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Adherence to Terms of Reference

The State Expert Appraisal Committee (SEAC), Karnataka has considered the Elevated Corridor proposal by Karnataka Road Development Corporation Limited (KRDCL) during its meeting held on 28th September 2018, and the Committee prescribed the following Terms of Reference (TOR) for preparing EIA/EMP report with latest one season baseline data other than monsoon for the proposed elevated corridor project.

The SEIAA Karnataka after due consideration of the relevant documents submitted by the project proponent and recommendation of the SEAC, has decided to accord the Standard Terms of Reference (TOR) along with additional Terms of Reference, in its meeting held on 12th October 2018, in accordance with the provisions of Environmental Impact Assessment Notification-2006 and its subsequent amendments made there on.

An Environment Impact Assessment (EIA) study has been undertaken for the proposed elevated corridor project in Bengaluru Metropolitan Region in accordance with the Terms of Reference (TOR) by the State Environmental Appraisal Committee (SEAC).

Point wise compliance with ToR provided by MoEF for the Project is as follows.

Sl. No.	Items	Section
1	Examine details of land use as per Master Plan and land use around 10 km radius of the project site. Analysis should be made based on latest satellite imagery for land use with raw images. Check on flood plain of any type.	Refer to Section 4.10
2	Submit details of environmentally sensitive place, land acquisition status, rehabilitation of communities/ villages and present status of such activities.	Refer to Section 4.7, Section 5.2.3 & 5.2.5 and Table No 5.10
3	Examine baseline environmental quality along with projected environmental road due to the project.	Refer to Section Chapter 4
4	Environmental data to be considered in relation to the project development would be (a) land, (b) ground water, (c) surface water, (d) air, (e) bio-diversity, (f) noise and vibrations, (g) socio economic and health.	Refer to Section Chapter 4
5	Submit a copy of the contour plan with slopes, drainage pattern of the site and surrounding area. Any obstruction of the same by the project	Refer to Section Section 4.7
6	Submit the details of the trees to be felled	Refer to Section Annexure 5

Sl. No.	Items	Section
	for the project.	
7	Submit the present land use and permission required for any conversion such as forest, agriculture etc.	Refer to Section 4.10
8	Submit Roles and responsibility of the developer etc. for compliance of environmental regulations under the provisions of EP Act.	Refer to Section 8.6
9	Ground water classification as per the Central Ground Water Authority.	Refer to Section 4.9
10	Examine the details of Source of water, water requirement, use of treated waste water and prepare a water balance chart.	Refer to Section 5.2.1
11	Rain water harvesting proposals should be made with due safeguards for ground water quality. Maximize recycling of water and utilization of rain water. Examine details.	Refer to Section 6.1.1
12	Examine soil characteristics and depth of ground water table for rain water harvesting.	Refer to Section 4.9
13	Examine details of solid waste generation treatment and its disposal.	Refer to Section 5.2.2
14	Examine and submit details of use of solar energy and alternative source of energy to reduce the fossil energy consumption. Energy conservation and energy efficiency.	Refer to Section 6.6
15	DG sets are likely to be used during construction and operational phase of the project. Emissions from DG sets must be taken into consideration while estimating the impacts on air environment. Examine and submit details.	Refer to Section 5.2.5
16	Examine road/ rail connectivity to the project site and impact on the traffic due to the proposed project. Present and future traffic and transport facilities for the region should be analyzed with measures for preventing traffic congestion and providing faster trouble free system to reach different destinations in the city.	Refer to Section 5.2.4
17	A detailed traffic and transportation study	Refer to Section 2.7, 2.8 & 2.10

Sl. No.	Items	Section
	should be made for existing and projected passenger and cargo traffic.	
18	Examine the details of transport of materials for construction which should include source and availability.	Refer to Section 2.11
19	Examine separately the details for construction and operation phases both for Environmental Management Plan and Environmental Monitoring Plan with cost and parameters.	Refer to Section Chapter 8
20	Submit details of a comprehensive Disaster Management Plan including emergency evacuation during natural and man-made disaster.	Refer to Section 8.1.3 & 8.1.4
21	Details of litigation pending against the project, if any, with direction / order passed by any Court of Law against the Project should be given.	No pending Litigation
22	The cost of the Project (capital cost and recurring cost as well as the cost towards implementation of EMP should be clearly spelt out.	Refer to Section 8.10 & Table 8.6
23	Any further clarification on carrying of the above studies including anticipated impacts due to the project and mitigative measure project proponent can refer to the model ToR available on Ministry website http://moef.nic.in/Manual/Townships .	Referred
Sl. No.	Additional TOR:	Section
1	The applicability of the Hon'ble National Green Tribunal order dated 4 th May 2016 in O.A No.222 of 2014 on buffer zone for water bodies and nalas may be studied and submitted.	Refer to Section 3.11 and 4.7
2	As per the proposal about 12 Lac cum of earth required to be brought from outside. The proponent should work out the alternative scheme to reduce the earthwork requirement.	Refer to Section 5.2.2, 8.1 and Appendix 1
3	Scientific handling of earthwork generated during construction may be detailed and	Refer to Section Appendix 1

Sl. No.	Items	Section
	submitted keeping in view best possible mitigation measures for dust.	
4	Scheme for treating Rain water harvested from the carriage way in order to arrest oil and grease entering into the soil/ water bodies.	Refer to Section 6.1
5	Impact on the nearest water body and archeological structures may be studied properly and submit.	Refer to Section 4.7, 5.2.3, 5.2.10, 3.1 & Table 8.1
6	The scheme for vertical garden on the pillars in order to reduce the heat effect & vehicular emissions may be worked out and submitted.	Refer to Section 6.4
7	Quantification of solar energy harvesting potential from the structure railings as well as carriage was to be worked out.	Refer to Section 6.6
8	Scheme to reuse the demolition debris after proper recycling.	Refer to Section 5.2.2 & Table 8.1
9	Carbon foot print to be studied and suitable offsets may be suggested.	Refer to Section 6.7
10	Steps taken to reduce the energy embodiment of the materials used may be detailed.	Refer to Section 6.8
11	Changes to the micro climate to be modeled and simulation studies to be submitted.	Refer to Section 4.5.2
12	List of trees to be felled, pruned, retained along with details of locality along with budget backup for plantation and its maintenance at least for 10 years.	Refer to Section Annexure 5 Section 8.10
13	To propose suitable location details to take up compensatory plantation with budget details.	Refer to Section 6.3 & 8.10
14	Propose suitable ornamental plants in the medians at ground level to improve the aesthetic view.	Refer to Section 6.5
15	Examine the possibility of transplanting at least 20% of trees that are proposed to be felled.	Refer to Section 6.2
16	Land use land cover analysis of project corridor area using high resolution satellite data.	Refer to Section 4.10

1. INTRODUCTION

1.1 Background

Bengaluru is one of the fastest growing cities in India. The city is also known as Silicon Valley of India. It is in forefront supporting the growth of Information Technology and several other service based industries attracting people and business from across the nation. This has led to the unpredicted and uncontrolled growth of population and traffic forcing city to face tough challenges in providing and extending basic infrastructure and services. Road transport is one such infrastructure which has been facing severe stress in the recent past.

Bengaluru being a multi-nodal city lacks wider roads connectivity to different parts and suffers from traffic congestion due to narrow roads. In addition, Bengaluru roads are too narrow and highly developed all along the roads for widening to cater for the growing numbers of vehicles. There are no good transit corridors between southern and northern, and eastern and western parts of the city.

Bengaluru's vehicle population has been growing day by day and the city roads are being added roughly 5 lakh vehicles every year. By February 2016, the number of non-transport vehicles such as two-wheelers and cars in the city had reached 54.67 lakh. According to State Transport Department, two-wheelers are numbering over 41.86 lakh followed by cars numbering 11.8 lakh. Number of transport vehicles stands at over 5.91 lakh. These numbers exclude the vehicles that come in and go out of the city. This out growing numbers vehicles are choking the city roads with frequent traffic jams and have made traffic police helpless.

Further, for various known reasons public is using the independent modes of transportation for commuting on existing limited road network adding to the congestion, accidents, noise and air pollution. As per the report on Comprehensive Traffic and Transportation Plan for Bangalore (CTTP) – 2011, an average Bangalorean spends more than 240 hours stuck in traffic every year and such delays are resulting in loss of productivity, in addition to deterioration of air quality, reduced quality of life, and increase in costs for services and goods.

The concept of elevated corridor evolved to counter the traffic woes of the city in the form of traffic congestion and provide solution for many of the traffic related problems. The initial idea on the proposed elevated corridor was through Centre for Smart Cities in late 2014 in the form of pre-feasibility report. This project plan was initially proposed and presented before BBMP's Technical Advisory Committee and the Urban Development Department (UDD) directed the BBMP to prepare a Detailed Feasibility Report. Given the scale and complexity of the project, UDD then decided to hand over the project to Karnataka Road Development Corporation Ltd.

The project is envisaged to separate the cross-city traffic and the neighborhood traffic, with an aim to decongest the core city and provide easy access to suburban towns and Bengaluru International Airport. The project is planned based on two traffic directions of the city - North-South and East-West, with interconnecting and loop elevated corridors. The basic idea is to decongest at grade roads by creating an

additional capacity in the form of elevated corridors. This enhances the traffic carrying capacity of the roads at grade. As the widening of Bengaluru city roads is not possible, we are only left with the option of going vertical by elevated corridors. In this context, Government of Karnataka has planned for elevated corridors to ensure safe, fast and congestion free connectivity to different parts of city by three main corridors (North-South and East-west (1&2)) and three connecting corridors. This project was announced by GoK in year 2015 and further included in the budget speech for the year 2016-17.

Following paragraphs are brought out from the report on Comprehensive Traffic and Transportation Plan for Bangalore (CTTP) – 2011. The analysis of collected data from primary and secondary sources has identified the following major issues regarding the transport system of Bangalore:

Road network capacity is inadequate. Most of the major roads are with four lane or less with limited scope for widening. The junctions are closely spaced on many roads. Many junctions in core area are with 5 legs. This makes traffic movement difficult. There is a need to optimize the available capacity by adopting transport system management measures and by making use of intelligent transportation systems.

Traffic composition on roads indicates very high share of two wheelers. The share of cars is also growing. This indicates inadequate public transport system. V/C ratios on most of the roads are more than 1. Overall average traffic speed is about 13.5 kmph in peak hour. This not only indicates the need of augmenting road capacity but also to plan high capacity mass transport systems on many corridors.

Outer cordon surveys indicate high through traffic to the city. This, points to the need of road bypasses not only for Bangalore Metropolitan Area (BMA) but also for Bangalore Metropolitan Region (BMR). High goods traffic also indicates the need of freight terminals at the periphery of the city.

The household travel surveys indicate high share of work trips. This segment of travel demand needs to be mostly satisfied by public transport system. Considering the large employment centres being planned in the BMA, the public/mass transport system needs to be upgraded/extended substantially.

At present, modal split in favour of public transport is about 46% (exclusive of walk trips). The trends show a decline in this share over the last two decades. This is further expected to fall unless adequate and quality public transport system is provided to the people of Bangalore. Share of two wheelers and cars in travel demand is disturbingly high. This trend needs to be arrested.

There is high pedestrian traffic in core area and some other areas in Bangalore. Footpath facilities are generally not adequate and their condition is deteriorating. Therefore up gradation of their facilities is very important. Share of cycle traffic has declined over the years. This mode of transport needs to be promoted by providing cycle tracks along the roads.

Parking is assuming critical dimensions in Bangalore. Parking facilities need to be augmented substantially. In the long run, city-wide public transport system needs to provide not only to reduce congestion on roads but also to reduce parking demand.

Area of the BMA has been increased as per Revised Master Plan-2015. This plan has provided for densification of existing areas, Mutation corridors, hi-tech areas etc. in various parts of the

city. This is likely to have a major impact on traffic demand. The transport network including mass transport system needs to be planned taking the proposed development in to consideration.

Major developments have been proposed in the suburban towns of Bangalore by BMRDA in the BMR. This is likely to increase interaction between Bangalore and these suburban towns. There will be need to provide commuter rail services to these towns from Bangalore.

Thus while planning for the transport system of Bangalore, the above problems and issues need to be kept in consideration. The issues relating to traffic and transportation in a large and growing city like Bangalore need to be viewed in the larger perspective of urban planning and development. Issues relating to land use planning and development control, public-private transportation policy and industrial location would need to be integrated at the perspective planning level. With Metro Rail under implementation there is the need to coordinate inter modal transport issues.

1.2 Objective of Environmental Impact Assessment

The main objective of the study is to identify, predict and evaluate the nature, magnitude and significance of the potential adverse environmental and social impacts of the proposed elevated corridor project on environment to ensure that the project implementation is sustained with minimal impacts on environment; to help for decision making by providing information on the environmental consequences by the project and to promote environmentally sound and sustainable development through the identification of appropriate alternatives and mitigation measures.

The Environment impact assessment report is prepared in order to achieve the following objectives:

- Understanding the requirements of proposed project.
- Review information about the general environmental settings along the project corridor as baseline data;
- Review the applicability of National and State framework and relevant guidelines and policies to the project implementation.
- Identify significant potential impacts of the project and characteristic of the impacts, magnitude, distribution, project affected group, and their duration to ensure that environmental considerations are given adequate importance in the selection and design of proposed improvements.
- Develop a broad frame work of mitigation measures and environmental management plan addressing identified impacts.

1.3 Methodology and Scoping

The scope of environmental impact assessment includes screening and scoping, environmental assessment and environmental management plan for the proposed project in line with EIA Notification 2006 and subsequent amendments. Scope as determined by detailed and comprehensive Terms of Reference (TOR) issued on 23.10.2018 by SEAC/SEIAA to address significant environmental concerns in respect

of the proposed project or activity for preparing Environment Impact Assessment (EIA) Report.

The scope of EIA/EMP studies are as follows.

- Collection of baseline data on various components of the environment such as Physical (Air, Water, soil & noise) parameters Biological components along with socioeconomic scenario of the project area.
- Review of policies and legal framework.
- Determination of the magnitude of environmentally significant impacts so that due consideration is given to them during planning, construction and operational phases of the project implementation.
- Identification and categorization of the potential impacts during pre-construction, construction and operation phases.
- Developing mitigation measures to sustain and maintain the environmental scenario. Providing compensatory developments wherever necessary, including plans for tree plantation.
- Preparation of Environmental Management Plan and Monitoring Plan.

1.4 Structure of the Report:

Chapter 1: Introduction - The section gives a brief background of the project and presents the scope of the study and the structure of the report.

Chapter 2: Project Description - Salient features of the proposed project such as project location, packages, design standards followed, construction methodology, proposed right of way (RoW), by passes for the built-up areas or congested stretches, etc. along with delineation of study area (Impact zone and influence zone) are discussed in this section.

Chapter 3: Policy, Legal & Administrative Framework - The policy, legal and administration framework within which the project is set. The major stakeholder departments of the State and Central Governments with their specific roles and the applicable acts and laws are described. This section includes the clearance requirements at various stages of pre-construction, construction and operation phases of the project implementation.

Chapter 4: Description of Environment - Describes the existing environmental scenario in detail. The section on meteorological baseline, components of the biophysical and natural environments along the corridor are described. Comprehensive pictures of the existing environmental features have been highlighted in this chapter

Chapter 5: Environmental Impact Assessment - The focus of this section is on the adverse impacts and their evasion, mitigation and enhancement measures. The beneficial impacts on the environment due to project have been detailed. The

enhancement measures for environmental sustainability and good engineering practices in addition to mitigation measures are presented.

Chapter 6: Additional Studies – In this section, additional studies have been done as per the some of the recommended TOR

Chapter 7: Environmental Management and Monitoring Plan - Details comprehensive and coherent environmental management plan along with an elaborate environmental monitoring plan for construction and operation phases of the project implementation.

Chapter 8: Project Benefits – Benefits of the project is discussed in this section.

Chapter 9 Conclusion - Conclusions and recommendations, on the basis of present study, past experiences and sensitivity of project corridors to improve the proposed corridor project.

Chapter 10: Disclosure of Consultants -

2. PROJECT DESCRIPTION

The project consists of total 6 corridors extending to an approximate length of 102.04 km with three main corridors running north to south (NS-1) and two corridors running east to west (EW-1 & EW-2). The other three corridors are connecting corridors (CC-1, CC-2 & CC-3) which provide access to EW corridors. The proposed elevated corridors attempts to connect the National Highways, (Tumkur – Old Madras Road (NH 4) (AH 47; Bellary - Hosur Road/Electronic City Road (NH 7) (AH 43); Sarjapur Main Road (SH 35); Kanakapura Main Road (NH 209); Mysore Road (SH 275); Doddaballapura Road and Singahalli road (SH 104).

Table 2-1: List of proposed elevated corridors

SI No.	Name of the Corridor	Length (Km)
1	NS-1: North-South Corridor-1 connecting Hebbal (Esteem Mall) to Central Silk Board (i.e., NH-7 towards Bellary to NH-7 towards Hosur)	26.89
2	EW-1: East-West Corridor-1 connecting K.R. Puram to Gorguntepalya (i.e., NH-4 towards Tumkur Road) including Rammurthy Nagar (Ring road) to ITPL Stretch	31.94
3	EW-2: East-West Corridor-2 connecting Varthur Kodi to Deepanjali Nagar and NICE Link Road (Mysore Road, NH - 275)	29.48
4	CC-1: Connecting Corridor-1 Connecting East-West Corridor-2 at Kalasipalya to Agara on Outer Ring Road	4.48
5	CC-2: Connecting Corridor-2 Connecting East-West Corridor-1 at Ulsoor to East-West Corridor-2 at D'souza circle.	2.80
6	CC-3: Connecting Corridor-3 Connecting East-West Corridor-1 at Wheeler's road jn. to Kalyan Nagar at Outer Ring Road	6.46
Total Length		102.04

The corridors are described in the following sections.

2.1 North - South Corridor Connecting Mekhri Circle and Silk Board Junction:

The corridor starts from Hebbal Flyover along Airport Road Esteem Mall at Airport Flyover and ends before Silk Board flyover via Jayamahar main road - Queen's Road-Indian Express Junction - Infantry Road Junction - Minsk Square - Kasturba Road - Hudson Circle - Audugodi Nala - Audugodi main road.

2.2 East - West Corridor - 1: Connecting NH48 (earlier NH-4) at Battarahalli and Gorguntepalya on Tumkur Road

The project corridor starts at Bhattarahalli on Old Madras Road and ends at Gorguntepalya junction on Tumkur road via Devasandra Main Road - Ramamurthy Nagar Main Road Junction (ITI) – KR Puram cable stayed bridge - Suranjandas Road Junction - 80 Feet Road junction - 100 feet Indiranagar road Junction - D Bhaskaran Road Junction - Kensington Road Junction (Philips buildings) – Ulsoor lake - St. John's Road – Millar's Road - Jayamahar Main Road – Mekhri Circle - CV Raman Road – Yeswanthapur flyover - Yeswanthapur Railway Station - Outer Ring Road junction Central Manufacturing Technology Institute (CMTI).

2.3 East - West Corridor - 2: Connecting SH-35, Varthur Kodi to Deepanjanli Nagar (West of Chord Road) NICE link road on Mysore road

The corridor takes off at Varthur kodi junction on SH-35 and ends at Deepanjanli Nagar on Mysore road (at NICE link road on Mysore road) via. Kundala halli gate junction – Marathahalli underpass - Suranjandas Road Junction - Old Airport road – Wind tunnel road junction - Domlur Junction - Trinity Church Junction - D’Souza circle - General K S Thimmaiah Road - Vellara Junction - Richmond Circle - K.H.Road - Lalbagh Main Road – Minerva junction - Chamarajpet 5th Main Road - 9th Cross Road - 1st Main Road Junction - Alur Venkata Rao Road - Sirsi Circle - Satellite Bus Station - Bapuji Nagar - Deepanjali Nagar - NICE Link Road (Mysore Road, NH - 275).

2.4 Connecting Corridor-1:

This corridor creates connectivity between North-South corridor and Sarjapura Road, corridor starts at Sarjapur Bridge at Agara and traverses via Jakkasandra - Madiwala Market Junction - Koramangala 100 Feet Road Junction

2.5 Connecting Corridor-2:

This corridor creates connectivity between East-West Corridor-1 and East-West Corridor-2, corridor starts from D’souza circle on Richmond road Junction and ends at Ulsoor Lake via General KS Thimmaiah Road - Trinity Junction & Ulsoor Lake Junction (connecting East West Corridor-1)

2.6 Connecting Corridor-3:

This corridor creates connectivity between St. Johns Church Road and Outer Ring Road (ORR) at Kalyan Nagar (The location where new airport expressway starts as in Master Plan), corridor starts from St. Johns Church Road Junction (East-West Corridor 1) and ends at Kalyan Nagar at Outer Ring Road via. Wheeler Road - ITC factory – Sevanagar - Banaswadi Main road.

As described above the corridors were studied and extensive walkover studies are made to ascertain first-hand information on the suitability in terms of adequate road widths, bottlenecks that may arise for planning, critical points which are to be considered, etc.

Further, the lane configuration of 6 lanes and 4 lanes has been relooked depending upon the traffic volumes, circulation plans and most importantly availability of RoW for construction, traffic diversions during construction. At locations, corridors have been split into two directions and taken on different routes as independent carriageways so that the structure can be accommodated within the available roadway widths and multilevel or Double Decker structures may be avoided.

Most of the abutting land on either side of the project corridors is either commercial or community holdings. Certain sections of Project corridors abutting land belongs to Defence

(Military), Railways, Public sectors like HAL and educational institutions. Few Religious structures are also exists.

There are bus stops with shelters along the corridors, there exists skywalks/foot over bridges, gantry sign boards, street lighting like high mast lamps etc. are also located at places. The project corridors are flanked by important community structures such as schools, colleges, and places of religious importance like temples, masjids and churches, etc. Implementation of the project may impact these structures and might have to be shifted to avoid the impact.

Phasing for Implementation of Elevated Corridor: After several rounds of discussion with the Technical Committee on the ease of implementation of the elevated corridor project, decision was taken to conveniently split different project corridors in to different phases, based on the stretches between critical obligatory junctions which are significant in decongesting the roads; type and area of land to be acquired; number of trees to be cut/pruned; etc. Total five phases are planned as presented in the table below.

