	10	C
67.		Talwar babool	Acacia auriculoformis	40	10	T
68.		Talwar babool	Acacia auriculoformis	40	08	T
69.		Subabool – 2Nos	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
80.		Ber	Zizyphu jujuba	40	08	C
81.		Ber	Zizyphu jujuba	50	08	C

S. No	Location	Common Name	Botanical Name	App. Girth (cm)	App. Height (m)	Cut (C) / Transplant (T)
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
06.08.1981	1981	851.2	30060

Date	Year	Discharge from Khadakwasla dam	
		(in cumecs)	(in cusecs)
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	-
26/08/1977	34,469	2	-

Date and Year	Maximum Discharge (cusecs)	Hours	Annual Rainfall (mm)
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 : PIER WISE AFFLUX COMPUTATION AND SUBMERGENCE

Pier Number		Adjacent Pier span	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

Pier Number		Adjacent Pier span	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)
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
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

Pier Number		Adjacent Pier span	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)
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
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 of Trees
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 of Trees
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 of Trees
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 of Trees
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 of Trees
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 of Trees
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 9.1: 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 9.2: **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 9.3: 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 9.4: 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 9.5: 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 9.6: 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 9.7: 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 9.8: 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 etc.		Others (please specify)
	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 9.9: 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	0.5 -0.75 %					

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
								Matter						
								Sodium	0-1 %					
								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 9.10 :*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 9.11: 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 9.12: 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 9.13 : 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 9.14: 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	

S No.	Description	Remarks
	No. of sites Rehabilitated	
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)