Table 2-2: Phasing for Implementation of Elevated Corridor

Corridor Packages	From	To	Length (km)		
			Main Line	One Way	TOTAL
PHASE I					
Package 1	Baptist Hospital	Mekhri Circle	7.60	0.00	7.60
	Mekhri Circle	Cantonment			
Package 2	Cantonment loop	Vital Mallya Junction	4.47	2.17	6.64
	Vital Mallya Junction	ITC Hotel			
Package 3	Adegodi (Hosur Road)	Silk Board	8.54		8.54
	Agara	St Johns Circle			
Package 4	Mekhri Circle Interchange		1.70	1.70	0.00
Total Length of Phase – I Corridors			22.31	2.17	24.47
PHASE II					
Package 1	Bhattarahalli	K.R.Puram Bridge	10.79	0.00	10.79
	Gopalan Mall	Ulsoor lake			
	Ulsoor Lake Interchange				
Package 2	Ulsoor Lake	Millers Road Junction	11.91	1.21	13.12
	Ulsoor Lake	D'souza Circle			
	Wheelers Road	Kalyan Nagar Flyover			
Package 3	Mekhri Circle	Peenya (Metro Station)	6.30	0.00	6.30
Package 4	Rammurthy Nagar (ORR)	NH 4	9.84	1.15	10.99
	Old Madras Road to ORR (Mahadevpura) Loop				
	ITI Interchange				
Total Length of Phase – II Corridors			38.84	2.36	41.20

Corridor Packages	From	To	Length (km)		
			Main Line	One Way	TOTAL
PHASE III					
Package 1	CBD Area		4.88	5.20	10.08
	Stretch Over Shanthinagar SWD				
Total Length of Phase – III Corridors			4.88	5.20	10.08
PHASE IV					
Package 1	Minerva Circle	Deepanjalinagar on Mysore Road	6.60	2.65	9.25
Total Length of Phase – IV Corridors			6.60	2.65	9.25
PHASE V					
Package 1	Varthur Kodi	After Marathahalli Junction	7.10	0.00	7.10
Package 2	After Marathahalli Junction	Richmond Circle	9.94	0.00	9.94
Total Length of Phase – V Corridors			17.04	0.00	17.04
TOTAL LENGTH (Km)			89.66	12.38	102.04

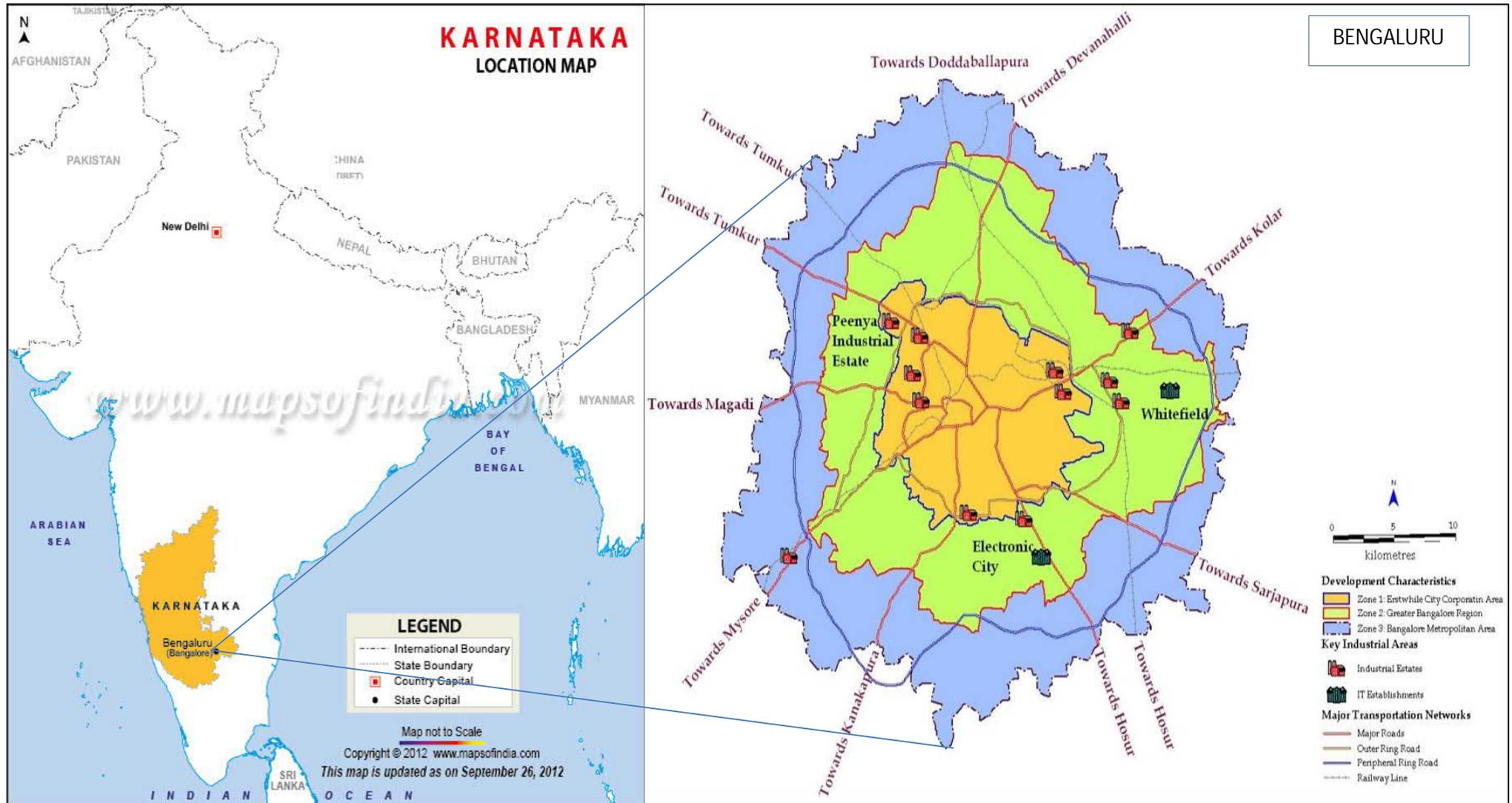
2.7 Proposals for the elevated corridor

The broad proposals for the elevated corridor project includes

- Elevated road along the major at-grade roads within Bangalore city
- Propose interchanges, ramps (entry and exit) and loops to provide acces to different arterial roads and at-grade roads
- Integration of elevated corridors with multi modal transportation systems such as BMRCL, BMTCL, Mono Rail, etc. which are in various stages of implementation.
- Design road furniture, median separation, provide road safety and traffic control features
- Design of drainage to facilitate easy flow of surface run off water to nearby major drains



Figure 2-1: Location of proposed elevated corridors, Bengaluru



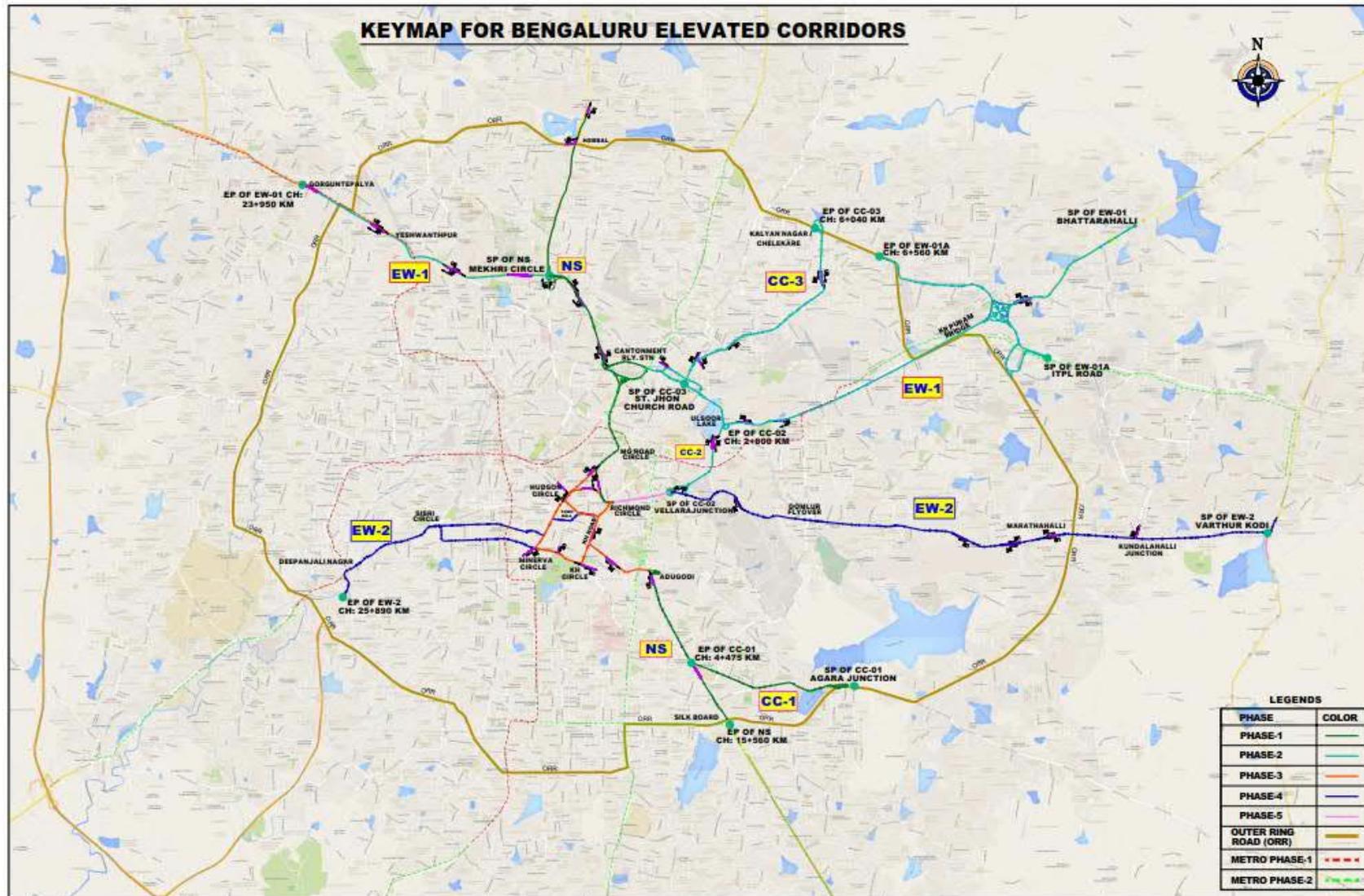


Figure 2-2: Location of proposed elevated corridors, Bengaluru



Table 2-3: Present and Future Traffic along the proposed project stretches

SI No.	Corridors /Sections	Section Length (in KM)	Without Corridors : Present Scenario				All Corridors Operational		
			2016				2037		
			Base Year Assigned Traffic (Vehicles)				Vehicles		
			Two Wheeler	Autos	Buses	Cars	Two Wheeler	Buses	Cars
NS									
1	Jayamahar Road	2.6	37,309	9,066	2,750	37,225	107000	141	51,791
2	Queens Road	3.13	24,860	6,475	1,277	25,005	58,350	148	40,179
3	Kasturba Road	2	40,068	10,428	5,658	52,001	65,100	164	40,226
4	Richmond Road- St. Joseph Jn.	1.8	23,669	4,689	1,915	19,943	81,098	125	42,940
5	St. Joseph Jn. - Siddaiah Road	1.8	21,907	5,166	3,181	20,260	83,229	233	44,735
6	Siddaiah Road - Wilson Garden	1.6	13,192	2,223	1,247	12,152	89,044	253	44,016
7	Hosur Road - Sarjapur Junction	2.3	34,004	8,166	4,515	24,891	99,866	254	52,083
8	Sarjapur Jn. - Orr	1.2	15,988	4,198	895	14,437	79,012	201	32,533
	TOTAL		210,997	50,411	21,438	205,914	662,699	1,519	348,503
EW -1									
1	Jalahalli - Yashwanthpur	3.35	55,163	10,710	7,131	44,766	37,908	36	8,492
2	Yashwanthpur - Iisc	1.5	44,561	8,754	4,095	36,837	64,089	115	24,854
3	Tumkur Road: Iisc - Mekhri Circle	2.5	55,391	11,855	7,486	45,686	88,978	160	43,006
4	Millers Road - St. Johns Church Road	1.6	23,071	6,160	2,424	32,199	77,099	139	42,386
5	Kensington Road - Murphy Road	2	32,552	9,047	3,817	37,635	83,570	117	39,386
6	Old Madras Road - Kr Puram Junction	3.64	84,671	14,367	6,584	83,626	89,207	219	40,543
7	Kr Puram Junction - Bhattarahalli	13.6	73,724	12,958	4,725	40,530	72,232	177	24,347
	TOTAL		369,133	73,851	36,262	321,279	513,083	963	223,014
EW-II									



Detailed Feasibility Report

VOL-IV Environmental Impact Assessment Report

SI No.	Corridors /Sections	Section Length (in KM)	Without Corridors : Present Scenario				All Corridors Operational		
			2016				2037		
			Base Year Assigned Traffic (Vehicles)				Vehicles		
			Two Wheeler	Autos	Buses	Cars	Two Wheeler	Buses	Cars
1	Deepanjali Nagar - Sultan Road	3	43,845	9,247	6,586	45,633	49,583	33	26,113
2	Kr Market - Richmond Circle	6.27	23,669	4,689	1,915	19,943	35,080	133	12,920
3	Chamrajapete - Kh Circle		11,564	1,902	810	11,861	32,485	35	17,462
4	Richmond Road - Hal Airport Road	2.5	34,913	8,224	1,567	35,361	95,883	226	45,461
5	Hal Airport Road - Domlur Flyover	3.5	34,913	8,224	1,567	35,361	81,888	162	44,434
6	Old Airport Road - Marathahalli (Orr)	6.5	45,823	8,313	3,175	41,752	74,119	144	39,702
7	Varthur Road	5.2	25,613	4,771	1,612	18,988	57,910	50	21,705
	TOTAL		220,340	45,370	17,232	208,899	426,948	783	207,797
CC-I									
1	Sarjapur Road	4.48	18,235	5,871	649	17,695	57,115	57	21,291
CC-II									
1	D'souza Circle - Bhaskaran Road	2.8	64,985	12,092	4,285	54,675	82,031	160	34,459
CC-III									
1	Banaswadi Road	6.46	19,079	4,228	1,698	19,240	30,602	76	17,118

2.8 Traffic Forecast:

Traffic growth rates have been estimated for the traffic flowing on the primary network within the city of Bangalore. The overall traffic growth rates have been estimated considering the growth rate used for passenger trip forecast as per the recommendations of Comprehensive Traffic and Transportation Plan (CTTP) for Bangalore, 2025 and the DPR for Bangalore Metro Phase I and II. The growth also considers the impact of Metro expansion in the city of Bangalore. Present and future traffic along the proposed project stretches is given in Table 2-3.

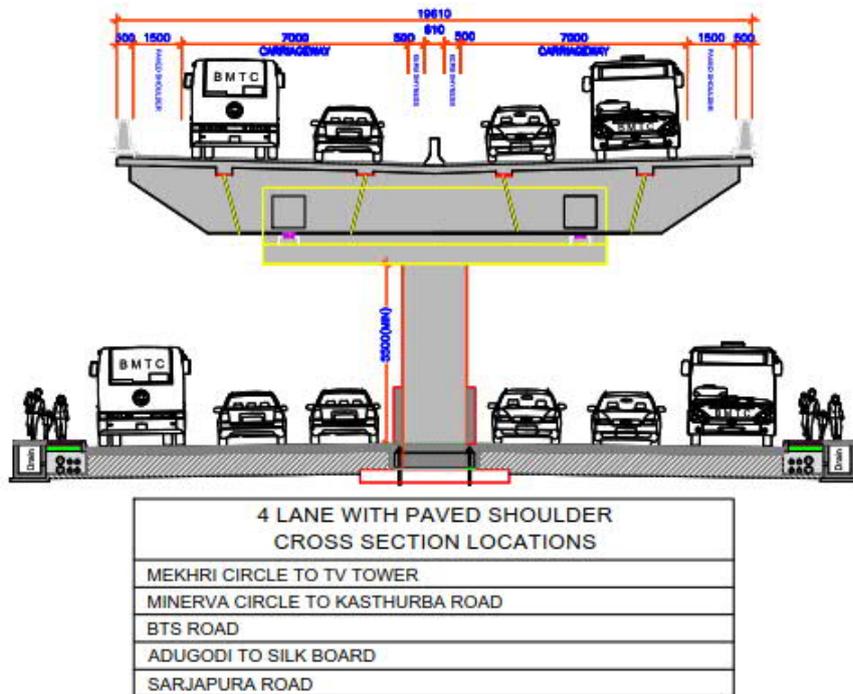
In order to analyze the vehicle growth in the city of Bangalore, the vehicle registration data of the city has been collected. The annual growth rates and Compound Average Growth Rate (%) of different vehicle types is presented below in Table 2-4.

Table 2-4: Growth of Registered vehicles in Bangalore (In Lakhs)

Year	TW	Cars	Autos	Buses	Trucks	Taxi Cab	Tractors / Trailers	Others	Total Vehicles
1980	1.12	0.36	0.10	0.05	0.08	0.00	0.04	0.01	1.75
1985	2.16	0.60	0.10	0.05	0.12	0.00	0.01	0.02	3.07
1990	4.59	0.91	0.17	0.05	0.19	0.00	0.04	0.04	5.98
1995	6.49	1.26	0.37	0.11	0.29	0.02	0.06	0.10	8.71
2000	10.67	2.14	0.61	0.21	0.42	0.04	0.12	0.17	14.38
2001	11.62	2.36	0.64	0.23	0.48	0.05	0.13	0.16	15.66
2002	12.92	2.61	0.68	0.25	0.53	0.05	0.15	0.20	17.39
2003	14.19	2.87	0.72	0.28	0.59	0.07	0.16	0.24	19.12
2004	15.86	3.36	0.74	0.34	0.68	0.10	0.20	0.28	21.57
2005	18.11	3.87	0.80	0.37	0.85	0.13	0.23	0.31	24.67
2006	20.74	4.54	0.91	0.39	0.92	0.16	0.29	0.46	28.41
2007	22.32	5.27	0.95	0.48	1.10	0.18	0.31	0.45	31.07
2008	22.64	5.53	0.96	0.49	1.19	0.19	0.32	0.54	31.85
2009	26.08	6.46	1.06	0.42	1.29	0.21	0.32	0.69	36.53
2010	25.47	7.24	0.93	0.73	1.38	0.20	0.13	0.78	36.86
2015	41.11	11.59	1.59	0.88	0.96	0.99	0.16	0.43	59.49
CAGR	10.75%	10.32%	8.10%	8.33%	7.27%	14.06%	5.10%	11.29%	10.51%

Source: Comprehensive Traffic and Transportation Plan for Bangalore, 2025; RTA Karnataka.

2.9 Typical Cross Sections proposed



TYPICAL 4-LANE CROSS SECTION

Figure 2-3: Typical Cross Section for four lane elevated corridor

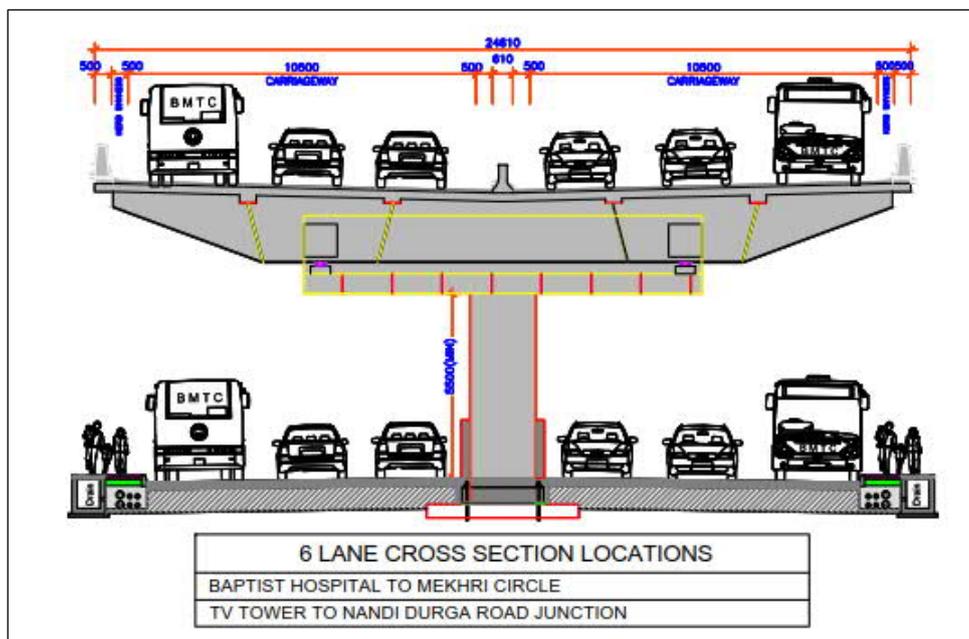


Figure 2-4: Typical Cross Section for six lane elevated corridor

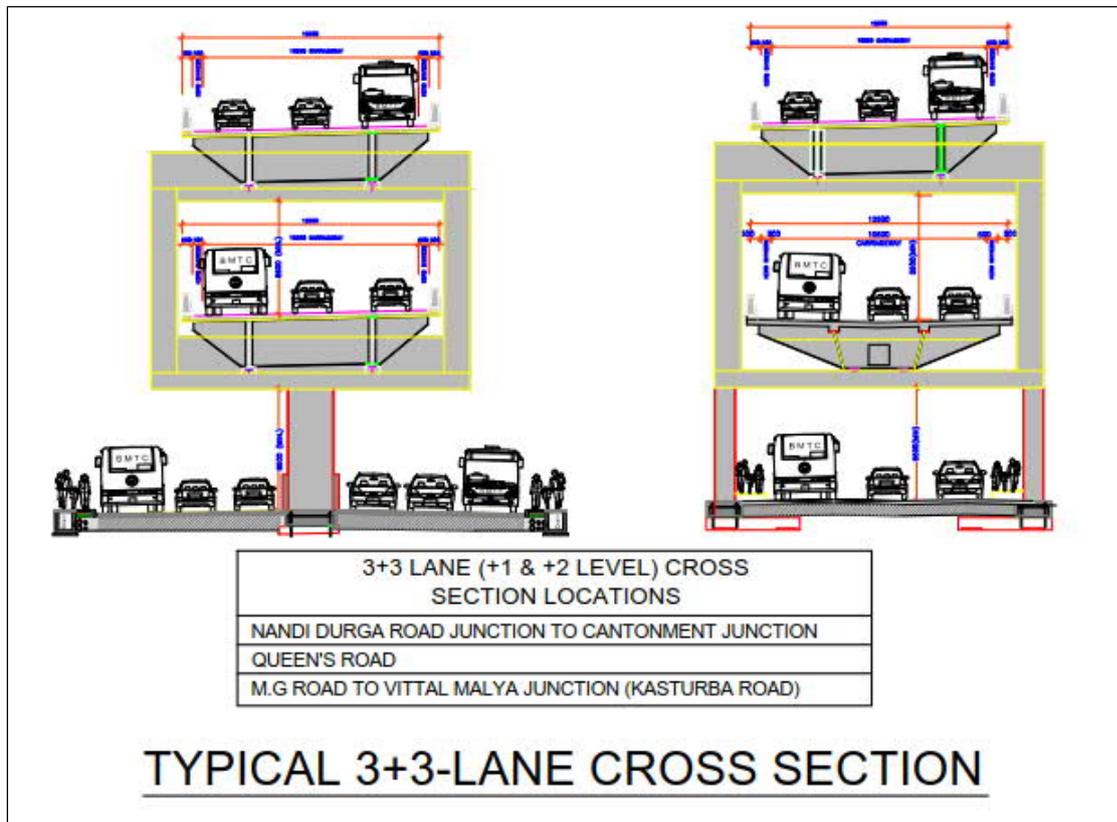


Figure 2-5: Typical Cross Section for six lane (3+3) elevated corridor

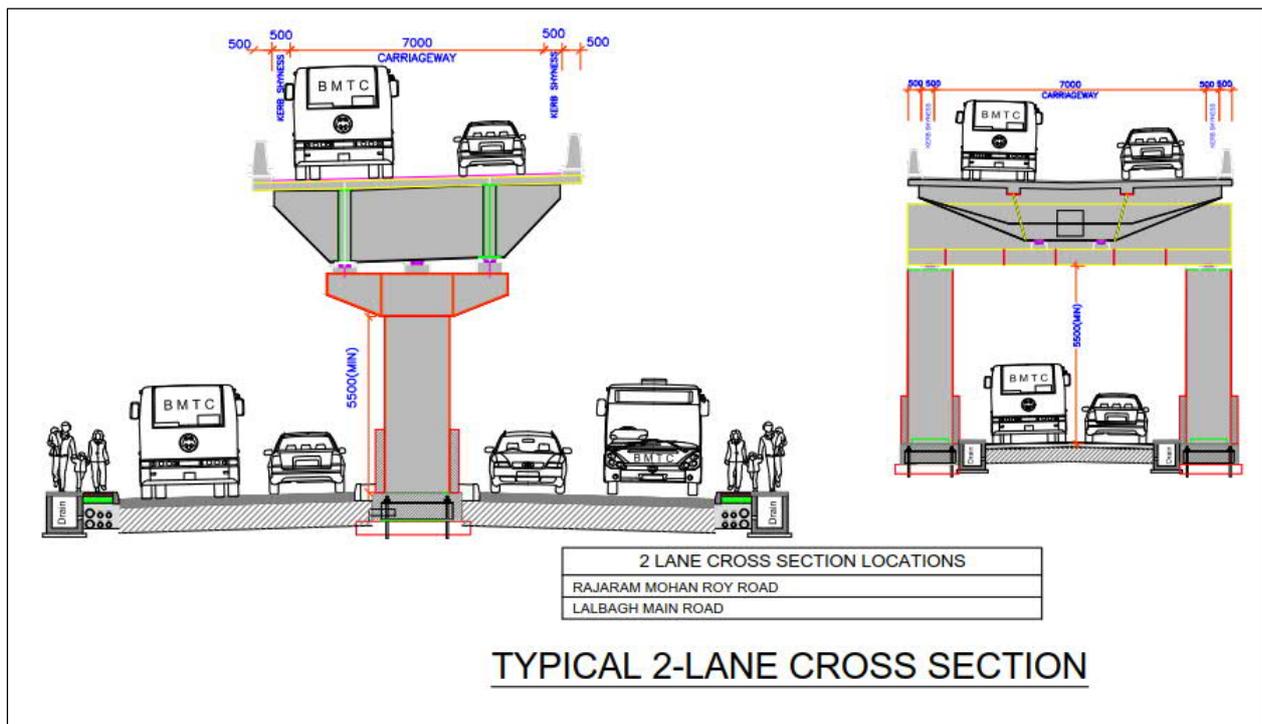


Figure 2-6: Typical Cross Section for two lane elevated corridor

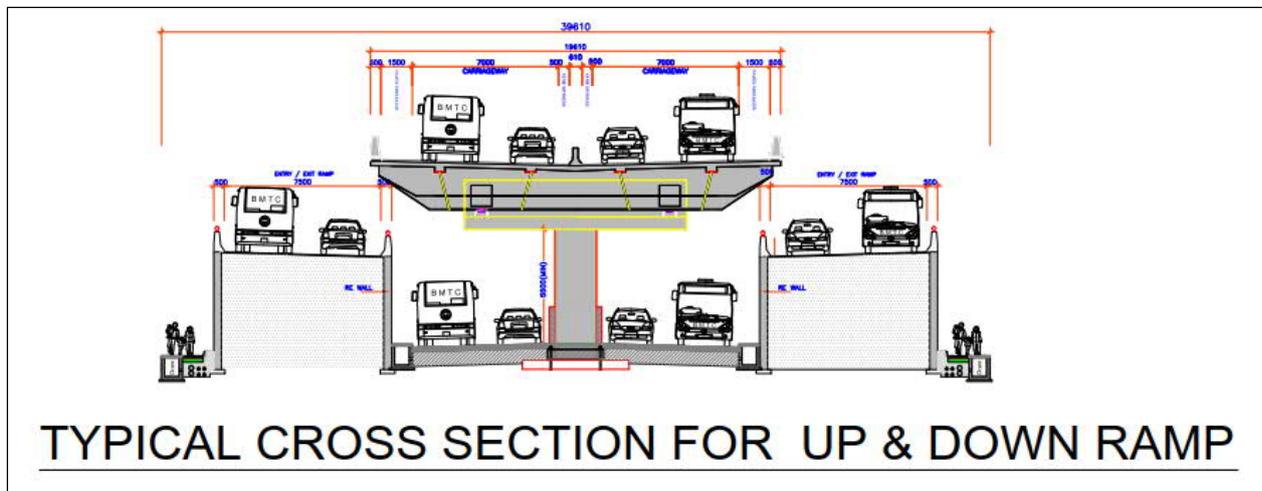


Figure 2-7: Typical Cross Section for up and down ramps of elevated corridor

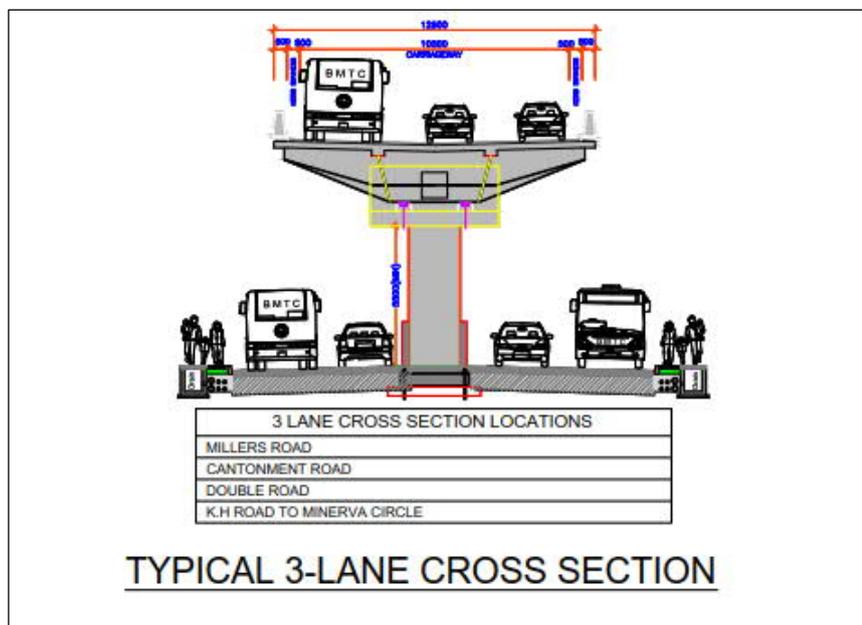


Figure 2-8: Typical Cross Section for three lane elevated corridor

2.10 Corridor of Impact (COI)

The alignment of the proposed elevated corridors improvement proposal is for two/four/six lanes depending on the requirement and the availability of the space. The width of the elevated corridors may vary from 18 m to 62 m. Stretch wise Corridor of Impact (COI) for the project road is given in Table 2-5. Considering the requirements of working space required during construction and safety of the adjacent tenancies, at grade COI will be 2 m (one m on either sides of the corridor) more than the COI of elevated structure.

Table 2-5: Corridor of Impact (CoI) for the Project Corridor

Sl. No	Chainage		Length (m)	Proposed lane configuration		Row of Elevated Corridor (m)
	From	To		Elevated corridor	At-grade road	
North-South Corridor-1 connecting Hebbal to Central silk board (Hebbal (Baptist Hospital) to Kaveri junction)						
1	0+000	0+190	190	2-lane	6-lane (3L+3L) S R (2L+2L)	10
2	0+190	0+477	287	2+2 lane	6-lane (3L+3L) S R (2L+2L)	18.61
3	0+477	0+775	298	2+2 lane LHS & RHS Ramp	6-lane (3L+3L) S R (2L+2L)	31.61
4	0+775	2+663	1888	3+3 lane	6-lane (3L+3L) S R (2L+2L)	25.61
5	2+663	2+740	77	2+2 lane LHS & RHS Ramp (taper section)	6-lane (3L+3L)	25.61 to 30.68
6	2+740	2+875	135	2+2 lane LHS & RHS Ramp	6-lane (3L+3L) S R (2L+2L)	31.3
7	2+875	3+110	235	2+2 lane with 1.5m P S on both sides	6-lane (3L+3L) S R (2L+2L)	46.5
8	3+110	3+240	130	2+2 lane with 1.5m P S on both sides	6-lane (3L+3L) S R (2L+2L)	46.5 to 32.5
9	3+240	4+090	850	2+2 lane with 1.5m P S on both sides	6-lane (3L+3L) S R	30.8
10	4+090	4+165	75	2+2 lane with 1.5m P S on both sides	6-lane (3L+3L) S R	31.3 to 37.6
11	4+165	4+420	255	2+2 lane with 1.5m P S on both sides	6-lane (3L+3L) S R	37.6
(Mekhri circle to Cantonment Railway station)						
12	0+000	0+360	360	Mekhri circle Triumphet interchange	6-lane (3L+3L) S R (2L+2L)	38.6
13	0+360	0+400	40	5+5 lane	6-lane (3L+3L) S R (2L+2L)	36.5
14	0+400	0+540	140	5+5 lane	6-lane (3L+3L) S R (2L+2L)	32.3
15	0+540	0+610	70	5+5 lane LHS Ramp (Taper section)	6-lane (3L+3L) S R (2L+2L)	31.8
16	0+610	0+830	220	3+3 lane LHS Ramp	6-lane (3L+3L) S R (2L+2L)	31.6
17	0+830	0+860	30	3+3 lane LHS & RHS Ramp	6-lane (3L+3L) S R (2L+2L)	33
18	0+860	0+905	45	3+3 lane RHS Ramp	6-lane (3L+3L) S R (2L+2L)	31
19	0+905	1+210	305	3+3 lane RHS Ramp	6-lane (3L+3L) S R (2L+2L)	32.1
20	1+210	1+550	340	3+3 lane	6-lane (3L+3L) S R (2L+2L)	25.6
21	1+550	1+600	50	3+3 lane	6-lane (3L+3L) S R (2L+2L)	25.6 to 22.6
22	1+600	1+650	50	3+3 lane	6-lane (3L+3L) S R (2L+2L)	22.6 to 18.2

Sl. No	Chainage		Length (m)	Proposed lane configuration		Row of Elevated Corridor (m)
	From	To		Elevated corridor	At-grade road	
23	1+650	1+720	70	3+3 lane	6-lane (3L+3L) S R (2L+2L)	18.2 to 13.5
24	1+720	2+000	280	3+3 lane	6-lane (3L+3L) S R (2L+2L)	13.5
25	2+000	2+360	360	3+3 lane RHS Ramp	6-lane (3L+3L) S R (2L+2L)	19.5
26	2+360	2+425	65	3+3 lane LHS Ramp	6-lane (3L+3L) S R (2L+2L)	19.5 to 13.5
27	2+425	2+445	20	3+3 lane LHS Ramp	6-lane (3L+3L) S R (2L+2L)	13.5
28	2+445	2+670	225	3+3 lane LHS Ramp	6-lane (3L+3L) S R (2L+2L)	20
(Cantonment Railway station to Richmond circle)						
29	2+670	2+780	110	3-lane	Follow existing	12.5
30	2+780	2+900	120	3-lane	Follow existing	12.5
31	3+765	3+840	75	2-lane	4 lane (2L+2L)	9
32	3+840	4+750	910	3-lane	Follow existing	12.5
33	4+750	5+800	1050	3+3lane (Double decker)	2-lane	12.5
34	5+800	6+340	540	3+3lane (Double decker)	6-lane (3L+3L)	
35	6+340	7+060	720	3+3lane (Double decker)	4-lane (2L+2L)	
36	0+000	0+195	195	3-lane	2-lane	12.5
37	0+195	0+495	300	2-lane RHS Ramp	2-lane	16
38	0+495	0+710	215	2-lane	2-lane	9
39	2+500	2+700	200	3-lane	2-lane	12.5
40	2+700	17+095	60	2-lane	2-lane	9
41	17+095	17+710	615	3-lane	3-lane	12.5
42	17+710	18+110	400	3-lane LHS Ramp	3-lane	16
43	18+110	18+200	90	3-lane	3-lane	12.5
44	0+000	0+300	300	2-lane (Ramps)	-	10
45	0+000	0+335	335	2-lane (Ramps)	-	10
46	0+195	0+495	300	5.5m (Ramps)	-	7
47	17+710	18+110	400	5.5m (Ramps)	-	7
(Minerva circle to Kasturba road)						
48	0+000	1+435	1435	4-lane	4-lane (2L+2L)	16
49	1+435	(7+865)	245	4-lane	4-lane (2L+2L)	16
50	(7+865)	7+725	140	3-Lane	4-lane (2L+2L)	12.5
51	7+725	7+440	285	3-lane LHS Ramp	6-lane (3L+3L)	19.5
52	7+440	7+060	380	3-Lane	6-lane (3L+3L)	12.5
53	0+000	0+250	250	5.5m (Ramps)	-	7
54	0+000	0+235	235	5.5m (Ramps)	-	7

Sl. No	Chainage		Length (m)	Proposed lane configuration		Row of Elevated Corridor (m)
	From	To		Elevated corridor	At-grade road	
55	0+000	0+285	285	5.5m (Ramps)	-	7
56	0+000	0+370	370	5.5m (Ramps)	-	7
(Town Hall to Richmond road)						
57	0+000	1+230	1230	2-lane	6-lane (3L+3L)	10
(Corporation to Richmond road)						
58	1+700	1+930	230	2-lane	4-lane (2L+2L)	10
59	1+930	2+275	345	2-lane LHS Ramp	4-lane (2L+2L)	17
60	2+275	2+500	225	2-lane	4-lane (2L+2L)	10
(KH circle to Minerva circle)						
61	18+200	18+740	540	3-lane	4-lane (2L+2L)	12.5
62	18+740	18+810	70	3-lane RHS Ramp	4-lane (2L+2L)	19.5
63	18+810	19+900	1090	3-lane	4-lane (2L+2L)	12.5
(KH road to Silk board flyover)						
64	9+120	10+680	1560	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	17.61
65	10+680	10+980	300	2+2 lane with 1.5m P S on both sides, LHS Ramp	4-lane (2L+2L) S R LHS (2L)	24.61
66	10+980	11+030	50	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	17.61
67	11+030	11+100	70	2+2 lane with 1.5m P S on both sides, LHS Ramp	4-lane (2L+2L)	24.61
68	11+100	12+840	1740	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	17.61
69	12+840	13+200	360	2+2 lane with 1.5m P S on both sides, RHS Ramp	4-lane (2L+2L)	27.61
70	13+200	13+300	100	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	17.61
71	13+300	13+650	350	2+2 lane with 1.5m P S on both sides, Ramp-LHS & RHS	4-lane (2L+2L)	37.61
72	13+650	13+765	115	2+2 lane with 1.5m P S on both sides, Ramp-LHS & RHS (taper section)	4-lane (2L+2L)	17.61
73	13+765	14+400	635	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	17.61
74	0+000	0+260	260	2-lane (Ramp)	-	10
East-West Corridor-1 connecting K.R.Puram to Goraguntapalya						
(Swami Vivekananda road)						
1	7+125	9+150	4050	2+2 lane with 1.5m P S on both sides	6-lane (3L+3L)	20.61

Sl. No	Chainage		Length (m)	Proposed lane configuration		Row of Elevated Corridor (m)
	From	To		Elevated corridor	At-grade road	
2	9+150	9+450	600	2+2 lane with 1.5m P S on both sides	6-lane (3L+3L)	20.61
3	9+450	9+790	680	2+2 lane with 1.5m P S on both sides	6-lane (3L+3L)	20.61
4	9+790	10+140	700	2+2 lane with 1.5m P S on both sides LHS Ramp	6-lane (3L+3L)	27.61
5	10+140	11+150	2020	2+2 lane with 1.5m P S on both sides	6-lane (3L+3L)	20.61
6	11+150	11+430	560	Ulsoor Triumphet interchange	6-lane (3L+3L)	20.61 to 30
7	11+430	11+820	780	2+2 lane with 1.5m P S on both sides LHS & RHS Ramp	6-lane (3L+3L)	36.61
8	11+820	12+555	1470	2+2 lane with 1.5m P S on both sides	6-lane (3L+3L)	20.61
9	12+555	12+620	130	2+2 lane with 1.5m P S on both sides	6-lane (3L+3L)	20.61
10	12+620	13+550	1860	3-lane	6-lane (3L+3L)	13.5
11	13+550	13+670	240	3-lane	6-lane (3L+3L)	13.5
12	13+670	13+960	580	2+2 lane with 1.5m P S on both sides	6-lane (3L+3L)	20.61
13	13+960	14+045	170	2-lane	6-lane (3L+3L)	10
14	6+755	7+125	740	2+2 lane with 1.5m P S on both sides LHS Ramp	4-lane (2L+2L)	20.61
15	9+790	10+140	700	5.5m (Ramps)	-	7
(St.Johns road to millers road)						
16	12+600	13+900	2600	3-lane	6-lane (3L+3L)	
17	0+000	0+240	240	2-lane (Ramps)	-	10
(Mekhri circle to Yeswantpur)						
18	18+000	19+035	1035	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
19	19+035	19+345	310	2+2 lane with 1.5m P S on both sides LHS Ramp	4-lane (2L+2L)	27.61
20	19+345	20+200	855	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
21	20+200	20+450	250	2+2 lane with 1.5m P S on both sides LHS Ramp	4-lane (2L+2L)	27.61
22	20+450	20+665	215	2+2 lane with 1.5m P S on both sides LHS Ramp	4-lane (2L+2L)	27.61
23	0+000	0+270	270	2-lane	-	10
24	19+035	19+345	310	5.5m (Intermediate lane)	-	7
25	20+200	20+450	250	5.5m (Intermediate)	-	7

Detailed Feasibility Report

VOL-IV Environmental Impact Assessment Report

Sl. No	Chainage		Length (m)	Proposed lane configuration		Row of Elevated Corridor (m)
	From	To		Elevated corridor	At-grade road	
East-West Corridor-2 connecting SH-35 to SH-17 from Varthur kodi on SH-35 to Jnanabharathi on SH-17 (upto Deepanjalai nagar)						
(HAL Airport road)						
1	0+750	3+760	3010	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
2	3+760	4+010	250	2+2 lane with 1.5m P S on both sides, LHS Ramp	4-lane (2L+2L)	27.61
3	4+010	4+350	340	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
4	4+350	5+030	680	2+2 lane with 1.5m P S on both sides (+2 level)	Follow existing RoB	20.61
5	5+030	5+660	630	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
6	5+660	5+945	285	2+2 lane with 1.5m P S on both sides, LHS & RHS Ramp	4-lane (2L+2L) S R LHS	34.61
7	5+945	6+590	645	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
8	6+590	7+055	465	2+2 lane with 1.5m P S on both sides, LHS & RHS Ramp	4-lane (2L+2L) S R LHS	34.61
9	7+055	7+865	810	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
10	7+865	8+135	270	2+2 lane with 1.5m P S on both sides, LHS Ramp	4-lane (2L+2L) S R LHS	27.61
11	8+135	8+550	415	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
12	8+550	8+890	340	2+2 lane with 1.5m P S on both sides, RHS Ramp	4-lane (2L+2L)	27.61
13	8+890	11+600	2710	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
14	11+600	11+885	285	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
15	11+885	12+260	375	2+2 lane with 1.5m P S on both sides, LHS & RHS Ramp	4-lane (2L+2L)	34.61
16	12+260	12+500	240	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
17	12+500	12+940	440	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
18	12+940	13+235	295	2+2 lane with 1.5m P S on both sides LHS Ramp	4-lane (2L+2L)	27.61

Sl. No	Chainage		Length (m)	Proposed lane configuration		Row of Elevated Corridor (m)
	From	To		Elevated corridor	At-grade road	
19	13+235	13+890	655	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
20	13+890	14+285	395	2+2 lane with 1.5m P S on both sides RHS Ramp	4-lane (2L+2L)	27.61
21	14+285	15+155	870	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
22	15+155	15+230	75	Junction converging and diverging	4-lane (2L+2L)	20.61 to 45
23	15+230	15+450	220	3-lane	4-lane (2L+2L)	13.5
24	15+450	15+530	80	Junction converging and diverging	4-lane (2L+2L)	20.61 to 45
25	15+530	17+025	1495	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
26	0+000	0+460	460	2-lane (Ramps)	-	10
27	0+000	0+275	275	2-lane (Ramps)	-	10
28	0+000	0+315	315	2-lane (Ramps)	-	10
(Minerva circle to chord road junction)						
29	19+940	20+780	840	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
30	20+780	22+255	1475	2-lane	4-lane (2L+2L)	9
31	22+255	24+880	2625	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
32	24+880	25+190	620	2+2 lane with 1.5m P S on both sides (Ramps)	4-lane (2L+2L)	20.61
(Tipu Sultan Palace road)						
33	3+015	4+442	1427	2-lane	4-lane (2L+2L)	9
Connecting corrdior-1 connecting North-South at St Johns junction to Agara junction on ORR						
1	0+000	250	250	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
2	0+250	3+800	540	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	17.61
3	3+800	4+100	70	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	17.61
4	0+000	0+250	500	4-lane with 1.5m P S (Ramps)	4-lane (2L+2L)	20.61
Connecting corrdior-3 connecting East-west corrdior-1 at Wheelers road junction to Kalyan Nagar Outer Ring Road						
(Dsouza circle to UIsoor lake)						
1	0+060	0+175	115	2-lane	4-lane (2L+2L)	10
2	0+175	0+470	295	2+2 lane, LHS Ramp	4-lane (2L+2L)	17
3	0+470	0+530	60	2-lane	4-lane (2L+2L)	10
4	0+530	1+150	620	2+2 lane with 1.5m P S on both sides (+2 level)	4-lane (2L+2L)	20.61

Sl. No	Chainage		Length (m)	Proposed lane configuration		Row of Elevated Corridor (m)
	From	To		Elevated corridor	At-grade road	
5	1+150	1+500	350	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
6	1+500	1+690	190	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
7	1+690	2+050	360	2+2 lane with 1.5m P S on both sides, LHS & RHS Ramp	4-lane (2L+2L)	34.61
8	2+050	2+195	145	2+2 lane with 1.5m P S on both sides	4-lane (2L+2L)	20.61
9	2+195	2+315	120	Tapered portion from 4-lane to 6-lane	4-lane (2L+2L)	20.61 to 25.6
10	0+175	0+470	295	2-lane (Ramps)	-	10
11	1+690	2+050	720	4-lane with 1.5m P S (Ramps)	4-lane (2L+2L)	20.61
(Victoria Layout)						
12	0+000	0+270	270	2-lane	2-lane	10
Connecting corridor-2 connecting East-west corridor-1 at Ulsoor to East-west corridor-2 on Dsouza circle						
(Wheelers road to Kachakarnahalli)						
1	0+000	4+120	4120	6-lane (3L+3L)	4-lane (2L+2L)	25.6
2	2+930	0+180	180	5.5m (Ramps)	-	7
3	3+220	0+160	160	5.5m (Ramps)	-	7

The very Objective of the elevated corridors in Bangalore will only be achieved if the proposal is integrated with development of Peripheral Ring Road (PRR) to avoid the through traffic from entering the City Core central area, development of Mass transit system including new Metro and Mono rail feeder corridors. The anticipated Mass Rail Transport System (MRTS) of Bangalore city could be strategically integrated with the Metro rail and Mono rail combinations to connect all the arterial and sub arterial roads with the potential Production and Attraction zones to meet the growing travel demand of the city. Policy level decisions are required to integrate the upcoming metro corridors / Mono rail corridors with the proposed elevated corridors so as to provide last mile connectivity and generate substantial shift of passengers from private to public modes. Access to MRTS is required to be optimized in both central as well as peripheral areas of the city of Bangalore to maximize its utility. Promoting public transit and strengthening mass transit network in the city can be a holistic way forward to solve the ever growing congestion impacts on the streets of Bangalore and thereby substantially improve the deteriorating quality of urban life as a whole.

Considering the above the GOK has envisioned constructing elevated corridors connecting North-South and East-West of Bangalore city to ensure fast and hassle free connectivity. However, the problem of traffic congestion can be solved only by reducing the traffic on roads either by restriction of usage of vehicles, providing mass transport facilities which encourage people to shift to public transport along with capacity augmentation of existing

road network. Reducing vehicles on roads by policy or through encouragement is difficult and is possible only by a massive capacity augmentation of roads which are sustainable for longer duration. Since widening of roads is limited due to non-availability of land for road right of way (RoW) widths, the only solution is to build road over roads, i.e. to add elevated roads over the existing major roads as a part of capacity augmentation. A detailed traffic study report has been prepared specially for the proposed elevated project.

2.11 Materials of Construction and its availability:

Materials such as Cement, aggregate stone, manufactured sand (Course & Fine), borrow soil, steel, Bitumen, emulsion, etc. will be used in construction of elevated corridor project. The quantity of materials used in construction is given in following Table 2-6.

All the materials required for construction shall be sourced from nearest possible locations to avoid long distance transportation. Construction of deck slabs of elevated structure will be cast ex-situ in construction camps / casting yards to avoid carrying huge quantities of raw material and also in avoiding any large casting in situ activities.

Table 2-6: Construction materials required per Kilometer

Corridor	Aggregate/Base materials (mt/km)	Cement (mt/km)	Bitumen (mt/km)	Steel Reinforcement (mt/km)	Emulsion (mt/km)	Borrow Earth
North-South Corridor	39592	8944	405	14356	16	35114
East-West Corridor-1	17524	4728	155	7099	5	10968
East-West Corridor-2	13318	3622	176	6753	6	10599
Connecting Corridor-1	18715	5072	229	9190	10	2742
Connecting Corridor-2	21111	5557	181	10484	8	13898
Connecting Corridor-3	11973	3104	141	5900	6	1902

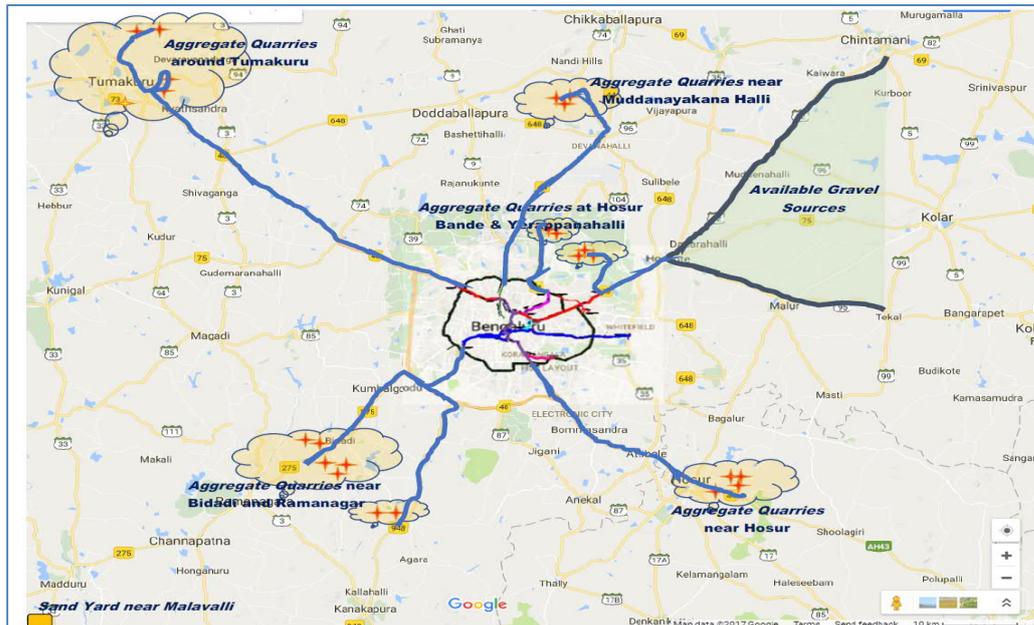


Figure 2-9: Quarry Locations Map

The Table 2-7 below gives the details of source and distance for aggregate.

Table 2-7: Aggregate quarries and the distance

Aggregate Source	Distance from Project Location
Hosur Bande and Yerappanahalli	< 20 Km from Connecting corridor 03 of the project
Muddanayakana Halli near Chickballapur	50 Km from North – South Corridor (Mekhri Circle)
Tumkur	60 Km from End point of East – West 01 Corridor
Bidadri / Ramnagar at Ivagilu / Harohalli	45 Km from end point of East West Corridor 02
Alur near Hosur	50 km from the end point of North and South Corridor

Sand sources are available near Malavalli at a distance of about 80 Km from Bangalore city. Manufactured sand production units are available within 80 Km distance from Project location.

3. POLICIES AND THE REGULATORY FRAMEWORK AND ITS APPLICABILITY

3.1 Constitutional Provisions

The Constitution of India, in Article 48, of Directive Principles of the State provides for the protection and preservation of the environment and it states that “the state shall endeavour to protect and improve the environment and to safeguard forests and wildlife of the country”.

Further Article 51-A (g), of fundamental duties, emphasizes that, “It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures.”

These two provisions of the constitution form the guiding principles for the environmental legislation in India. The Government of India has laid down various policy guidelines, regulations, acts and legislations pertaining to sustainability and protection of the environment and its various components.

3.2 Environment Impact Assessment Notification and its applicability to the project:

As per the EIA Notification, prior Environmental Clearance (EC) is required for certain types of projects. All developmental projects can be categorized under Category ‘A’ and Category ‘B’, subject to certain considerations listed in the Schedule.

Elevated corridors do not have a mention in the list of projects qualifying for environmental clearance as per EIA Notification and its amendment. Though, certain stretches of alignment of elevated corridor forms a part National Highways (NH 4 & NH 7) and State Highways, elevated corridors cannot be classified as NH or SH looking at their functional and locational roles.

As the elevated corridors are proposed for decongesting Bengaluru city roads projects can be classified under transportation sector, and considering these elevated corridors as a part of national and state highways which do have mention in the schedule of Notification, the total length of the main elevated corridor is 102.04 km, but it involves additional right of way or land acquisition less than 40 m along the existing alignments. The proposed six elevated corridors having a length of 102.04 km is to decongest the internal city roads and to give access controlled connectivity to the arterial roads which are connecting important neighbouring towns and cities. The elevated corridors are not continuous in nature to be considered as one project, but it constitutes of 6 different corridors connecting different parts of the city, hence the total length of all six corridors need not be considered as length to be qualified for environmental clearance.

The elevated corridor will be supported by pier structures from the median and all possible efforts will be made to limit width of the corridor within the available Right of Way (ROW). Hence, additional right of way or total width of acquisition along the proposed alignments does not exceed 40 m. In fact, one of the main objectives is, to minimise the land acquisition except for junction improvements and at entry and exit points to link proposed elevated corridors with the existing roads beneath (at grade). Hence considering both length and width of the project corridor do not qualify for environmental clearance.

However, an elevated corridors project is being considered under Townships and Area Development Projects (Item 8(b) of the Notification as per the NGT judgement in case of steel flyover project from Basaveshwara Circle to Hebbal, Bangalore (Application Nos. 243 & 245 of 2016 (SZ) for environmental clearance under Area Development projects and Townships, Category 8 (b) of EIA Notification, 2006 and subsequent amendments.

Proposed elevated corridor project has total built-up area of approximately 21,89,000 sqm and as it exceeds 3,00,000 sq. mtrs. qualifying under Schedule 8(b) of EIA Notification,.

The elevated corridor project is significantly different from building and construction projects in terms of project requirements, construction activities, environmental impacts and mitigation measures. The excerpts from EIA Notification for Highways and Area Development projects and Townships are given in the following table for reference.

Project or Activity	Category with threshold limit		Condition if any
	A	B	
8	Building / Construction projects / Area Development projects and Townships		
8(b)	Townships and Area Development projects	<p>≥1,50,000 sq. mtrs and < 3,00,000 sq. mtrs built up area or covering an area ≥ 50 ha and < 150 ha</p> <p>≥ 3,00,000 sq. mtrs of built up area or covering an area ≥ 150 ha¹</p>	Note - General Condition shall not apply".

¹ Amendment made through Notifications dated 9th December 2016; 13th March 2018; & 3rd April 2018.

3.3 The Environment (Protection) Act, 1986

The Environment (Protection) Act, popularly known as EP Act, is an umbrella legislation that supplements existing environmental regulations. Empowered by the EP Act, MoEF, the Government of India has issued the EIA Notification (as discussed in section 8.2.2) regulating the siting of industry and operations, procuring clearances to establish industries and development of projects with appropriate EIA studies, coastal zone regulations and other aspects of environment protection:

This Act, empowers the Government of India (section 6) to formulate rules to regulate environmental pollution by stipulating standards and maximum allowable limits to prevent air, water, noise, soil and other environmental pollutants.

Prohibits operations that emit pollutants in excess of standards (section 7); Regulates handling of hazardous substances and identifies persons responsible for discharges and pollution prevention (section 9); Section 17 deals with offences committed by Government Departments

Formulated Environmental (Protection) Rules, 1986, Hazardous Wastes (Management and Handling) Rules, 1989 and Manufacture, Storage & Import of Hazardous Chemical Rules, 1989 in accordance with the sections 6,8 and 25 of EP Act.

3.4 Water (Prevention and Control of Pollution) Act, 1974

The Water Act is the first environmental regulation that was brought to the state and central levels, with pollution control boards to control / regulate environmental pollution in India. Amended twice in 1978 and 1988, the Act vests regulatory authority on the State Pollution Control Boards and empowers them to establish, and enforce, standards for industries and local authorities discharging effluents.

This provides for the prevention and control of water pollution, and the maintaining and restoring of the wholesomeness of water. 'Pollution' means such contamination of water, or such alteration of the physical, chemical or biological properties of water, or such discharge of any sewage, or trade effluent, or of any other liquid, gaseous or solid substance into water (whether directly or indirectly) as may, or is likely to, create a nuisance for health or safety, or to domestic, commercial, industrial, agricultural or other legitimate uses, or to the life and health of animals or plants or of aquatic organisms.

The act resulted in the establishment of the Central and State level Pollution Control Boards, whose responsibilities include managing water quality and effluent standards, as well as monitoring water quality, prosecuting offenders and issuing licenses for construction and operation of certain facilities.

The project requires getting No-Objection Certificate/Consent from the Karnataka State Pollution Control Board (KSPCB) under the Water (Prevention and Control of Pollution) Act of 1974, the Cess Act of 1977. KSPCB reviews and accords consent for establishment by stipulating certain specific and general conditions after accepting the application for the project.

3.5 Air (Prevention and Control of Pollution) Act, 1981

Similar to the Water Act, the Air Act vests regulatory authority on the State Pollution Control Boards and empowers them to enforce air quality standards to prevent air pollution in the country. Section 21 of the act requires an application to be made to the state board to establish or operate any industrial operation and project activity.

The project requires getting No-Objection Certificate/Consent from the Karnataka State Pollution Control Board (KSPCB) under the Air (Prevention and Control of Pollution) Act of 1981; the Air (Prevention and Control of Pollution) Rules of 1982 and Air (Prevention and Control of Pollution) Amendment Act, 1987. As in the case of the Water Act, the KSPCB reviews and accords consent for establishment by stipulating certain specific and general conditions after accepting the application for the project.

3.6 The Hazardous Wastes (Management and Handling) Rules, 2016

The Central Government formulated these rules under the Environment (Protection) Act, 2016. Under these rules it is required that the operator or occupier of a facility dealing with hazardous waste ensures that the hazardous waste is packaged in a suitable manner for storage and transport and the labelling and packaging shall be easily visible and be able to withstand physical conditions and climatic factors. Packaging, labelling and transport of hazardous wastes shall be in accordance with the provisions of the rules issued by the Central Government under the Motor Vehicles Act, 1988, and other guidelines issued from time to time. These Rules also requires that in case of an accident during transportation of hazardous wastes, the operator or occupier of a facility shall immediately report to the State Pollution Control Board in the prescribed form.

This statute applies to the elevated corridor project as it involves handling (including storing) and transshipment of hazardous bituminous materials for pavement construction.

3.7 Wildlife Protection Act, 1972

This act is promulgated to provide for the protection of wild animals, birds and plants and for matters connected therewith. The act is not applicable to the elevated corridor project as none of the corridors are either passing through or adjacent to the wild life sensitive areas.

3.8 The Indian Forest Act, 1927

This statute provides power to the Government to classify forestland and declare an area to be a reserved forest, a protected forest or a village forest. The act prohibits a number of activities including making fresh clearings, tree felling, lopping, burning, grazing, quarrying, manufacturing activities, hunting, shooting, etc. in the forest. Violation of provisions of Section 26 specifically with regards to creating fire, felling, girdling, lopping, etc. of trees, quarrying and manufacturing operations or clearing up of any forest land for construction projects is punishable with imprisonment with a fine.

This Act is not applicable as none of the corridors are located adjacent to the forest land.

3.9 Forest (Conservation) Act, 1980 (as Amended In 1988)

As per Section 26 of the Indian Forest Act, 1927 a number of activities are prohibited in forest areas, and prior approval is required from the Central Government to use /divert forest land for non-forest purposes. The project corridor is not adjacent to or passing through forest sections.

3.10 The Ancient Monuments and Archaeological Sites and Remains Act 2010

The archaeological sites/remains/monuments in the country are protected by ASI (Archaeological Survey of India) or the State Directorate of Archaeology.

Under the Act, areas within the radii of 100m and 300m from the "Protected Property" are designated as "Protected Areas" and "Controlled Areas" respectively. Development activities (including building, mining, excavating, blasting) is not permitted in the "Protected Areas". Development activities likely to damage the protected property are not permitted in the "Controlled Areas" without prior permission from the Archaeological Survey of India (ASI).

Tipu Sultan's Palace: the palace of Tipu Sultan was begun by Haider Ali in 1781 AD and completed by Tipu Sultan in 1791 AD. This is a splendid structure now present within the old fort. It is of two storeys with a large open courtyard in front originally with a fountain and small, ornamental garden.

Old Dungeon Fort & Gates: Old Dungeon Fort & Gates or Bengaluru Fort began in 1537 as a mud fort by Sri Kempe Gowda I, a vassal of the Vijaynagar Empire and the founder of Bengaluru. Haider Ali in 1761 replaced the mud fort with a stone fort. The army of the British East India Company, led by Lord Cornwallis on 21st March 1791 captured the fort in the siege of Bengaluru during the Third Mysore War (1790–1792). Today, the fort's Delhi gate, on Krishna Rajendra (KR) Road and two bastions are the primary remains of the fort.

In addition to the above notified monuments, there are a few heritage buildings listed as per Bangalore Development Authority's Revised Master Plan (RMP) – Volume I 2031 imposing development restrictions in 12 heritage zones, apart from listing out 558 heritage sites. The proposed heritage zones in the city are Central Administrative Heritage Zone, Pete & Bengaluru Fort Heritage Zone, Gavipuram, Basavanagudi and VV Puram Heritage Zone, MG Road Heritage Zone, Shivajinagar Heritage Zone, Cleveland Town Heritage Zone, Richards Town Heritage Zone, Malleswaram Heritage Zone, Ulsoor Heritage Zone, Whitefield Inner Circle Heritage Zone, Begur Temple Heritage Zone and Bengaluru Palace Heritage Zone. In addition, 558 sites have been further classified under built heritage value (533), natural heritage value (16) and cultural heritage value (9). An NOC from the committee is must for most development activities in these zones and the listed heritage sites. The draft plan allows no new development on Queens Road, and no building taller than 12 m in Basavanagudi. No flyovers and other infrastructure are allowed in any of the zones.

Other statutory requirements applicable for the project include Public Liability Insurance Act, 1991, The Motor Vehicles Act, 1988, Minimum Wages Act, 1948; Contract Labour Act, 1970; Child Labour (Prohibition and Regulation) Act 1996 along with Rules, 1988; etc.

3.11 National Green Tribunal (NGT) Order dated 4th May 2016 in O.A. No. 222 of 2014
The National Green Tribunal was constituted in 2010 for effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources including enforcement of any legal rights relating to environment and giving relief and compensation for damages to persons and property. The tribunal will have jurisdiction over all civil cases relating to implementation of The Water Act 1974; The Water Cess Act 1977; The Forest Conservation Act 1980; The Air Act 1981; The Environment Protection Act 1986; The Public Liability Insurance Act 1991; and The Biological Diversity Act 2002.

Applicability: Vide its Order, NGT has fixed the distance from water bodies (lakes and Rajakaluves) to prohibit construction activities. The distance in the case of Water bodies, wetlands and Rajakaluves shall be maintained as below.

- 75m from the periphery of water body or Lakes, to be maintained as green belt and buffer zone.
- 50m from the edge of the primary Rajakaluves.
- 35m from the edges in the case of secondary Rajakaluves
- 25m from the edges in the case of tertiary Rajakaluves

The buffer/green belt zone would be treated as no construction zone for all intent and purposes. This is absolutely essential for the purposes of sustainable development particularly keeping in mind the ecology and environment of the areas in question.

This Tribunal order is applicable for all the construction projects which are within buffer zone from the periphery of water bodies like Ulsoor Lake, Varthur Lake, Agara Lake and Vrishabhavathi Stream/River.

3.12 The Right to Fair Compensation and Transparency in Land Acquisition and Rehabilitation and Resettlement Act, 2013 (RFCTLARR Act 2013)

This is an act which replaces both the Land Acquisition Act 1894 and National Resettlement and Rehabilitation Policy 2007. This is an Act to ensure, in consultation with institutions of local self-government and Gram Sabhas established under the Constitution, a humane, participative, informed and transparent process for land acquisition for development of essential infrastructural facilities, industrialisation and urbanisation with the least disturbance to the owners of the land and other affected families and provide fair compensation to the affected families whose land has been acquired or proposed to be acquired or are affected by such acquisition and make adequate provisions for such affected persons for their rehabilitation and resettlement.

Government of Karnataka has issued Rules as provided in Section 109 of RFCTLARR Act 2013 namely "The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (Karnataka) Rules, 2015". These Rules, inter-alia, provide for the following.

Chapter II deals with the matters pertaining to Social Impact Assessment (SIA) Study and all matters concerning the same including its publication, (Rules.3 to 13).

Chapter III deals with the Process of Obtaining the Prior Consent (Rules 16-19)

Chapter IV deals with the Preliminary Notification For Acquisition (Rule 20)

Chapter V deals with the Rehabilitation and Resettlement Scheme and matters relating thereto (Rules 21- 38)

Rule 40 empowers the government for removal of difficulties either in the interpretation of the provisions of the Rules and implementation of the provisions

This act is applicable for the proposed project as it involves land acquisition, demolition of properties thus affecting families which are adjacent to proposed alignment.

3.13 Karnataka Industrial Area Development Board Act

The project will adopt the KIADB Act for implementation.

Salient Features of the Section 28 of KIADB Act

- If at any time, in the opinion of the State Government, any land is required for development by the Board, or for any other purpose in furtherance of the objects of this Act, the State Government may by notification, give notice of its intention to acquire such land.
- On publication of a notification under sub-section (1), the State Government shall serve notice upon the owner or where the owner is not the occupier, on the occupier of the land and on all such persons known or believed to be interested therein to show cause, within thirty days from the date of service of the notice, why the land should not be acquired.
- After considering the cause, if any, shown by the owner of the land and by any other person interested therein, and after giving such owner and person an opportunity of being heard, the State Government may pass such orders as it deems fit.
- After orders are passed under sub-section (3), where the State Government is satisfied that any land should be acquired for the purpose specified in the notification issued under sub-section (1), a declaration shall, by notification in the official Gazette, be made to that effect.
- On the publication in the official Gazette of the declaration under sub-section (4), the land shall vest absolutely in the State Government free from all encumbrances.
- Where any land is vested in the State Government under sub-section (5), the State Government may, by notice in writing, order any person who may be in possession of the land to surrender or deliver possession thereof to the State Government or any person duly authorized by it in this behalf within thirty days of the service of the notice.
- If any person refuses or fails to comply with an order made under sub-section (5), the State Government or any officer authorized by the State Government on it's behalf may take possession of the land, and may for that purpose use such force as may be necessary.

- Where the land has been acquired for the Board, the State Government, after it has taken possession of the land, may transfer the land to the Board for the purpose for which the land has been acquired.

Section 29 of KIADB Act - 2007 compensation

- Where any land is acquired by the State Government under this Chapter, the State Government shall pay for such acquisition compensation in accordance with the provisions of this Act.
- Where the amount of compensation has been determined by agreement between the State Government and the person to be compensated, it shall be paid in accordance with such agreement.
- Where no such agreement can be reached, the State Government shall refer the case to the Deputy Commissioner for determination of the amount of compensation to be paid for such acquisition as also the person or persons to whom such compensation shall be paid.
- On receipt of a reference under sub-section (3), the Deputy Commissioner shall serve notice on the owner or occupier of such land and on all persons known or believed to be interested herein to appear before him and state their respective interests in the said land

3.14 Clearances required for the project corridors

After reviewing various applicable acts and statutes mentioned above, it is understood that following clearances or permissions are required. A summary of clearances required for the project is shown in Table 3-1.

Table 3-1: List of Clearances Required for the Project Road

Sl. No.	Subject	Relevant Act	Authority Granting Clearance/ In charge	When required	Responsibility	Remarks
1	Environmental Clearance	EIA Notification, 2006 (including amendments) issued under Environment Protection Act, 1986	SEAC, GOK	Before Construction	Project Implementation Unit (PIU), KRDCL	Supported by EIA, EMP and Project Reports.
2	Consent / NOC for sub-projects	Air (Prevention and Control of Pollution) Act, 1974 Water (Prevention and control of Pollution) Act, 1981	KSPCB, Karnataka	Before Construction	PIU, KRDCL	Appropriate forms, (Form I & Form XIII) with requisite fees, to be completed
3	Permission for cutting, pruning and transportation of trees	Karnataka Tree Preservation Act, 1976 & Forest Conservation Act, 1980	State Forest Department, Govt of Karnataka	Before Construction	PIU, KRDCL	Exact number and location of trees to be furnished
4	Permission for construction of elevated corridor within protected area of protected Monuments and Heritage structures of Bangalore.	The Ancient Monuments and Archaeological Sites and Remains Act 1958 and subsequent amendments. listed in Revised Master Plan	National Monument Authority, GOI.	Before Construction	PIU, KRDCL	Appropriate forms, (Form VII with requisite Annexures, to be completed
5	No Objection Certificate (NOC) for Crushers, Batching Plants,	Air (Prevention and Control of Pollution) Act, 1981 and Noise Pollution (Regulation	KSPCB, Karnataka	During Construction	Contractor/Supplier	Appropriate forms, (Form I & Form XIII) with requisite fees, to be completed

Sl. No.	Subject	Relevant Act	Authority Granting Clearance/ In charge	When required	Responsibility	Remarks
	Wet Mix Macadam plants, Hot mix plants	and Control) Rules, 2000				
6	Storage, handling and transport of hazardous materials	Hazardous Waste (Management and Handling) Rules, 1989 and Manufacturing, Storage and Import of Hazardous Chemicals Rules, 1989	KSPCB, Karnataka	During Construction	Contractor	If bituminous is used for the pavement.
7	Traffic Management and Regulation during operation	Local Traffic Police instructions/Regulations	Bangalore Traffic Police	During Construction	Contractor	Prior permission from the Traffic Department
8	Installation of Generators	Air (Prevention and Control of Pollution) Act, 1974	KSPCB	Before Installation	Contractor	
9	License for storing Diesel/Fuel	Petroleum Rules, 2002 (Amended in the year 2011) of the Petroleum Act, 1934.	Commissioner of Explosives	During Construction	Contractor	
10	Location/ layout of workers camp, equipment and storage yards	Environment Protection Act, 1986 The Building and Other Constructions Workers' (Regulation of employment &	KSPCB, District Health Officer	During Construction	Contractor	

Sl. No.	Subject	Relevant Act	Authority Granting Clearance/ In charge	When required	Responsibility	Remarks
		Conditions of Service) Act, 1996. International Labour Organisation (ILO)				
11	Employing Labour/ workers	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	District Labor Commissioner	Before Construction	Contractor	
12	Permission for withdrawal of groundwater for construction	Environment (Protection) Act, 1986	Central Ground Water Board, Ahmedabad	During Construction	Contractor	
13	Rehabilitation & Resettlement of Displaced families	KIADB Act with compensation at par with RFCTLARRA 2013.	Gol	Before start of construction	PIU, KRDCL	The project will adopt the KIADB Act for acquisition and compensation will be paid at par with RFCTLARRA 2013

4. DESCRIPTION OF ENVIRONMENT

Assessment of the impacts of the proposed elevated corridor project is done after site visits undertaken by the consultants. An attempt has been made to understand the environmental profile of the project implementation area and baseline environmental condition of the study area with respect to physical and biological environment along the project corridor. The data presented on the base line environmental components in the vicinity of project corridor was collected through field inspection and secondary sources of information for the environmental attributes supplementing with relevant maps. Study area for baseline data is based on corridor of impact upto 100 M and corridor of influence upto 10 km from the elevated structure. Discussion on the environmental profile has been made considering the proposed alignment of the project corridors within the city of Bengaluru.

4.1 Location:

Bengaluru (Urban) District is located (Figure 1-1) in the south eastern portion of Karnataka State with geographical area of nearly 2190 sq. km. It is bounded by Bengaluru (Rural) district on the south-western, western, northern and north-eastern sides and bordered by Tamil Nadu State on the south-eastern direction. District lies between 12° 39' to 13° 14' N Latitude and 77° 19' to 77° 51' E Longitude. Greater Bengaluru is a metropolitan area consisting of the metropolis of Bengaluru and its neighbouring regions. In January 2007, the Karnataka Government issued a notification to merge 100 wards of the erstwhile Bengaluru Mahanagara Palike with seven City Municipal Councils (CMC)s, one Town Municipal Council (TMC) and 111 villages around the city to form a single administrative area. Administrative map of Bengaluru Urban district is presented in Figure 1-5.

Proposed elevated project corridors are located within Bangalore city. The alignment of each corridor is explained in the paragraphs below.

The North - South Corridor - starts from Baptist Hospital along Airport Road and ends at Silk Board flyover via Mekhri circle - Jayamahall Main Road - Queen's Road-Indian Express Junction - Infantry Road Junction - Minsk Square - Kasturba Road - Hudson Circle - Audugodi - Audugodi main road & Silk Board .

East - West Corridor - 1 (EW - 1): starts at Batrahalli on Old Madras Road and ends at Gorguntapalya junction on Tumkur road via. Devasandra Main Road - Ramamurthy Nagar Main Road Junction (ITI) – KR Puram cable stayed bridge - Suranjandas Road Junction - 80 Feet Road junction - 100 feet Indiranagar road Junction - D Bhaskaran Road Junction - Kensington Road Junction (Philips buildings) – Ulsoor lake - St. John's Road – Millars road - Jayamahall Main Road – Mekri circle - CV Raman road – Yeswanthapur flyover - Yeshwanthpur Railway Station - Outer Ring Road junction (CMTI).

East - West Corridor - 2 (EW - 2): The corridor takes off at Varthur kodi junction on SH-35 – ends at NICE link road on Mysore road via. Kundala halli gate junction – Marathahalli underpass - Suranjandas Road Junction - Old Airport road – Wind tunnel road junction - Domlur Junction - Trinity Church Junction - D'Souza circle - General K S Thimayya Road - Vellara Junction - Richmond Circle – K H Road - Lalbagh Main Road – Minerva junction - Chamarajpet 5th Main Road - 9th Cross Road - 1st Main Road Junction - Alur Venkata Rao

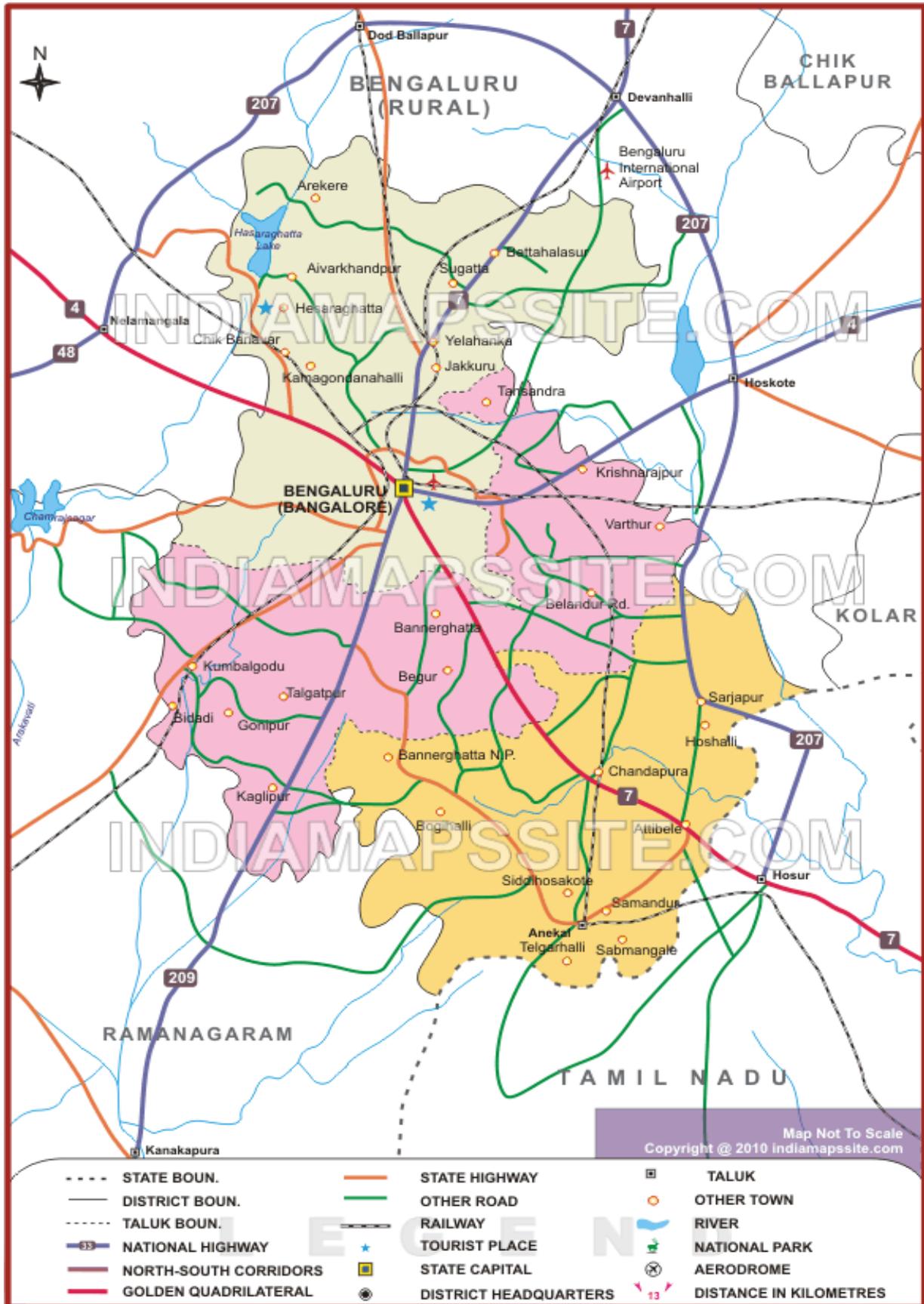
Road - Sirsi Circle - Satellite Bus Station - Bapuji Nagar - Deepanjali Nagar, -Nayandahalli Junction - Rajarajeshwari Nagar Gate.

Connecting Corridor - 1 (CC-1): This corridor creates connectivity between North-South corridor and Sarjapura road, corridor starts at Sarjapur bridge at Agara and traverses via Jakkasandra - Madiwala Market Junction - Koramangala 100 Feet Road Junction

Connecting Corridor - 2 (CC-2): This corridor creates connectivity between East-West Corridor-1 and East-West Corridor-2, corridor starts from D'souza circle on Richmond road Junction and ends at Ulsoor Lake via General KS Thimmaiah Road - Trinity Junction & Ulsoor Lake Junction (connecting East West Corridor-1)

Connecting Corridor-3 (CC-3): This corridor starts from St. Johns Church Road Junction (East-West Corridor 1) and ends at Kalyan Nagar at Outer Ring Road via. Wheeler Road - ITC factory – Sevanagar - Banaswadi Main road.

Figure 4-1: Administrative map of Bengaluru Urban district



4.2 Physiography

Physiographically, Bengaluru Urban district can be divided into rocky upland, plateau & flat topped hills at a general elevation of about 900 amsl (above mean sea level) with its major part sloping towards south and south-east forming pediplains interspersed with hills all along the western part. The pediplains form the major part of the district underlain by granites and gneisses with the highest elevation of 839 to 962 m. amsl. Major part of the pediplain constitute low relief area having matured dissected rolling topography with erosional land slope covered by a layer of red loamy soil of varied thickness. Major part of the pediplains is dissected by streamlets flowing in southern direction.

4.3 Topography

Bengaluru lies on top of south Karnataka Plateau (Mysore Plateau) and has two types of unique topographies. The North Bengaluru taluk is a relatively more level plateau and lies between an average of 839 to 962 meters above mean sea level. Prominent ridge runs in the middle of taluk in NNE-SSW direction and lies east of the Vrishabhavathi River. The highest point in the city, Doddabettahalli, (954 m above Mean Sea Level) is on this ridge. There are gentle slopes and valleys on either side of this ridge. The low-lying area is marked by a series of water tanks varying in size from a small pond to those of considerable extent, but all fairly shallow. The South Bengaluru taluk has an uneven landscape with a combination of hills and valleys. The southern and western portions of the city consist of granite and gneissic masses. The eastern portion is a plane, with intermittent minor undulations.

4.4 Climate

Bengaluru has a tropical Savanna climate (Koppen climate classification Aw) with distinct wet and dry seasons. Due to its elevation, Bengaluru enjoys a pleasant and equable climate throughout the year. The highest temperature recorded was 39.2 °C on 24 April 2016 and the lowest was 7.8 °C in 1884. Winter temperatures rarely drop below 14 °C and summer temperatures seldom exceed 36 °C.

Rainfall - Bengaluru receives about 970 mm of rain annually, the wettest months being August, September, and October. The heaviest rainfall recorded in a 24-hour period was 159.7 mm recorded on 1 October 1997. November 2015 (290.4 mm) was recorded as one of the wettest months in Bengaluru with heavy rains causing severe flooding in some areas.

Data on rainfall for Bangalore urban district is given in the following Figure and the Table

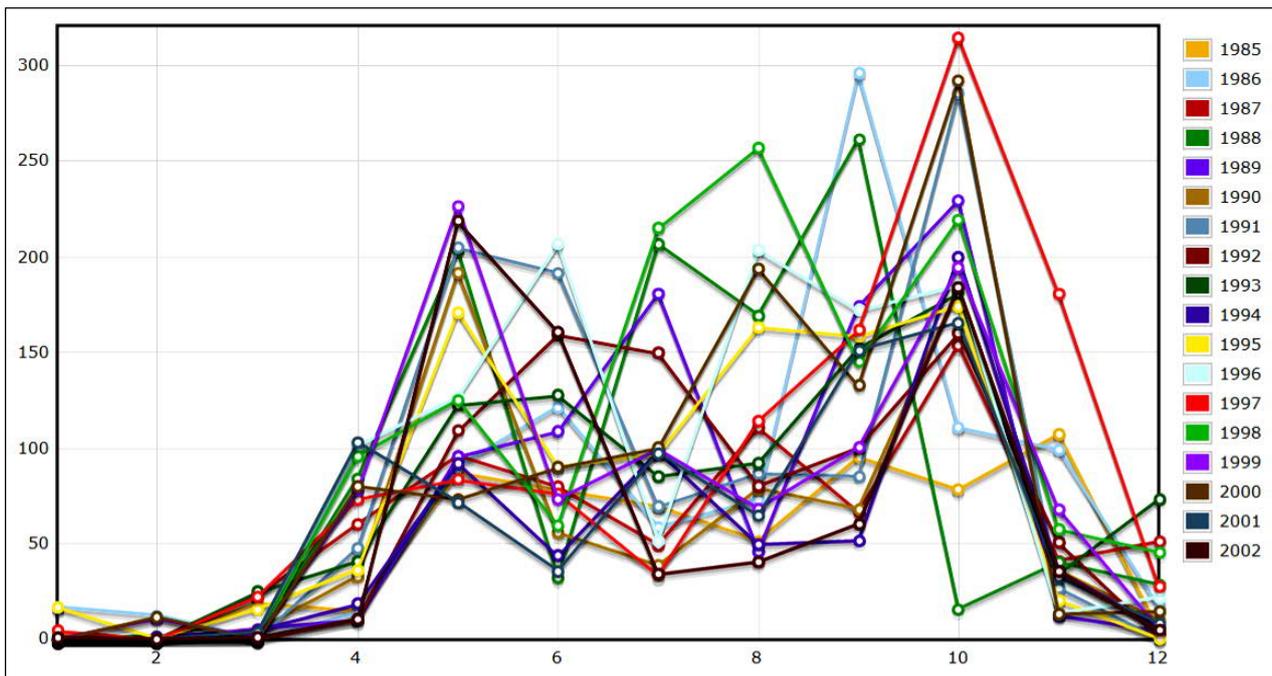


Figure 4-2: Graphical representation of variation in rainfall through 1985 to 2002 (Bengaluru Urban district)

Table 4-1: Month wise rainfall and Annual total rainfall data for Bangalore urban district

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Rainfall (in mm)
1985	2.96	0.09	18.42	14.41	86.58	77.57	69.11	51.41	94.86	77.87	106.82	4.58	604.69
1986	16.72	12.42	0.26	13.45	90.12	121.30	58.53	72.59	295.45	110.34	98.76	16.81	906.76
1987	0.20	0.00	22.42	60.15	95.83	79.41	49.26	110.25	66.28	153.86	40.91	50.75	729.31
1988	0.00	1.54	0.43	84.22	202.75	32.38	206.16	169.13	261.10	15.69	39.93	28.42	1041.76
1989	0.06	0.00	5.49	9.87	95.21	108.34	180.46	45.99	173.79	229.16	12.12	4.15	864.63
1990	0.98	0.19	4.55	32.72	191.15	55.36	38.32	78.44	68.04	183.54	35.81	9.38	698.49
1991	0.03	0.02	0.26	47.80	204.38	191.57	69.05	86.44	85.20	285.12	26.57	0.32	996.75
1992	0.07	0.00	0.00	10.61	108.71	159.07	149.41	80.33	100.15	159.65	50.40	1.04	819.44
1993	0.00	0.02	24.73	40.83	122.39	127.30	85.22	92.28	152.13	180.65	34.26	73.32	933.13
1994	0.43	1.41	4.87	18.34	92.14	43.56	98.22	49.76	51.71	199.81	35.93	6.67	602.85
1995	16.37	0.10	15.62	36.34	170.96	90.00	96.59	162.77	158.10	174.22	19.97	0.25	941.28
1996	0.03	0.04	0.70	101.24	126.53	206.44	51.53	203.06	171.74	184.89	13.34	21.87	1081.41
1997	4.44	0.00	22.58	73.29	83.37	76.10	33.48	114.25	161.38	314.38	180.44	27.50	1091.20
1998	0.03	0.18	0.19	95.81	125.06	59.41	214.57	256.60	144.88	219.25	57.15	45.44	1218.56
1999	0.04	10.57	0.56	77.58	226.05	73.12	99.26	68.21	100.09	194.14	67.57	5.65	922.83
2000	0.04	11.83	0.07	80.11	73.29	89.69	99.86	193.46	132.48	291.84	13.41	14.70	1000.77
2001	0.46	0.12	3.65	102.72	71.60	35.69	97.21	64.21	150.75	165.14	32.04	8.25	731.83
2002	0.61	0.12	0.71	10.39	218.10	160.31	33.81	40.27	60.21	183.97	35.17	4.54	748.19
2004	5.40	1.20	5.50	47.50	205.30	75.70	210.40	65.20	186.90	197.30	25.70	0.00	1026.10
2005	1.60	4.40	13.40	75.10	115.70	127.90	136.40	194.00	173.50	446.00	56.50	6.30	1350.80



Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Rainfall (in mm)
2006	0.30	0.00	62.70	25.20	133.90	190.50	53.60	44.20	31.50	48.90	48.00	0.30	639.10
2007	0.00	0.20	0.00	104.90	79.50	57.20	154.00	146.50	223.70	163.00	21.10	34.50	984.60
2008	0.10	9.90	115.40	30.40	87.10	59.20	182.50	247.40	105.60	210.90	47.60	0.30	1096.40
2009	0.10	0.00	15.20	63.90	123.80	125.40	30.20	162.20	335.30	35.20	66.80	17.50	975.60
2010	5.40	0.00	17.40	97.50	123.90	67.30	112.30	121.10	149.90	95.80	166.80	2.70	960.10

Source: http://www.indiawaterportal.org/met_data/

Humidity - The average annual relative humidity in Bengaluru is 65.2% and average monthly relative humidity ranges from 45% in March to 79% in August. On an average, July is the most humid and January is the least humid month.

Temperature - The coolest month in Bengaluru is January with an average low temperature of 15.1 °C and the hottest month is April with an average high temperature of 35 °C. The highest temperature ever recorded in Bengaluru is 39.2 °C as there was a strong El Nino in 2016, The lowest ever recorded is 7.8 °C in January 1884. Winter temperatures rarely drop below 14 °C and summer temperatures seldom exceed 36 °C.

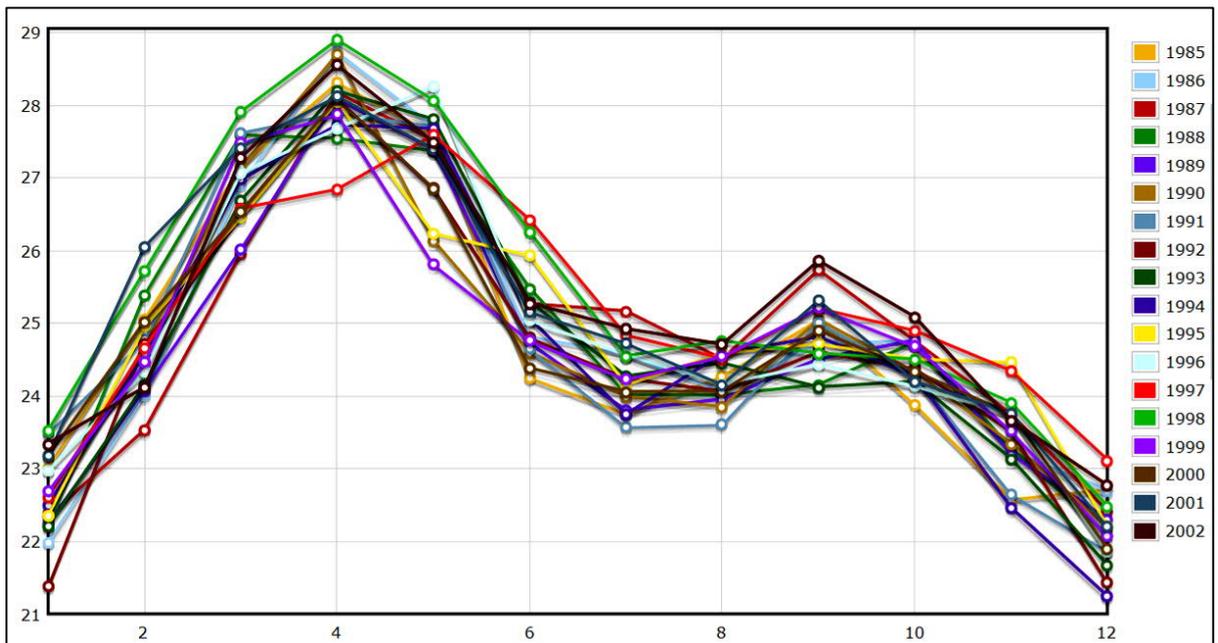


Figure 4-3: Graphical representation of variation in monthly average temperature from 1985 to 2002 (Bengaluru Urban district)

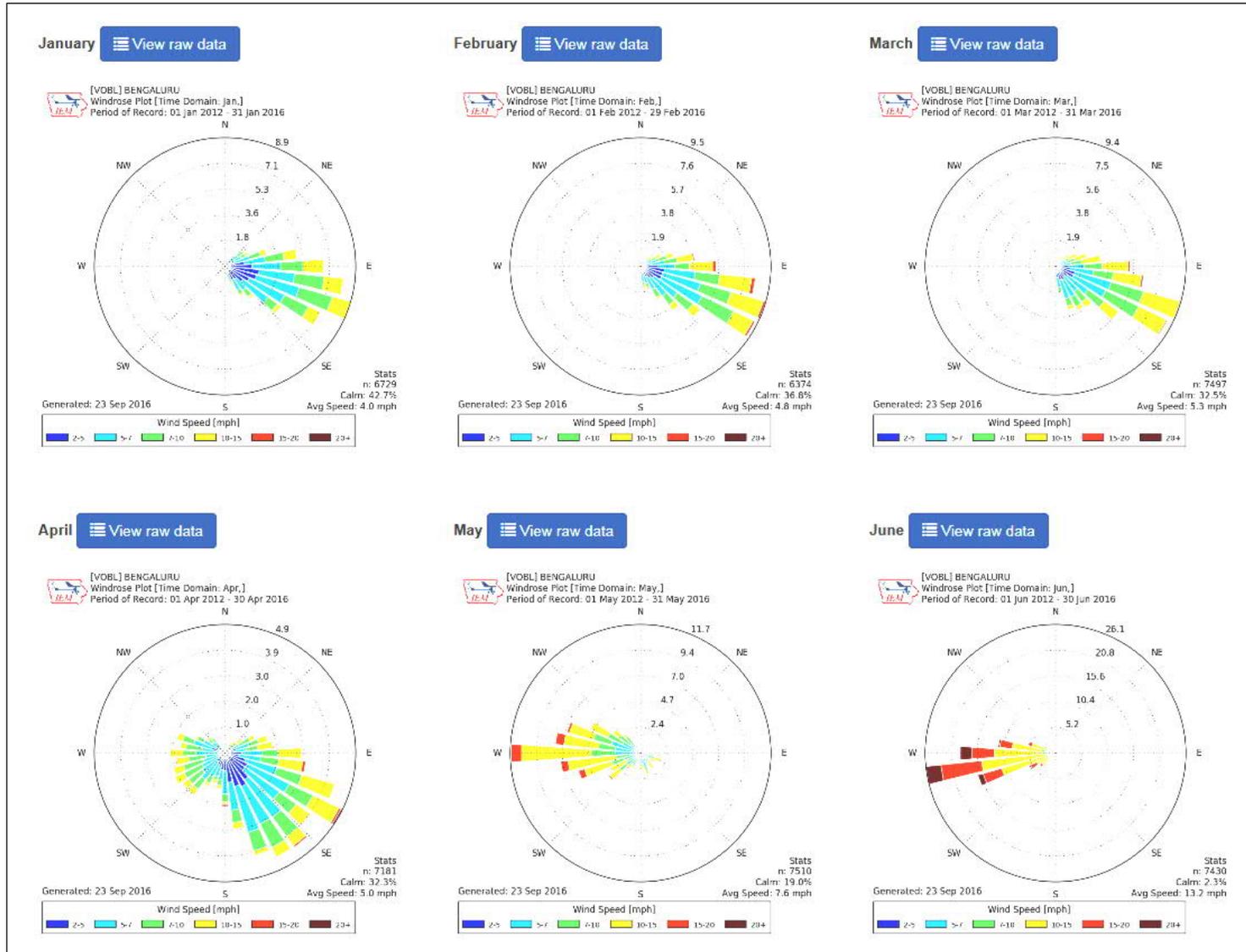
Table 4-2: Month wise annual average temperature data for Bangalore urban district

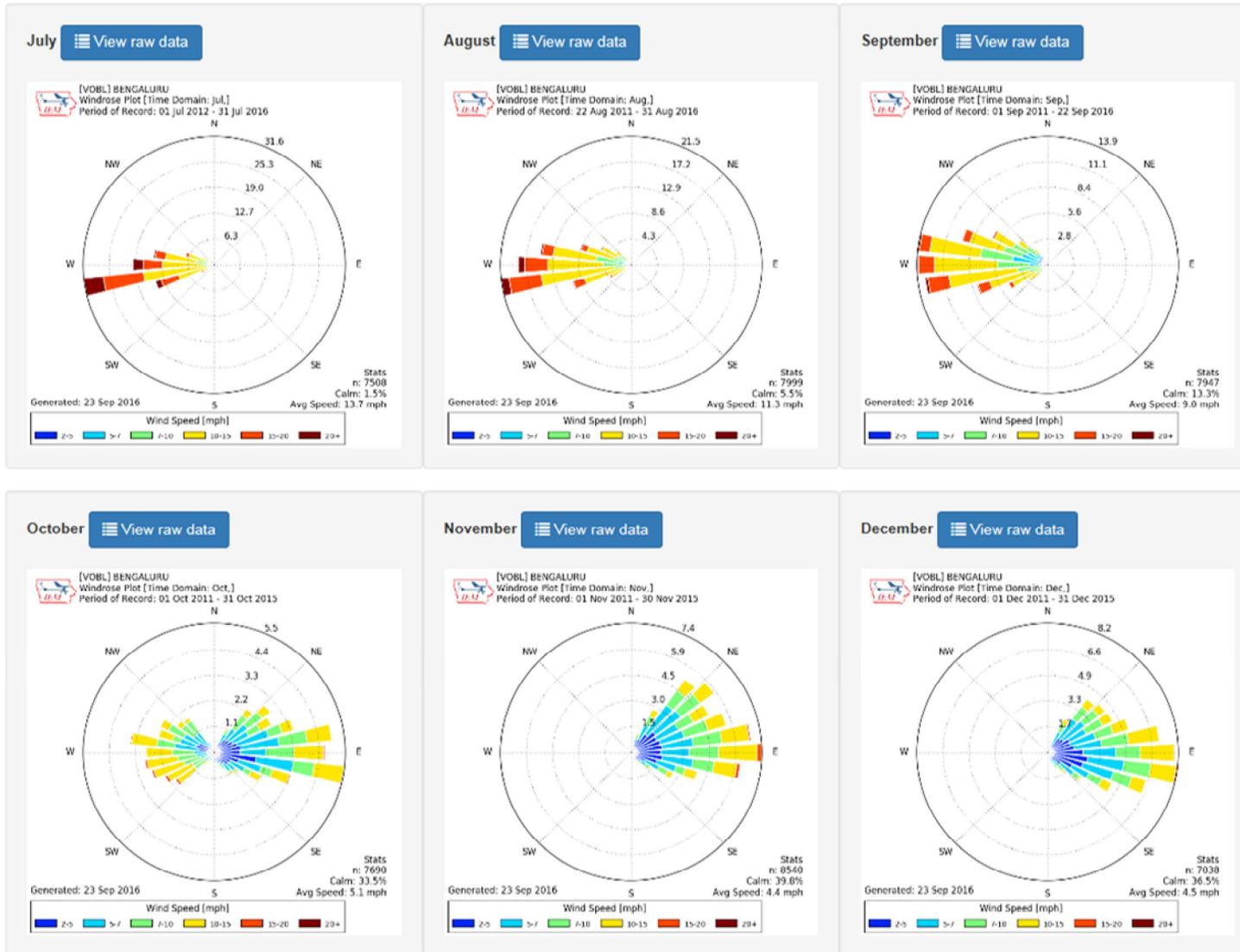
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average Temperature (°Celsius)
1985	23.02	25.07	27.18	28.32	27.62	24.26	23.76	24.28	25.06	23.88	22.58	22.72	24.81
1986	21.99	24.02	26.91	28.74	27.71	24.82	24.58	24.05	24.73	24.76	23.24	22.71	24.85
1987	22.34	23.54	25.96	28.18	27.53	25.28	25.17	24.51	25.74	24.76	23.75	22.42	24.93

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average Temperature (°Celsius)
1988	22.21	25.39	27.60	27.55	27.38	25.49	24.02	24.01	24.16	24.74	23.29	22.09	24.83
1989	22.25	24.09	26.02	28.09	27.40	24.72	23.81	23.96	24.51	24.77	23.20	22.31	24.59
1990	22.40	24.70	27.15	28.71	26.14	24.60	23.99	23.85	25.06	24.33	23.35	22.20	24.71
1991	23.50	24.78	27.64	27.91	27.73	24.66	23.58	23.62	25.02	24.29	22.66	21.87	24.77
1992	21.39	24.74	26.48	28.10	26.87	24.81	24.26	24.09	24.63	24.39	23.54	21.44	24.56
1993	22.22	24.16	26.69	28.20	27.82	25.30	24.28	24.46	24.13	24.20	23.14	21.67	24.69
1994	22.50	24.59	26.98	27.74	27.69	25.07	23.75	24.59	24.82	24.27	22.47	21.25	24.64
1995	22.37	24.98	26.47	28.07	26.25	25.95	24.17	24.61	24.73	24.52	24.48	22.23	24.90
1996	22.98	24.35	27.08	27.69	28.27	25.05	24.58	24.17	24.44	24.14	23.75	21.86	24.86
1997	22.61	24.66	26.58	26.85	27.60	26.43	24.84	24.52	25.21	24.90	24.35	23.12	25.14
1998	23.53	25.72	27.92	28.91	28.08	26.26	24.55	24.76	24.59	24.51	23.91	22.48	25.43
1999	22.71	24.47	27.49	27.89	25.82	24.77	24.24	24.56	25.22	24.70	23.53	22.09	24.79
2000	23.17	25.03	26.54	28.09	26.86	24.39	24.06	24.07	24.91	24.34	23.75	21.90	24.76
2001	23.20	26.06	27.43	28.13	27.40	25.16	24.73	24.16	25.32	24.21	23.77	22.21	25.15
2002	23.35	24.13	27.28	28.56	27.50	25.29	24.93	24.72	25.87	25.09	23.67	22.78	25.26



Figure 4-4: Monthly Climatology of Bengaluru





Source: http://mesonet.agron.iastate.edu/sites/windrose.phtml?station=VOBL&network=IN__ASOS

Baseline air quality data was collected for three months from November 2018 to January 2019 at various identified representative locations. Noise levels, water quality and soil quality were analysed for representative locations in the project area.

4.5 Ambient Air Quality

The air quality was monitored at 10 locations along the study area to assess the baseline ambient air status of the area, and also to check its conformity with the ambient air quality standards specified by Central Pollution Control Board (CPCB). The monitoring locations were selected based on the potential sensitive receptors, predominant wind direction and topography of the study area. Other factors considered while selection of the monitoring stations includes representative nature of the sample; accessibility; availability of power.

Ambient Air Quality Monitoring (AAQM) stations were set up at 10 locations with due consideration to the above mentioned points. Ambient Air Quality Monitoring Locations are shown in Figure 4-5 and details of the monitoring stations are given in Table 4-3.

Table 4-3: Details of Ambient Air Monitoring Stations

Location Code	Air & Noise Sampling Locations
A-1	Mekhri Circle
A-2	Wheeler Road Junction
A-3	ITI Campus Junction along NH4
A-4	Indian Express
A-5	Lifestyle Junction, Richmond Road
A-6	Domlur SAARC Park
A-7	Marathhalli Junction
A-8	St John Medical College & Hospital
A-9	Minerva Circle (Bangalore Medical College)
A-10	Deepanjalinagar, Mysore Road

The sampling and analysis of ambient air quality parameters was carried out as per the procedures detailed in relevant Parts of IS-5182 (Indian Standards for Ambient Air Quality Parameters). The applied testing procedures are given in brief in Table 4-4.

Table 4-4: Details of Ambient Air Monitoring Stations

Parameter	Method/ Protocol Followed	Analysis Procedure
PM ₁₀	IS-5182 (Pt-23)	- Sample collection for PM-10 with fine dust sampler NPM-FDS 2.5A without PM-2.5 inlet.
PM _{2.5}	IS-5182 (Pt-23)	- Sample collection for PM-2.5 with fine dust sampler NPM-FDS 2.5A with impactor. - Analysis by gravimetric method.
SO ₂	IS:5182 (Pt.-2)	- Sample collection in multi-gas sampler, absorption in Potassium tetrachloromercurate solution. - The absorbance of the intensely colored para-rosaniline methyl sulphonic acid was measured and the amount of SO ₂ in the sample was computed.
NO _x	IS:5182 (Pt.-)	- Sample collection carried out through orifice-tipped Impinger



Parameter	Method/ Protocol Followed	Analysis Procedure
	6)	containing solutions of sodium hydroxide and sodium arsenite. - The ambient NO _x concentrations were computed from the total nitrite ion present in the impingers, overall efficiency of the Impinger and the procedure, and the volume of air sampled.
CO	IS:5182 (Pt.10)	- Collection of air in rubber bladder and aspirator. - Analysis by electrochemical sensor

Figure 4-5: Air and Noise Sampling Locations

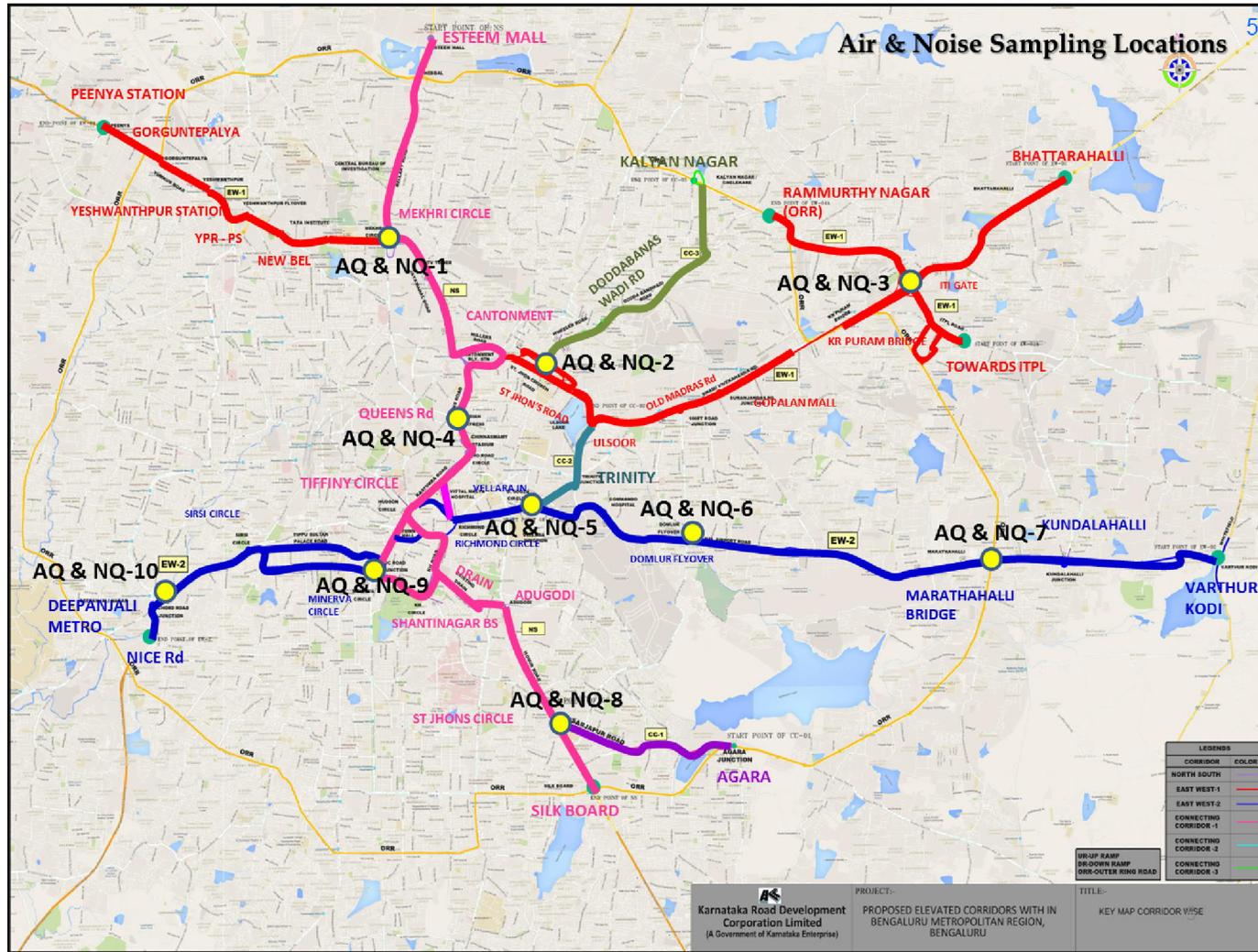


Table 4-5: Ambient Air Quality at Mekhri Circle

A1 - Mekhri Circle							
November 2018							
Dates	Sample No	PM ₁₀ , µg/ m ³	PM _{2.5} , µg/ m ³	SO ₂ , µg/ m ³	NO ₂ , µg/ m ³	CO, mg/ m ³	Pb, µg/ m ³
NAAQ Standards		100	60	80	80	4	1
05-11-2018	I	96.7	39.2	7.32	30.18	0.97	0.082
08-11-2018	II	97.2	52.2	6.96	27.82	0.95	0.044
14-11-2018	III	101.6	53.1	7.72	29.21	0.91	0.041
17-11-2018	IV	95.8	45.8	7.91	27.86	0.98	0.092
20-11-2018	V	93.6	53.6	8.11	28.89	0.86	0.105
23-11-2018	VI	99.4	46.6	8.43	28.29	1.07	0.117
26-11-2018	VII	97.7	52.3	8.01	28.24	0.079	0.990
29-11-2018	VIII	104.7	48.8	7.77	27.70	0.056	1.020
December 2018							
03-12-2018	I	100.6	44.4	7.68	28.54	1.00	0.043
7-12-2018	II	99.7	44.7	8.48	27.96	0.93	0.063
11-12-2018	III	98.1	49.6	7.27	29.56	0.91	0.090
14-11-2018	IV	103.4	50.5	8.07	28.08	0.98	0.071
17-12-2018	V	101.3	43.2	7.89	28.37	0.86	0.030
21-12-2018	VI	98.9	50.9	8.69	28.75	1.07	0.063
24-12-2018	VII	97.1	43.9	7.45	27.68	0.95	0.039
28-12-2018	VIII	102.6	50.1	8.25	28.18	1.02	0.044
January 2019							
01-01-2019	I	99.5	36.6	6.34	27.61	0.81	0.078
04-01-2019	II	101.5	35.1	8.11	29.24	0.90	0.101
07-01-2019	III	97.3	38.4	6.50	31.24	0.84	0.083
10-01-2019	IV	98.2	40.2	6.86	30.79	0.75	0.090
16-01-2019	V	102.1	37.9	7.53	32.15	0.80	0.074
19-01-2019	VI	100.7	41.2	8.34	28.59	0.96	0.105
21-01-2019	VII	99.8	43.6	7.98	28.08	0.82	0.137
25-01-2019	VIII	92.8	44.2	7.67	27.62	0.68	0.079

NAAQS: National Ambient Air Quality Standards

Table 4-6: Ambient Air Quality at Wheeler Road Junction (Opp to HQ MEG Centre)

A2 - Wheeler Road Junction(Opp to HQ MEG Centre)							
November 2018							
Dates	Sample No	PM ₁₀ , µg/ m ³	PM _{2.5} , µg/ m ³	SO ₂ , µg/ m ³	NO ₂ , µg/ m ³	CO, µg/ m ³	Pb, µg/ m ³
NAAQ Standards		100	60	80	80	4	1
11-05-2018	I	90.3	43.3	7.15	27.26	0.42	0.091
11-08-2018	II	91.5	41.1	6.79	28.12	0.42	0.042
14-11-2018	III	88.5	44.7	7.55	28.44	0.35	0.018
17-11-2018	IV	91.9	43.5	7.35	26.76	0.6	0.116
20-11-2018	V	85.9	42.5	7.94	27.97	0.3	0.111
23-11-2018	VI	94.1	45.4	7.75	27.37	0.64	0.157
26-11-2018	VII	82.6	41.9	7.90	26.02	0.043	0.41
29-11-2018	VIII	89.4	42.8	7.19	27.78	0.016	0.47
December 2018							
03-12-2018	I	91.1	44.3	7.51	27.62	0.44	0.021
07-12-2018	II	88.0	44.6	7.80	26.86	0.37	0.018
11-12-2018	III	90.5	40.3	7.10	28.46	0.35	0.073
14-12-2018	IV	87.4	41.2	7.39	26.98	0.42	0.062
17-12-2018	V	91.3	43.1	7.72	27.45	0.30	0.029
21-12-2018	VI	88.2	41.6	8.01	27.83	0.51	0.037
24-12-2018	VII	90.7	43.8	7.28	26.58	0.39	0.022
28-12-2018	VIII	87.6	40.8	7.57	27.26	0.46	0.011
January 2019							
01-01-2019	I	89.8	32.9	8.21	33.43	0.41	0.082
04-01-2019	II	90.8	26.4	8.73	34.63	0.48	0.102
07-01-2019	III	95.4	39.5	8.06	37.81	0.52	0.026
10-01-2019	IV	83.4	36.4	8.56	38.36	0.51	0.076
16-01-2019	V	87.6	28.8	9.23	39.72	0.50	0.02
19-01-2019	VI	89.6	39.00	8.96	36.98	0.58	0.095
21-01-2019	VII	81.9	35.80	8.57	35.90	0.57	0.127
25-01-2019	VIII	87.5	38.90	8.33	35.44	0.44	0.047

Table 4-7: Ambient Air Quality at ITI Campus Junction along NH4

A3 - ITI Campus Junction along NH4							
November 2018							
Dates	Sample No	PM ₁₀ , µg/ m ³	PM _{2.5} , µg/ m ³	SO ₂ , µg/ m ³	NO ₂ , µg/ m ³	CO, µg/ m ³	Pb, µg/ m ³
NAAQ Standards		100	60	80	80	4	1
05-11-2018	I	88.6	37.2	5.98	27.04	0.03	0.053
08-11-2018	II	85.2	32.5	5.62	26.68	0.36	0.037
14-11-2018	III	90.1	33.9	6.38	27.67	0.27	0.065
17-11-2018	IV	93.7	36.6	6.49	26.32	0.32	0.174
20-11-2018	V	88.1	35.5	6.77	27.05	0.21	0.189
23-11-2018	VI	89.5	40.7	7.70	27.15	0.45	0.082
26-11-2018	VII	95.0	34.8	6.67	26.70	0.051	0.30
29-11-2018	VIII	96.8	39.6	6.41	26.57	0.094	0.39
December 2018							
03-12-2018	I	85.4	39.7	6.34	27.40	0.35	0.102
07-12-2018	II	90.7	40.0	7.12	26.42	0.27	0.027
11-12-2018	III	88.6	34.9	5.93	28.02	0.26	0.060
14-12-2018	IV	89.1	35.8	6.71	26.54	0.32	0.051
17-12-2018	V	92.4	38.5	6.55	27.23	0.21	0.053
21-12-2018	VI	91.1	36.2	7.33	27.61	0.41	0.043
24-12-2018	VII	89.7	39.2	6.11	26.14	0.30	0.070
28-12-2018	VIII	91.7	35.4	6.89	27.04	0.36	0.084
January 2019							
01-01-2019	I	85.8	40.1	7.59	26.28	0.39	0.186
04-01-2019	II	86.6	28.2	8.16	25.43	0.40	0.324
07-01-2019	III	88.9	33.2	7.85	26.74	0.45	0.138
10-01-2019	IV	82.1	30.5	8.02	27.29	0.37	0.126
16-01-2019	V	90.3	34.4	8.69	28.65	0.28	0.125
19-01-2019	VI	86.3	32.60	8.39	24.78	0.36	0.177
21-01-2019	VII	80.6	29.90	8.00	26.75	0.49	0.209
25-01-2019	VIII	83.4	30.40	7.69	26.29	0.35	0.301

Table 4-8: Ambient Air Quality at Indian Express

A4 - Indian Express							
November 2018							
Dates	Sample No	PM ₁₀ , µg/ m ³	PM _{2.5} , µg/ m ³	SO ₂ , µg/ m ³	NO ₂ , µg/ m ³	CO, µg/ m ³	Pb, µg/ m ³
NAAQ Standards		100	60	80	80	4	1
05-11-2018	I	94.2	38.5	5.84	26.45	0.56	0.125
08-11-2018	II	89.6	35.4	6.48	26.09	0.52	0.024
14-11-2018	III	93.8	36.9	6.24	27.18	0.44	0.035
17-11-2018	IV	95.5	39.1	6.10	25.83	0.49	0.096
20-11-2018	V	92.9	34.6	6.93	28.16	0.4	0.097
23-11-2018	VI	102.3	41.6	6.30	26.56	0.58	0.135
26-11-2018	VII	92.6	32.9	6.53	25.09	0.075	0.49
29-11-2018	VIII	99.6	37.7	7.64	28.97	0.219	0.52
December 2018							
03-12-2018	I	92.6	37.8	6.20	26.81	0.50	0.036
07-12-2018	II	89.7	38.1	6.35	25.93	0.43	0.032
11-12-2018	III	90.9	33.9	5.79	27.53	0.41	0.073
14-12-2018	IV	91.8	34.8	5.94	26.05	0.48	0.030
17-12-2018	V	93.4	36.6	6.41	26.64	0.47	0.019
21-12-2018	VI	94.5	35.2	6.56	27.02	0.57	0.031
24-12-2018	VII	91.0	37.3	5.97	25.65	0.45	0.026
28-12-2018	VIII	90.3	34.4	6.12	26.45	0.52	0.023
January 2019							
01-01-2019	I	88.3	37.3	6.97	27.37	0.43	0.088
04-01-2019	II	93.5	38.9	7.54	30.36	0.56	0.081
07-01-2019	III	115.7	35.5	7.95	34.09	0.60	0.072
10-01-2019	IV	103.9	33.7	7.83	35.04	0.63	0.073
16-01-2019	V	98.4	41.3	8.50	36.40	0.49	0.044
19-01-2019	VI	100.4	34.90	6.77	29.71	0.51	0.096
21-01-2019	VII	97.7	30.10	7.38	27.84	0.63	0.103
25-01-2019	VIII	102.4	34.60	7.07	27.38	0.53	0.087

Table 4-9: Ambient Air Quality at Lifestyle Junction, Richmond Road

A5 - Life Style Junction on Richmond Road							
November 2018							
Dates	Sample No	PM ₁₀ , µg/ m ³	PM _{2.5} , µg/ m ³	SO ₂ , µg/ m ³	NO ₂ , µg/ m ³	CO, µg/ m ³	Pb, µg/ m ³
NAAQ Standards		100	60	80	80	4	1
05-11-2018	I	102.6	53.9	6.91	23.79	0.51	0.077
08-11-2018	II	96.1	43.7	6.55	23.43	0.5	0.059
14-11-2018	III	94.4	45.3	7.31	26.5	0.55	0.124
17-11-2018	IV	95.6	47.6	7.52	25.15	0.61	0.145
20-11-2018	V	100.9	46.7	7.70	24.5	0.4	0.128
23-11-2018	VI	93.3	44.3	8.14	23.9	0.70	0.093
26-11-2018	VII	95.2	41.5	7.60	25.53	0.067	0.48
29-11-2018	VIII	96.3	47.7	7.38	27.31	0.186	0.65
December 2018							
03-12-2018	I	90.6	46.2	7.27	24.15	0.56	0.074
07-12-2018	II	91.5	46.5	8.09	25.25	0.56	0.034
11-12-2018	III	95.9	42.6	6.86	26.85	0.47	0.056
14-12-2018	IV	93.4	43.5	7.68	25.37	0.61	0.043
17-12-2018	V	94.8	45.0	7.48	23.98	0.42	0.047
21-12-2018	VI	92.2	43.9	8.30	24.36	0.70	0.054
24-12-2018	VII	92.6	45.7	7.04	24.97	0.51	0.096
28-12-2018	VIII	94.5	43.1	7.86	23.79	0.65	0.028
January 2019							
01-01-2019	I	94.0	45.4	7.12	21.48	0.57	0.137
04-01-2019	II	122.7	40.6	8.22	24.55	0.66	0.105
07-01-2019	III	109.7	38.1	9.10	23.78	0.70	0.080
10-01-2019	IV	116.4	44.5	9.22	26.13	0.69	0.068
16-01-2019	V	102.8	43.0	9.89	27.49	0.45	0.075
19-01-2019	VI	98.7	37.60	8.49	23.90	0.77	0.02
21-01-2019	VII	97.0	43.90	8.10	21.95	0.59	0.098
25-01-2019	VIII	99.9	41.50	7.79	29.49	0.55	0.081

Table 4-10: Ambient Air Quality at Domlur SAARC Park

A-6 Domlur SAARC Park							
November 2018							
Dates	Sample No	PM ₁₀ , µg/ m ³	PM _{2.5} , µg/ m ³	SO ₂ , µg/ m ³	NO ₂ , µg/ m ³	CO, µg/ m ³	Pb, µg/ m ³
NAAQ Standards		100	60	80	80	4	1
05-11-2018	I	91.2	40.2	6.39	28.61	0.62	0.068
08-11-2018	II	98.7	47.9	6.03	28.25	0.26	0.098
14-11-2018	III	96.4	46.5	6.81	28.69	0.47	0.115
17-11-2018	IV	94.7	43.8	6.87	27.34	0.38	0.131
20-11-2018	V	95.7	48.4	7.18	29.37	0.31	0.165
23-11-2018	VI	97.8	42.1	7.07	28.72	0.48	0.087
26-11-2018	VII	96.5	45.9	7.08	26.60	0.107	0.43
29-11-2018	VIII	97.5	36.8	7.25	28.13	0.212	0.40
December 2018							
03-12-2018	I	84.0	43.4	6.75	28.97	0.52	0.097
07-12-2018	II	82.3	43.7	7.12	27.44	0.31	0.047
11-12-2018	III	80.9	44.3	6.34	29.04	0.43	0.121
14-12-2018	IV	81.7	45.2	6.71	27.56	0.36	0.088
17-12-2018	V	84.8	42.2	6.96	28.80	0.38	0.149
21-12-2018	VI	82.9	45.6	7.33	29.18	0.45	0.104
24-12-2018	VII	83.6	42.9	6.52	27.16	0.47	0.139
28-12-2018	VIII	81.9	44.8	6.89	28.61	0.40	0.083
January 2019							
01-01-2019	I	107.2	44.6	7.43	26.98	0.49	0.122
04-01-2019	II	112.7	47.8	7.91	23.56	0.50	0.141
07-01-2019	III	91.0	35.0	7.74	24.22	0.47	0.104
10-01-2019	IV	94.7	26.7	7.56	25.77	0.42	0.093
16-01-2019	V	83.6	39.8	8.43	27.13	0.41	0.076
19-01-2019	VI	97.1	33.50	8.13	22.91	0.54	0.095
21-01-2019	VII	93.9	26.10	7.75	27.45	0.46	0.101
25-01-2019	VIII	86.9	26.60	7.44	25.99	0.38	0.097

Table 4-11: Ambient Air Quality at Marathalli Junction

A-7 Marathalli Junction							
November 2018							
Dates	Sample No	PM ₁₀ , µg/ m ³	PM _{2.5} , µg/ m ³	SO ₂ , µg/ m ³	NO ₂ , µg/ m ³	CO, µg/ m ³	Pb, µg/ m ³
NAAQ Standards		100	60	80	80	4	1
05-11-2018	I	95.3	47.2	6.63	26.55	0.79	0.054
08-11-2018	II	89.7	39.7	6.27	26.33	0.7	0.112
14-11-2018	III	92.1	40.3	7.03	28.59	0.73	0.127
17-11-2018	IV	90.5	41.8	6.78	27.24	0.68	0.114
20-11-2018	V	94.3	37.4	7.42	27.71	0.69	0.156
23-11-2018	VI	91.7	39.4	7.43	26.27	0.77	0.149
26-11-2018	VII	98.9	38.6	7.44	27.62	0.119	0.71
29-11-2018	VIII	91.6	41.4	6.64	26.07	0.164	0.72
December 2018							
03-12-2018	I	89.7	41.1	6.99	26.91	0.82	0.062
07-12-2018	II	92.1	41.4	7.35	27.34	0.63	0.080
11-12-2018	III	89.1	37.2	6.58	28.94	0.73	0.137
14-12-2018	IV	91.5	38.1	6.94	27.46	0.68	0.112
17-12-2018	V	89.9	39.9	7.20	26.74	0.68	0.059
21-12-2018	VI	92.3	38.5	7.56	27.12	0.77	0.117
24-12-2018	VII	89.3	40.6	6.76	27.06	0.77	0.149
28-12-2018	VIII	91.7	37.7	7.12	26.55	0.72	0.051
January 2019							
01-01-2019	I	91.8	38.5	7.07	26.63	0.70	0.121
04-01-2019	II	89.8	27.6	8.19	27.62	0.68	0.148
07-01-2019	III	84.4	34.7	8.48	23.67	0.61	0.132
10-01-2019	IV	88.1	36.1	8.27	28.22	0.54	0.096
16-01-2019	V	90.2	35.7	8.94	29.58	0.47	0.428
19-01-2019	VI	92.2	36.20	8.65	26.97	0.56	0.148
21-01-2019	VII	94.5	35.50	8.26	27.10	0.58	0.095
25-01-2019	VIII	100.3	37.50	8.15	26.64	0.49	0.102

Table 4-12: Ambient Air Quality at St. John's Medical College & Hospital

A-8 St. John's Medical College & Hospital (junction)							
November 2018							
Dates	Sample No	PM ₁₀ , µg/ m ³	PM _{2.5} , µg/ m ³	SO ₂ , µg/ m ³	NO ₂ , µg/ m ³	CO, µg/ m ³	Pb, µg/ m ³
NAAQ Standards		100	60	80	80	4	1
05-11-2018	I	94.5	38.2	7.45	29.11	0.33	0.085
08-11-2018	II	93.9	39.9	7.09	28.75	0.28	0.040
14-11-2018	III	97.1	40.5	7.85	29.56	0.22	0.102
17-11-2018	IV	96.6	43.6	7.90	28.21	0.29	0.108
20-11-2018	V	94.9	41.2	8.24	29.82	0.17	0.081
23-11-2018	VI	98.2	44.6	7.19	29.22	0.39	0.153
26-11-2018	VII	93.5	42.7	8.71	27.47	0.146	0.23
29-11-2018	VIII	92.8	46.9	7.47	28.63	0.118	0.39
December 2018							
03-12-2018	I	94.9	41.8	7.81	29.47	0.31	0.084
07-12-2018	II	90.8	42.1	8.15	28.31	0.22	0.124
11-12-2018	III	92.3	38.1	7.40	29.91	0.22	0.034
14-12-2018	IV	95.2	39.0	7.74	28.43	0.27	0.130
17-12-2018	V	93.1	40.6	8.02	29.3	0.17	0.033
21-12-2018	VI	91.6	39.4	8.36	29.68	0.36	0.046
24-12-2018	VII	92.5	41.3	7.58	28.03	0.26	0.099
28-12-2018	VIII	90.4	38.6	7.92	29.11	0.31	0.025
January 2019							
01-01-2019	I	95.1	37.8	7.28	30.61	0.32	0.119
04-01-2019	II	99.3	42.8	8.32	22.58	0.38	0.086
07-01-2019	III	95.0	32.5	7.85	21.59	0.35	0.058
10-01-2019	IV	97.2	31.7	7.88	23.41	0.30	0.053
16-01-2019	V	97.4	45.2	8.06	24.77	0.29	0.041
19-01-2019	VI	88.4	36.80	8.55	21.93	0.44	0.076
21-01-2019	VII	96.7	32.40	7.64	31.08	0.48	0.129
25-01-2019	VIII	91.7	31.80	7.33	35.62	0.37	0.078

Table 4-13: Ambient Air Quality at Minerva Circle

A-9 Minerva Circle							
November 2018							
Dates	Sample No	PM ₁₀ , µg/ m ³	PM _{2.5} , µg/ m ³	SO ₂ , µg/ m ³	NO ₂ , µg/ m ³	CO, µg/ m ³	Pb, µg/ m ³
NAAQ Standards		100	60	80	80	4	1
05-11-2018	I	100.5	41.7	8.04	29.68	0.60	0.110
08-11-2018	II	94.6	48.7	7.68	29.32	0.46	0.084
14-11-2018	III	96.2	49.6	8.44	30.21	0.54	0.151
17-11-2018	IV	99.1	43.4	8.22	28.86	0.53	0.071
20-11-2018	V	97.3	45.7	8.83	30.39	0.56	0.062
23-11-2018	VI	97.9	42.4	8.34	29.79	0.67	0.129
26-11-2018	VII	99.0	44.9	8.73	29.24	0.126	0.60
29-11-2018	VIII	90.2	43.6	8.08	30.12	0.123	0.63
December 2018							
03-12-2018	I	93.3	45.9	8.40	30.04	0.65	0.016
07-12-2018	II	96.2	46.2	8.79	28.96	0.48	0.041
11-12-2018	III	92.7	45.7	7.99	30.56	0.56	0.019
14-12-2018	IV	95.6	46.6	8.38	29.08	0.53	0.039
17-12-2018	V	93.5	44.7	8.61	29.87	0.51	0.041
21-12-2018	VI	96.4	47.0	9.00	30.25	0.62	0.075
24-12-2018	VII	92.9	45.4	8.17	28.68	0.60	0.043
28-12-2018	VIII	95.8	46.2	8.56	29.68	0.57	0.008
January 2019							
01-01-2019	I	89.2	42.3	7.68	29.74	0.64	0.065
04-01-2019	II	90.7	37.1	8.58	21.26	0.58	0.051
07-01-2019	III	94.3	35.3	8.37	34.42	0.65	0.077
10-01-2019	IV	91.9	34.2	7.73	35.97	0.53	0.095
16-01-2019	V	85.4	39.6	7.40	37.33	0.65	0.059
19-01-2019	VI	87.5	38.20	8.81	20.61	0.57	0.152
21-01-2019	VII	93.6	33.60	8.42	30.21	0.60	0.150
25-01-2019	VIII	89.7	35.90	8.29	31.75	0.59	0.116

Table 4-14: Ambient Air Quality at Deepanjali Nagar, Mysore Road

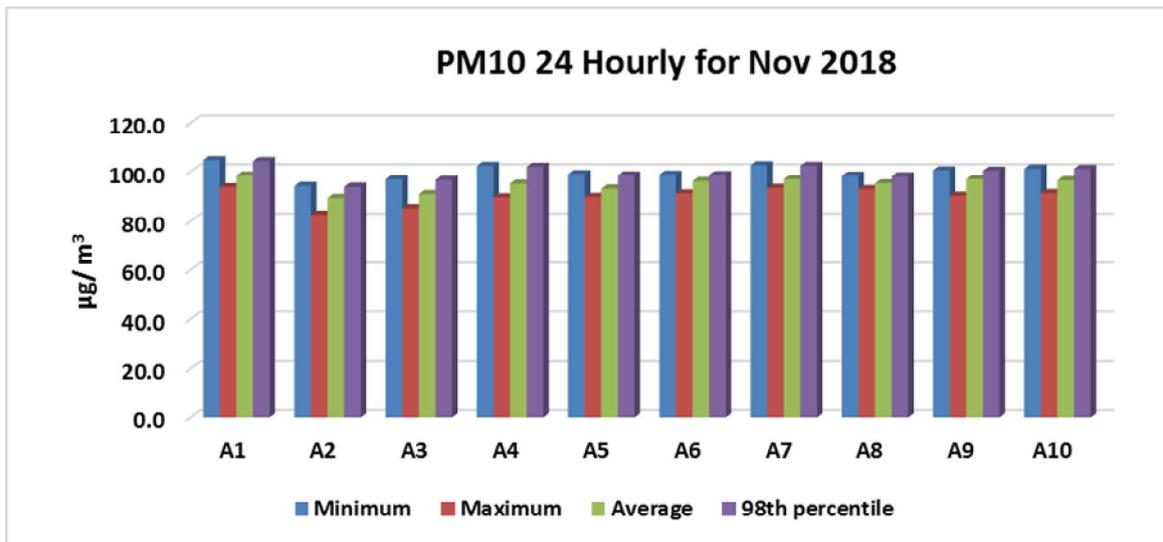
A - 10 Deepanjalinagar ,Mysore Road							
November 2018							
Dates	Sample No	PM ₁₀ , µg/ m ³	PM _{2.5} , µg/ m ³	SO ₂ , µg/ m ³	NO ₂ , µg/ m ³	CO, µg/ m ³	Pb, µg/ m ³
NAAQ Standards		100	60	80	80	4	1
05-11-2018	I	99.8	49.8	7.16	28.46	0.63	0.060
08-11-2018	II	91.2	41.3	6.71	28.26	0.4	0.090
14-11-2018	III	92.3	43.9	8.07	30.93	0.61	0.142
17-11-2018	IV	100.8	39.5	7.74	29.58	0.54	0.101
20-11-2018	V	94.8	44.8	7.86	29.17	0.37	0.083
23-11-2018	VI	92.7	37.6	7.84	29.03	0.64	0.190
26-11-2018	VII	98.3	42.4	7.76	28.84	0.121	0.59
29-11-2018	VIII	101.2	40.9	7.88	29.98	0.159	0.57
December 2018							
03-12-2018	I	90.3	37.9	7.43	28.82	0.56	0.080
07-12-2018	II	91.9	39.7	7.89	29.68	0.49	0.137
11-12-2018	III	89.7	38.1	8.02	31.28	0.47	0.072
14-12-2018	IV	88.3	41.2	7.58	29.8	0.54	0.079
17-12-2018	V	90.5	38.2	7.64	28.65	0.42	0.077
21-12-2018	VI	91.1	40.4	8.10	29.03	0.63	0.093
24-12-2018	VII	89.9	38.9	7.20	29.40	0.51	0.071
28-12-2018	VIII	90.5	39.6	7.66	28.46	0.58	0.026
January 2019							
01-01-2019	I	86.9	30.3	7.49	31.13	0.55	0.108
04-01-2019	II	92.6	35.5	8.00	24.79	0.650	0.056
07-01-2019	III	98.8	39.4	7.59	23.35	0.67	0.075
10-01-2019	IV	95.9	32.6	8.05	24.89	0.50	0.062
16-01-2019	V	92.0	28.9	8.72	26.25	0.74	0.019
19-01-2019	VI	97.8	34.50	8.23	24.12	0.64	0.093
21-01-2019	VII	91.2	33.40	7.90	31.60	0.71	0.125
25-01-2019	VIII	91.3	24.80	7.59	33.22	0.75	0.088

Table 4-15: Ambient Air Quality at different AAQ stations for November 2018

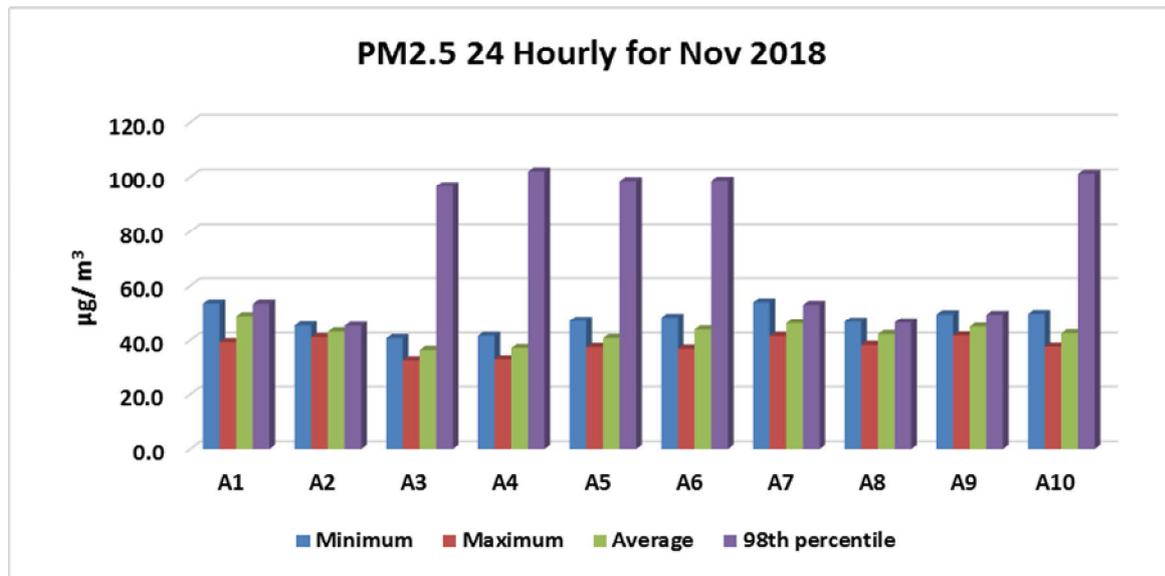
Parameters	Observed	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
PM10 24 Hourly (in µg/m ³)	NAAQS	100	100	100	100	100	100	100	100	100	100
	Minimum	93.6	82.6	85.2	89.6	89.7	91.2	93.3	92.8	90.2	91.2
	Maximum	104.7	94.1	96.8	102.3	98.9	98.7	102.6	98.2	100.5	101.2
	Average	98.3	89.3	90.9	95.1	93.0	96.1	96.8	95.2	96.9	96.4
	98th Percentile	104.3	93.8	96.5	101.9	98.4	98.6	102.4	98.0	100.3	101.1
PM 2.5	NAAQS	60	60	60	60	60	60	60	60	60	60

Parameters	Observed	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
24 Hourly (in $\mu\text{g}/\text{m}^3$)	Minimum	39.2	41.1	32.5	32.9	37.4	36.8	41.5	38.2	41.7	37.6
	Maximum	53.6	45.4	40.7	41.6	47.2	48.4	53.9	46.9	49.6	49.8
	Average	49.0	43.2	36.4	37.1	40.7	44.0	46.3	42.2	45.0	42.5
	98th Percentile	53.5	45.3	96.5	101.9	98.4	98.6	53.0	46.6	49.5	101.1
SO ₂ 24 Hourly (in $\mu\text{g}/\text{m}^3$)	NAAQS	80	80	80	80	80	80	80	80	80	80
	Minimum	6.96	6.79	5.62	5.84	6.27	6.03	6.55	7.09	7.68	6.71
	Maximum	8.43	7.94	7.7	7.64	7.44	7.25	8.14	8.71	8.83	8.07
	Average	7.78	7.45	6.50	6.51	6.96	6.84	7.39	7.74	8.30	7.63
	98th Percentile	8.39	7.93	7.57	7.54	7.44	7.24	8.08	8.64	8.82	8.04
NO _X 24 Hourly (in $\mu\text{g}/\text{m}^3$)	NAAQS	80	80	80	80	80	80	80	80	80	80
	Minimum	27.7	26.02	26.32	25.09	26.07	26.6	23.43	27.47	28.86	28.26
	Maximum	30.18	28.44	27.67	28.97	28.59	29.37	27.31	29.82	30.39	30.93
	Average	28.52	27.47	26.90	26.79	27.05	28.21	25.01	28.85	29.70	29.28
	98th Percentile	30.04	28.40	27.60	28.86	28.47	29.28	27.20	29.78	30.36	30.80
CO 8 Hourly (in mg/m^3)	NAAQS	4	4	4	4	4	4	4	4	4	4
	Minimum	0.06	0.02	0.03	0.08	0.12	0.07	0.07	0.12	0.12	0.12
	Maximum	1.07	0.64	0.45	0.58	0.79	0.7	0.7	0.39	0.67	0.64
	Average	0.73	0.35	0.22	0.41	0.58	0.44	0.44	0.24	0.45	0.43
	98th Percentile	1.06	0.63	0.44	0.58	0.79	0.60	0.69	0.38	0.66	0.64
Pb, $\mu\text{g}/\text{m}^3$	NAAQS	1	1	1	1	1	1	1	1	1	1
	Minimum	0.04	0.02	0.04	0.02	0.05	0.07	0.06	0.04	0.06	0.06
	Maximum	1.02	0.47	0.39	0.52	0.72	0.43	0.65	0.39	0.63	0.59
	Average	0.311	0.177	0.161	0.190	0.268	0.187	0.220	0.149	0.230	0.228
	98th Percentile	1.02	0.46	0.38	0.38	0.52	0.43	0.63	0.37	0.63	0.59

PM 10 for Nov 2018				
Location	Max	Min	Avg	98 th Percentile
A1	104.7	93.6	98.3	104.3
A2	94.1	82.6	89.3	93.8
A3	96.8	85.2	90.9	96.5
A4	102.3	89.6	95.1	101.9
A5	98.9	89.7	93.0	98.4
A6	98.7	91.2	96.1	98.6
A7	102.6	93.3	96.8	102.4
A8	98.2	92.8	95.2	98.0
A9	100.5	90.2	96.9	100.3
A10	101.2	91.2	96.4	101.1

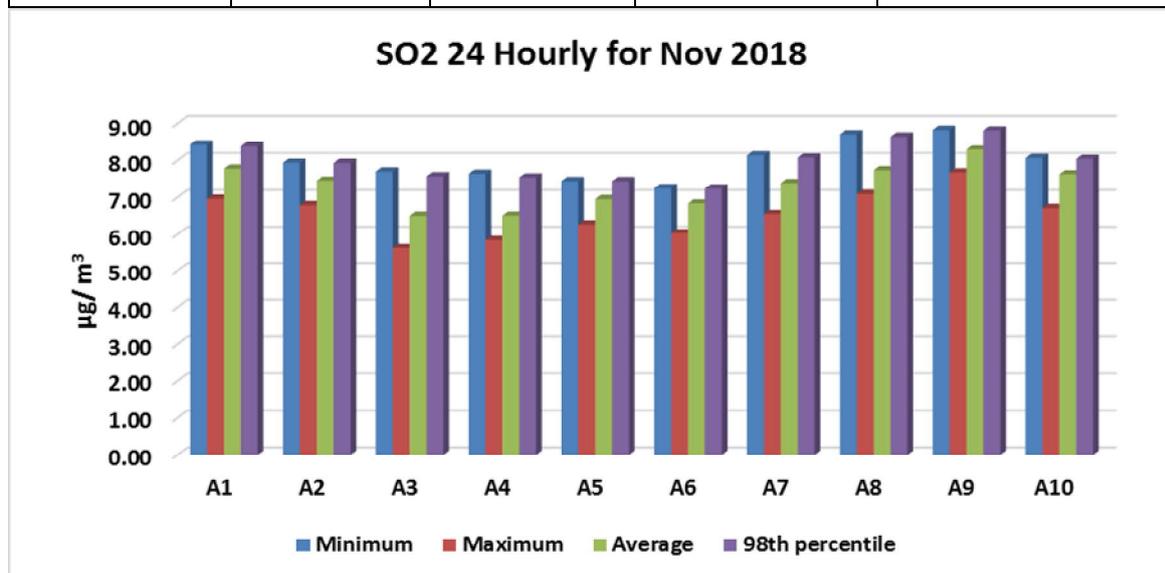


PM 2.5 for Nov 2018				
Location	Max	Min	Avg	98 th Percentile
A1	53.6	39.2	49.0	53.5
A2	45.4	41.1	43.2	45.3
A3	40.7	32.5	36.4	96.5
A4	41.6	32.9	37.1	101.9
A5	47.2	37.4	40.7	98.4
A6	48.4	36.8	44.0	98.6
A7	53.9	41.5	46.3	53.0
A8	46.9	38.2	42.2	46.6
A9	49.6	41.7	45.0	49.5
A10	49.8	37.6	42.5	101.1

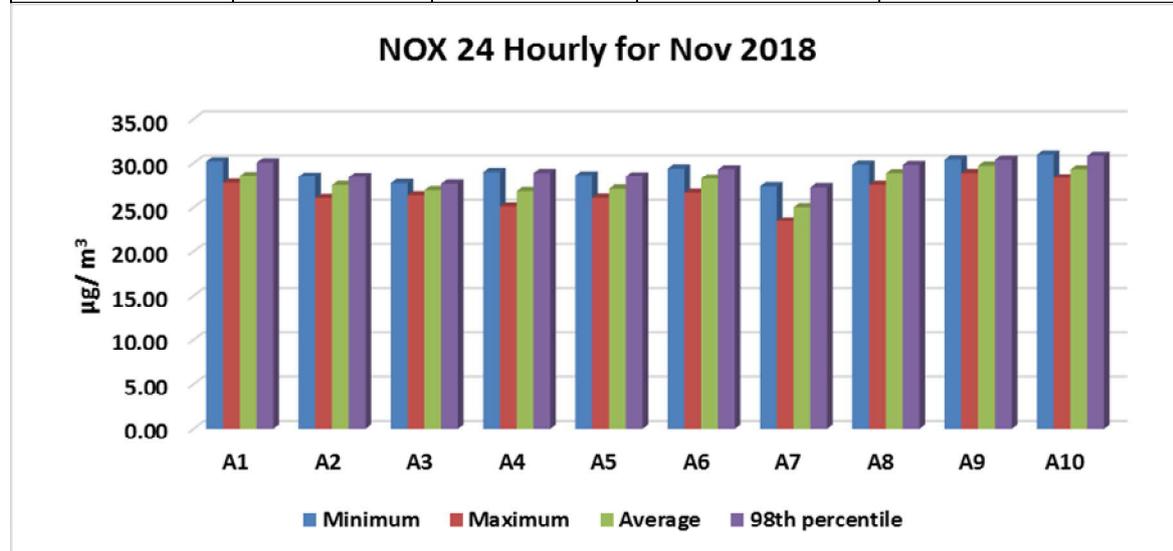


SO2 for Nov 2018

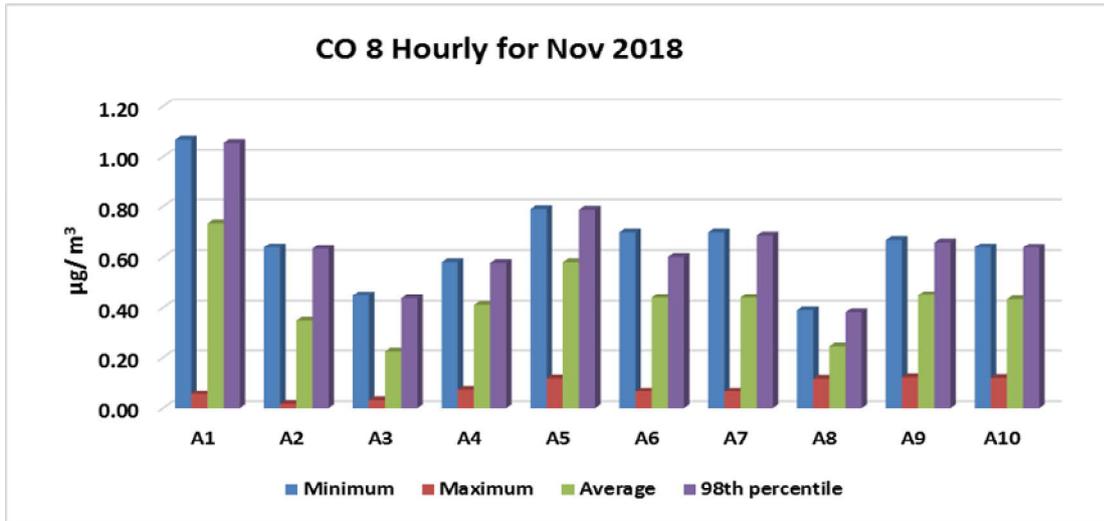
Location	Max	Min	Avg	98th Percentile
A1	8.43	6.96	7.78	8.39
A2	7.94	6.79	7.45	7.93
A3	7.70	5.62	6.50	7.57
A4	7.64	5.84	6.51	7.54
A5	7.44	6.27	6.96	7.44
A6	7.25	6.03	6.84	7.24
A7	8.14	6.55	7.39	8.08
A8	8.71	7.09	7.74	8.64
A9	8.83	7.68	8.30	8.82
A10	8.07	6.71	7.63	8.04



NOX for Nov 2018				
Location	Max	Min	Avg	98 th Percentile
A1	30.18	27.70	28.52	30.04
A2	28.44	26.02	27.47	28.40
A3	27.67	26.32	26.90	27.60
A4	28.97	25.09	26.79	28.86
A5	28.59	26.07	27.05	28.47
A6	29.37	26.60	28.21	29.28
A7	27.31	23.43	25.01	27.20
A8	29.82	27.47	28.85	29.78
A9	30.39	28.86	29.70	30.36
A10	30.93	28.26	29.28	30.80



CO for Nov 2018				
Location	Max	Min	Avg	98 th Percentile
A1	1.07	0.06	0.73	1.06
A2	0.64	0.02	0.35	0.63
A3	0.45	0.03	0.22	0.44
A4	0.58	0.08	0.41	0.58
A5	0.79	0.12	0.58	0.79
A6	0.70	0.07	0.44	0.60
A7	0.70	0.07	0.44	0.69
A8	0.39	0.12	0.24	0.38
A9	0.67	0.12	0.45	0.66
A10	0.64	0.12	0.43	0.64



Location	Max	Min	Avg	98th Percentile
A1	1.02	0.04	0.311	1.02
A2	0.47	0.02	0.177	0.46
A3	0.39	0.04	0.161	0.38
A4	0.52	0.02	0.190	0.38
A5	0.72	0.05	0.268	0.52
A6	0.43	0.07	0.187	0.43
A7	0.65	0.06	0.220	0.63
A8	0.39	0.04	0.149	0.37
A9	0.63	0.06	0.230	0.63
A10	0.59	0.06	0.228	0.59

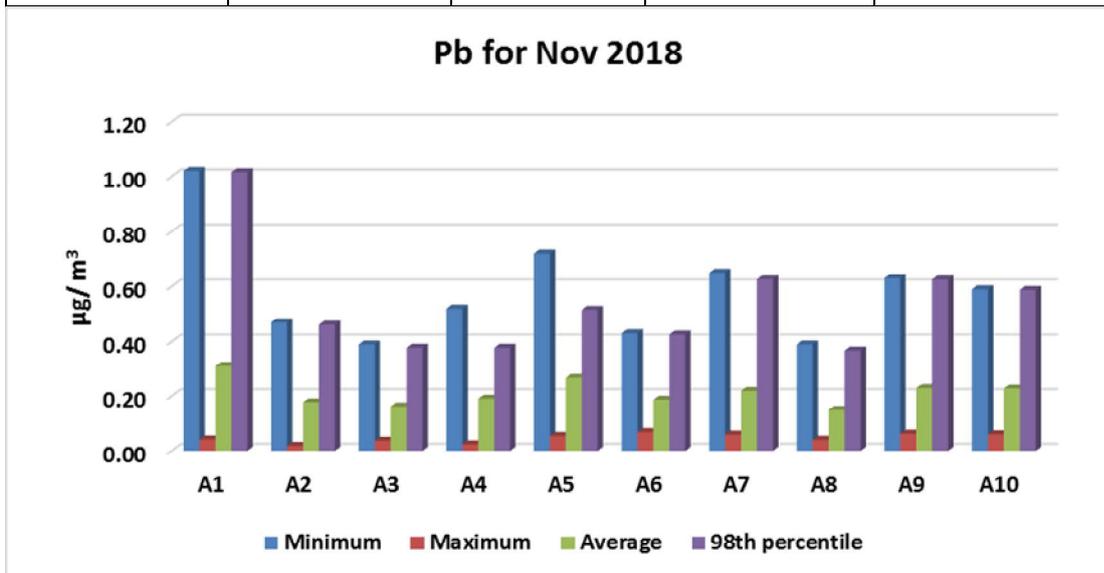
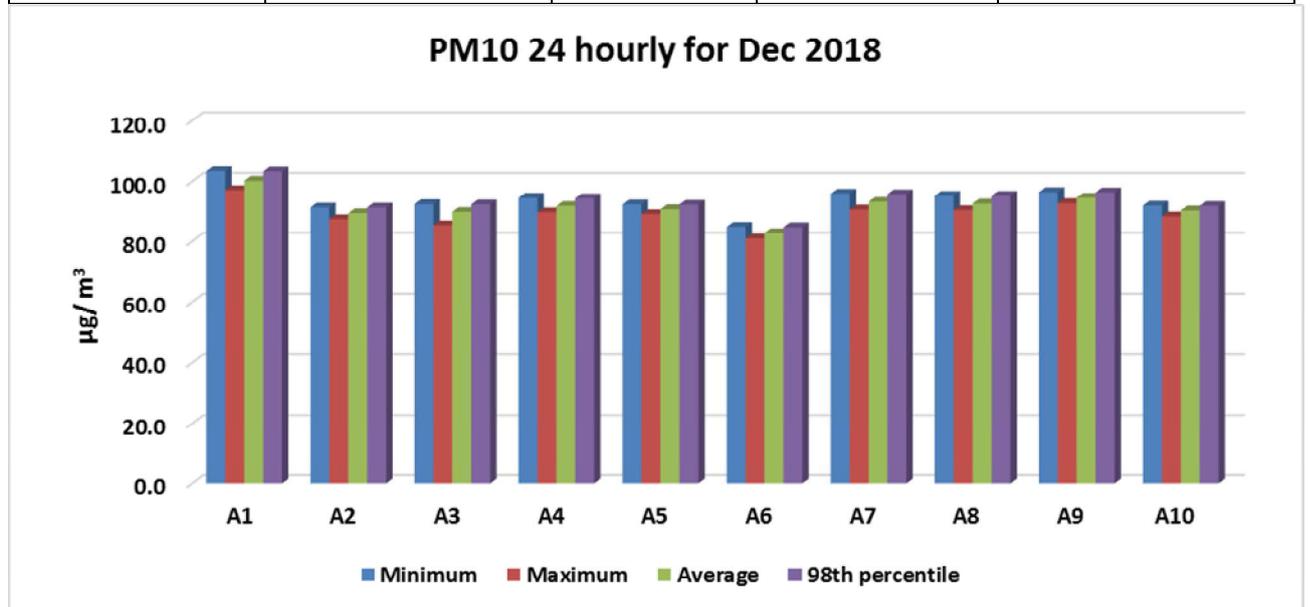


Table 4-16: Ambient Air Quality at different AAQ stations - December 2018

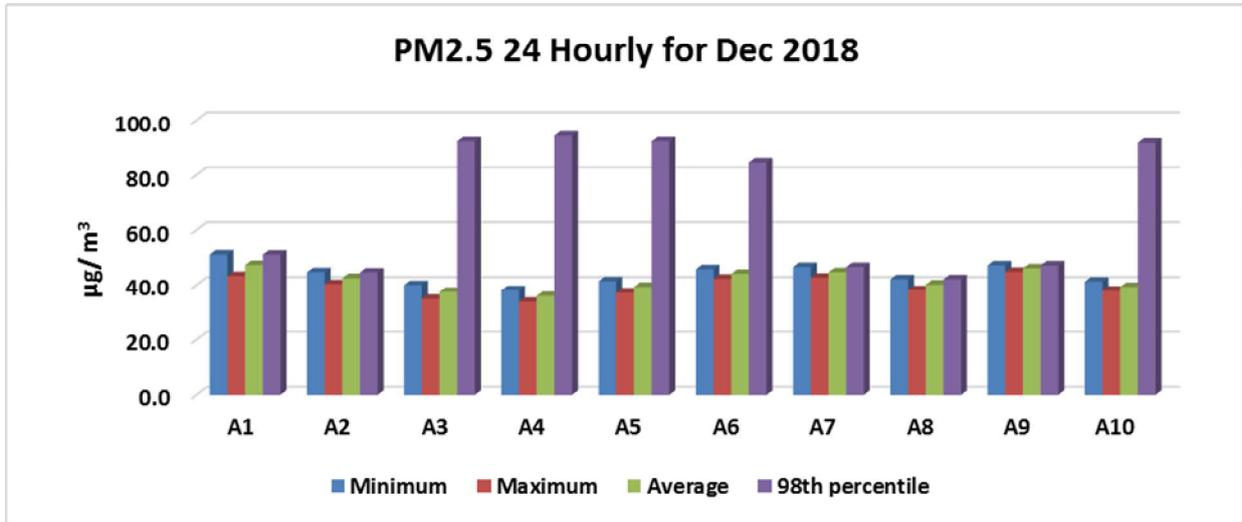
Parameters	Observed	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
PM10 24 Hourly (in $\mu\text{g}/\text{m}^3$)	NAAQS	100	100	100	100	100	100	100	100	100	100
	Minimum	97.1	87.4	85.4	89.7	89.1	80.9	90.6	90.4	92.7	88.3
	Maximum	103.4	91.3	92.4	94.5	92.3	84.8	95.9	95.2	96.4	91.9
	Average	100.2	89.4	89.8	91.8	90.7	82.8	93.2	92.6	94.6	90.3
	98th Percentile	103.3	91.3	92.3	94.3	92.3	84.7	95.7	95.2	96.4	91.8
PM 2.5 24 Hourly (in $\mu\text{g}/\text{m}^3$)	NAAQS	60	60	60	60	60	60	60	60	60	60
	Minimum	43.2	40.3	34.9	33.9	37.2	42.2	42.6	38.1	44.7	37.9
	Maximum	50.9	44.6	40.0	38.1	41.4	45.6	46.5	42.1	47.0	41.2
	Average	47.16	42.46	37.46	36.01	39.31	44.01	44.56	40.11	45.96	39.26
	98th Percentile	50.88	44.53	42.30	44.35	42.27	84.69	46.43	42.03	46.98	41.79
SO ₂ 24 Hourly (in $\mu\text{g}/\text{m}^3$)	NAAQS	80	80	80	80	80	80	80	80	80	80
	Minimum	7.27	7.1	5.93	5.79	6.58	6.34	6.86	7.4	7.99	7.20
	Maximum	8.69	8.01	7.33	6.56	7.56	7.33	8.3	8.36	9	8.1
	Average	7.97	7.55	6.62	6.17	7.06	6.83	7.57	7.87	8.49	7.69
	98th Percentile	8.66	7.98	7.30	6.54	7.53	7.30	8.27	8.33	8.97	8.09
NO _X 24 Hourly (in $\mu\text{g}/\text{m}^3$)	NAAQS	80	80	80	80	80	80	80	80	80	80
	Minimum	27.68	26.58	26.14	25.65	26.6	27.16	23.79	28.03	28.68	28.46
	Maximum	29.56	28.46	28.02	27.53	28.94	29.18	26.85	29.91	30.56	31.28
	Average	28.39	27.38	27.05	26.51	27.27	28.35	24.84	29.03	29.64	29.39
	98th Percentile	29.45	28.37	27.96	27.46	28.73	29.16	26.64	29.88	30.52	31.07
CO 8 Hourly (in mg/m^3)	NAAQS	4	4	4	4	4	4	4	4	4	4
	Minimum	0.9	0.3	0.21	0.41	0.63	0.42	0.42	0.2	0.48	0.42
	Maximum	1.07	0.51	0.41	0.57	0.82	0.7	0.7	0.36	0.65	0.63
	Average	0.97	0.41	0.31	0.48	0.73	0.56	0.56	0.27	0.57	0.53
	98th Percentile	1.06	0.50	0.40	0.56	0.81	0.51	0.69	0.35	0.65	0.62
Pb, $\mu\text{g}/\text{m}^3$	NAAQS	1	1	1	1	1	1	1	1	1	1
	Minimum	0.03	0.01	0.03	0.02	0.05	0.05	0.03	0.03	0.01	0.03
	Maximum	0.09	0.07	0.10	0.07	0.15	0.15	0.10	0.13	0.08	0.14
	Average	0.06	0.03	0.06	0.03	0.10	0.10	0.05	0.07	0.04	0.08
	98th Percentile	0.09	0.07	0.10	0.10	0.07	0.15	0.09	0.13	0.07	0.13



PM10 for December 2018				
Location	Max	Min	Avg	98th Percentile
A1	103.4	97.1	100.2	103.3
A2	91.3	87.4	89.4	91.3
A3	92.4	85.4	89.8	92.3
A4	94.5	89.7	91.8	94.3
A5	92.3	89.1	90.7	92.3
A6	84.8	80.9	82.8	84.7
A7	95.9	90.6	93.2	95.7
A8	95.2	90.4	92.6	95.2
A9	96.4	92.7	94.6	96.4
A10	91.9	88.3	90.3	91.8

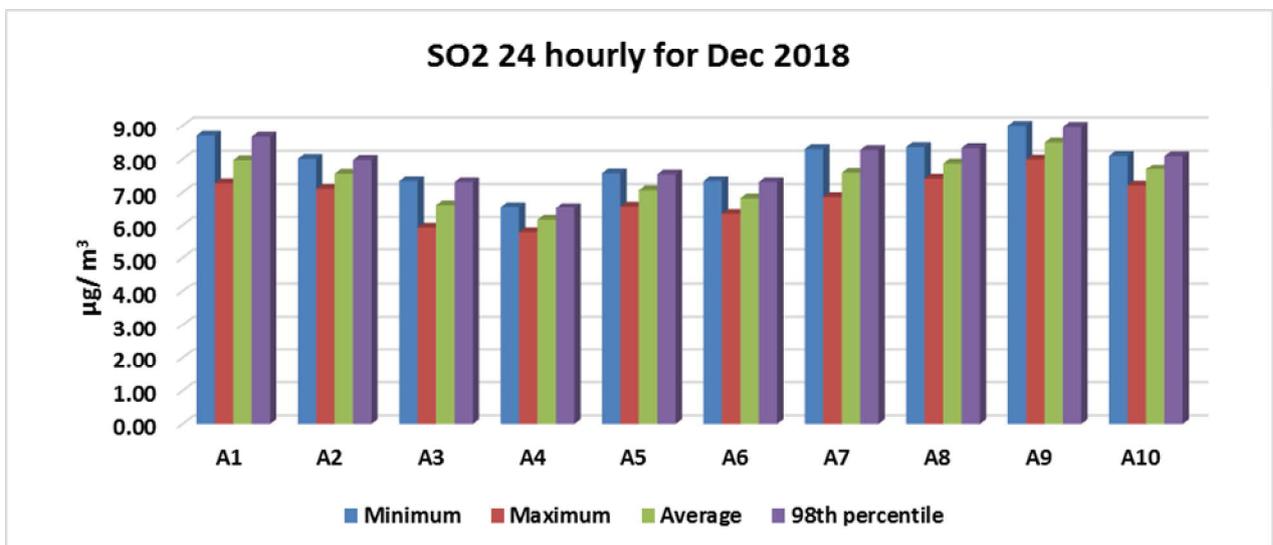


PM2.5 for December 2018				
Location	Max	Min	Avg	98th Percentile
A1	50.9	43.2	47.2	50.9
A2	44.6	40.3	42.5	44.5
A3	40.0	34.9	37.5	92.3
A4	38.1	33.9	36.0	94.3
A5	41.4	37.2	39.3	92.3
A6	45.6	42.2	44.0	84.7
A7	46.5	42.6	44.6	46.4
A8	42.1	38.1	40.1	42.0
A9	47.0	44.7	46.0	47.0
A10	41.2	37.9	39.3	91.8



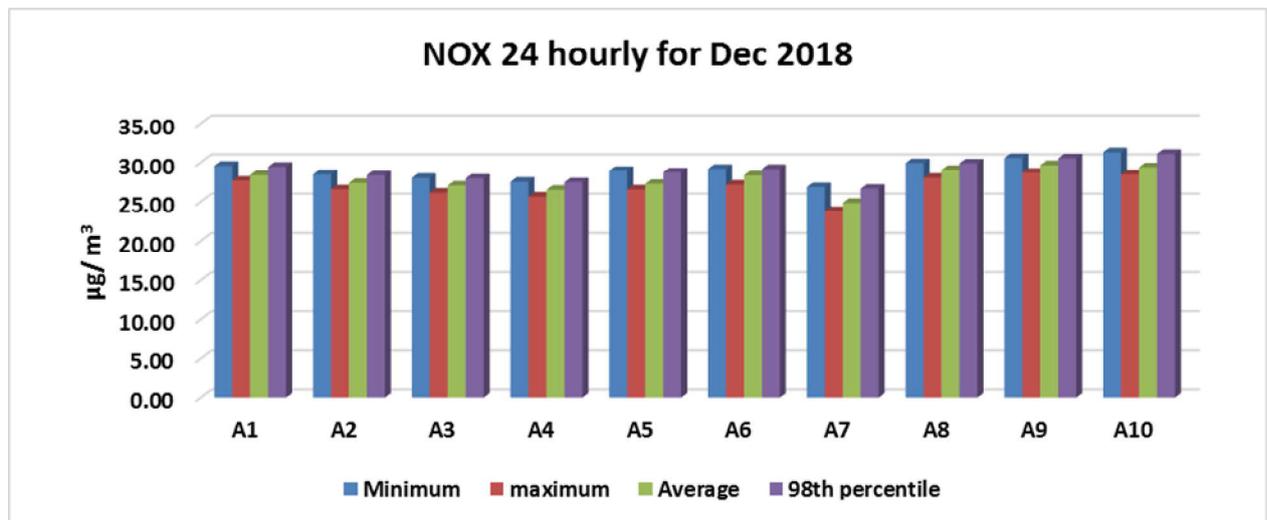
SO2 for December 2018

Location	Max	Min	Avg	98th Percentile
A1	8.69	7.27	7.97	8.66
A2	8.01	7.10	7.55	7.98
A3	7.33	5.93	6.62	7.30
A4	6.56	5.79	6.17	6.54
A5	7.56	6.58	7.06	7.53
A6	7.33	6.34	6.83	7.30
A7	8.30	6.86	7.57	8.27
A8	8.36	7.40	7.87	8.33
A9	9.00	7.99	8.49	8.97
A10	8.10	7.20	7.69	8.09

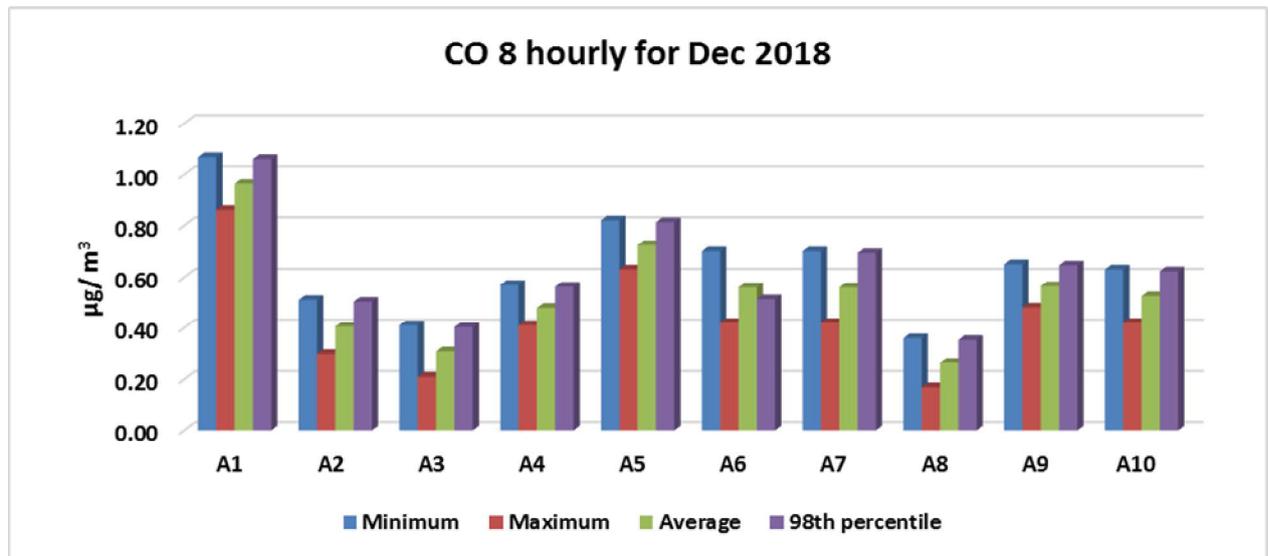




NOX for Dec 2018				
Location	Max	Min	Avg	98 th Percentile
A1	29.56	27.68	28.39	29.45
A2	28.46	26.58	27.38	28.37
A3	28.02	26.14	27.05	27.96
A4	27.53	25.65	26.51	27.46
A5	28.94	26.55	27.27	28.73
A6	29.18	27.16	28.35	29.16
A7	26.85	23.79	24.84	26.64
A8	29.91	28.03	29.03	29.88
A9	30.56	28.68	29.64	30.52
A10	31.28	28.46	29.39	31.07



CO for Dec 2018				
Location	Max	Min	Avg	98 th Percentile
A1	1.07	0.86	0.97	1.06
A2	0.51	0.30	0.41	0.50
A3	0.41	0.21	0.31	0.40
A4	0.57	0.41	0.48	0.56
A5	0.82	0.63	0.73	0.81
A6	0.70	0.42	0.56	0.51
A7	0.70	0.42	0.56	0.69
A8	0.36	0.17	0.27	0.35
A9	0.65	0.48	0.57	0.65
A10	0.63	0.42	0.53	0.62



Pb for Dec 2018

Location	Max	Min	Avg	98 th Percentile
A1	0.090	0.030	0.055	0.087
A2	0.073	0.011	0.034	0.071
A3	0.102	0.027	0.061	0.099
A4	0.073	0.019	0.034	0.099
A5	0.149	0.051	0.096	0.068
A6	0.149	0.047	0.104	0.148
A7	0.096	0.028	0.054	0.093
A8	0.130	0.025	0.072	0.129
A9	0.075	0.008	0.035	0.071
A10	0.137	0.026	0.079	0.131

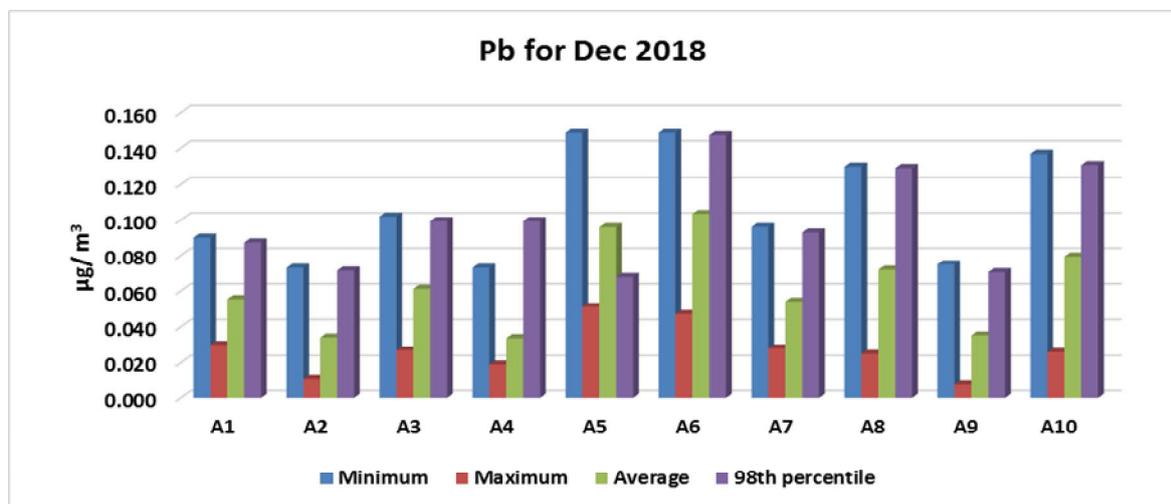
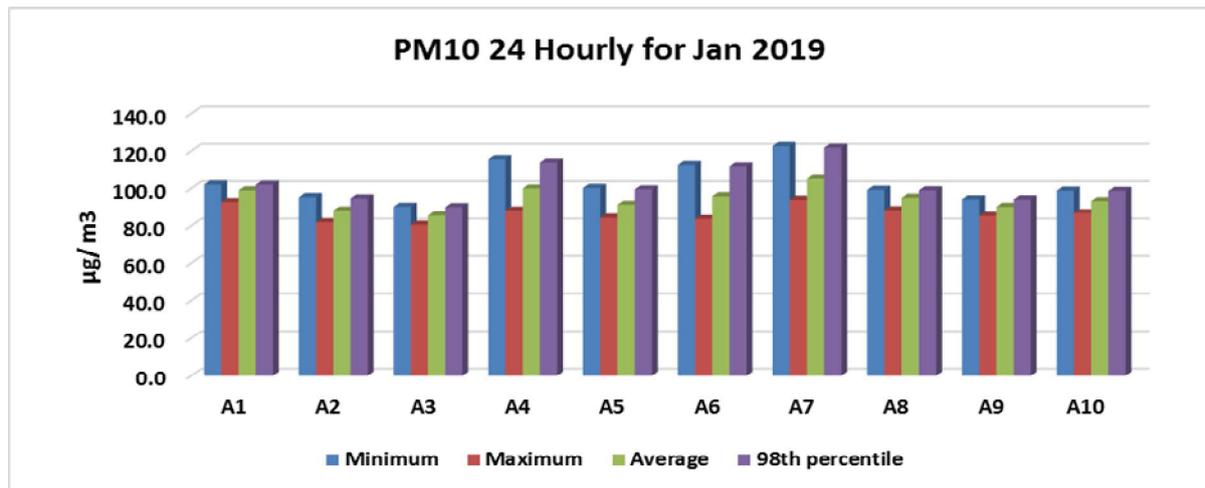


Table 4-17: Ambient Air Quality at different AAQ stations – January 2019

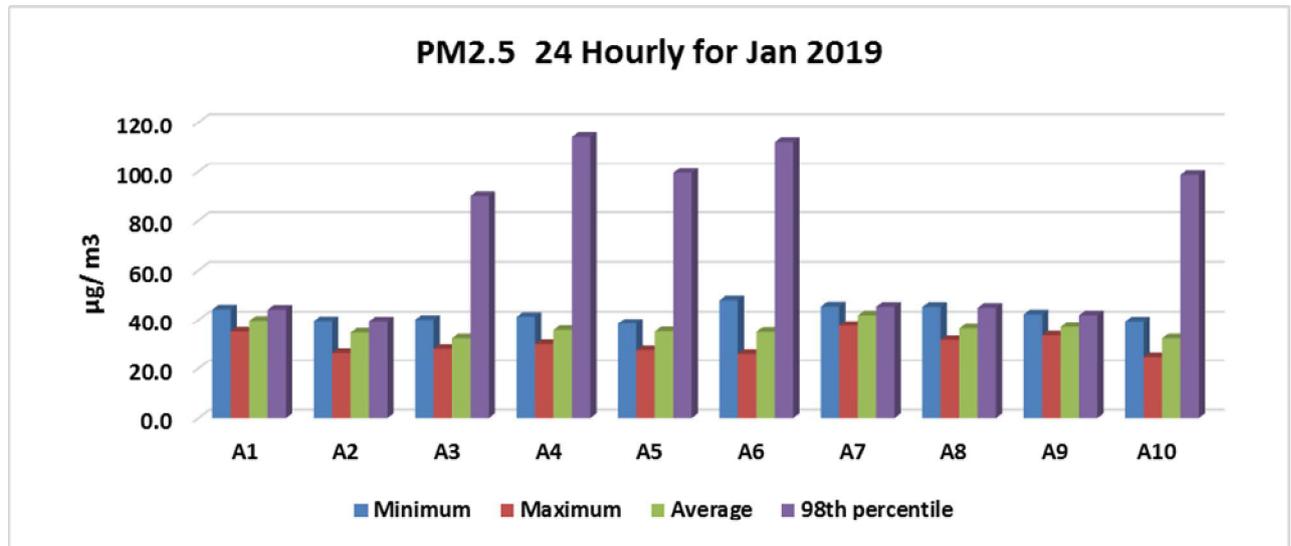
Parameters	Observed	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
PM10 24 Hourly (in $\mu\text{g}/\text{m}^3$)	NAAQS	100	100	100	100	100	100	100	100	100	100
	Minimum	92.8	81.9	80.6	88.3	84.4	83.6	94.0	88.4	85.4	86.9
	Maximum	102.1	95.4	90.3	115.7	100.3	112.7	122.7	99.3	94.3	98.8
	Average	99.0	88.2	85.5	100.0	91.4	95.9	105.1	95.1	90.3	93.3
	98th Percentile	102.0	94.7	90.1	114.0	99.5	112.0	121.8	99.0	94.2	98.7
PM 2.5 24 Hourly (in $\mu\text{g}/\text{m}^3$)	NAAQS	60	60	60	60	60	60	60	60	60	60
	Minimum	35.13	26.42	28.16	30.10	27.63	26.10	37.60	31.70	33.60	24.80
	Maximum	44.2	39.5	40.1	41.3	38.5	47.8	45.4	45.2	42.3	39.4
	Average	39.7	34.7	32.4	35.8	35.2	35.0	41.8	36.4	37.0	32.4
	98th Percentile	44.1	39.5	90.1	114.0	99.5	112.0	45.3	44.9	41.9	98.7
SO2 24 Hourly (in $\mu\text{g}/\text{m}^3$)	NAAQS	80	80	80	80	80	80	80	80	80	80
	Minimum	6.34	8.06	7.59	6.77	7.07	7.43	7.12	7.28	7.40	7.49
	Maximum	8.34	9.23	8.69	8.5	8.94	8.43	9.89	8.55	8.81	8.72
	Average	7.42	8.58	8.05	7.50	8.25	7.80	8.49	7.86	8.16	7.95
	98th Percentile	8.31	9.19	8.65	8.42	8.90	8.39	9.80	8.52	8.78	8.65
NOX 24 Hourly (in $\mu\text{g}/\text{m}^3$)	NAAQS	80	80	80	80	80	80	80	80	80	80
	Minimum	27.61	33.43	24.78	27.37	23.67	22.91	21.48	21.59	20.61	23.35
	Maximum	32.15	39.72	28.65	36.40	29.58	27.45	29.49	35.62	37.33	33.22
	Average	29.41	36.54	26.53	31.02	27.06	25.50	24.85	26.45	30.16	27.42
	98th Percentile	32.02	39.53	28.46	36.21	29.39	27.41	29.21	34.98	37.14	32.99
CO 8 Hourly (in mg/m^3)	NAAQS	4	4	4	4	4	4	4	4	4	4
	Minimum	0.68	0.41	0.28	0.43	0.47	0.45	0.45	0.29	0.53	0.5
	Maximum	0.96	0.58	0.49	0.63	0.7	0.77	0.77	0.48	0.65	0.75
	Average	0.82	0.50	0.39	0.55	0.58	0.62	0.62	0.37	0.60	0.65
	98th Percentile	0.95	0.58	0.48	0.63	0.70	0.53	0.76	0.47	0.65	0.75
Pb, $\mu\text{g}/\text{m}^3$	NAAQS	1	1	1	1	1	1	1	1	1	1
	Minimum	0.074	0.02	0.13	0.044	0.095	0.076	0.02	0.04	0.051	0.02
	Maximum	0.137	0.127	0.324	0.103	0.428	0.141	0.137	0.129	0.152	0.125
	Average	0.093	0.072	0.198	0.081	0.159	0.104	0.083	0.080	0.096	0.078
	98th Percentile	0.133	0.124	0.321	0.321	0.102	0.138	0.133	0.128	0.152	0.123



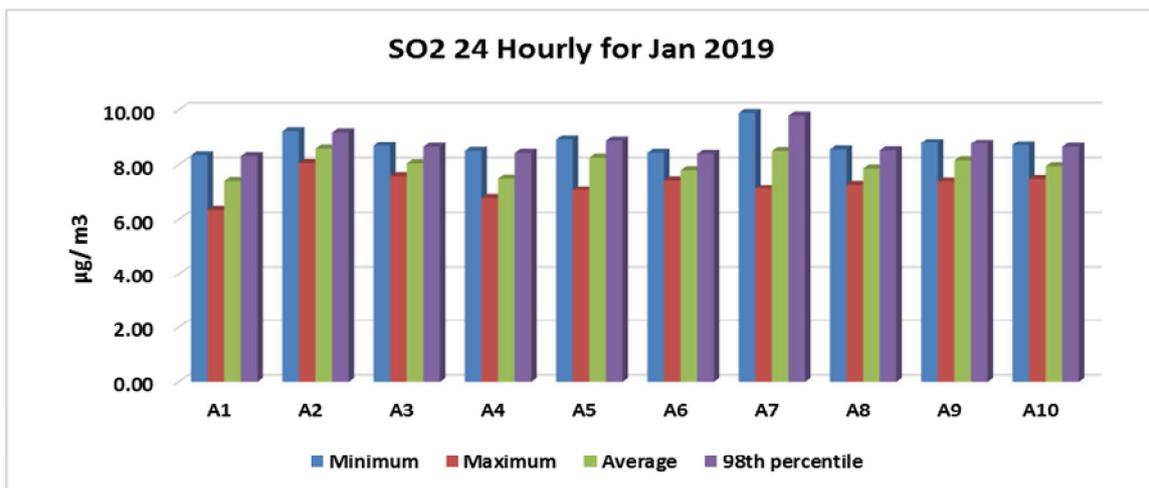
PM10 for Jan 2019				
Location	Max	Min	Avg	98th Percentile
A1	102.1	92.8	99.0	102.0
A2	95.4	81.9	88.2	94.7
A3	90.3	80.6	85.5	90.1
A4	115.7	88.3	100.0	114.0
A5	100.3	84.4	91.4	99.5
A6	112.7	83.6	95.9	112.0
A7	122.7	94.0	105.1	121.8
A8	99.3	88.4	95.1	99.0
A9	94.3	85.4	90.3	94.2
A10	98.8	86.9	93.3	98.7



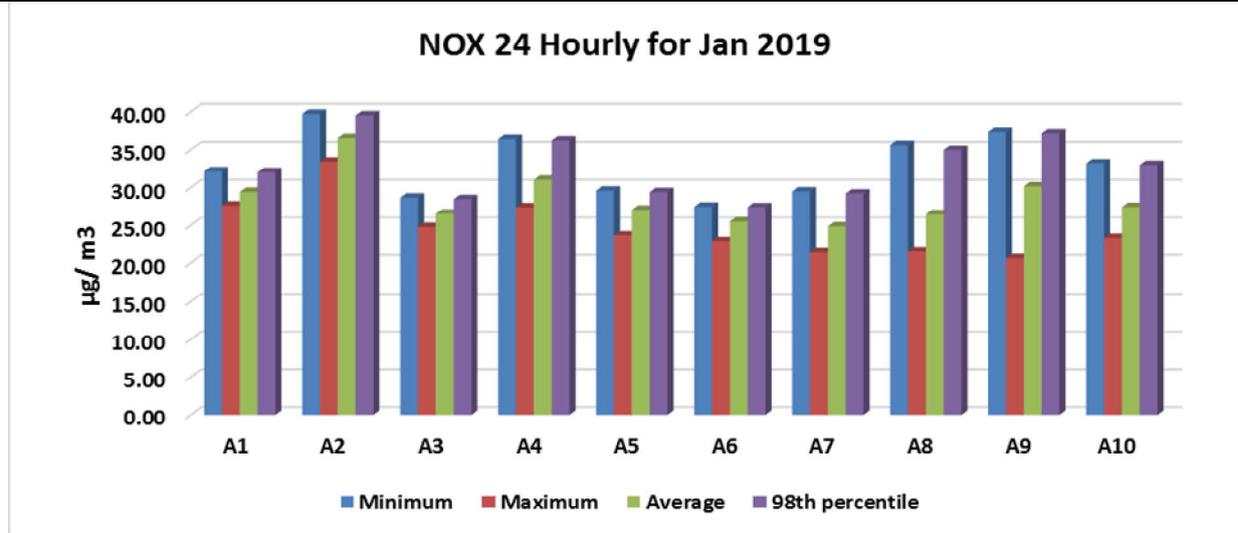
PM 2.5 for Jan 2019				
Location	Max	Min	Avg	98th Percentile
A1	44.2	35.1	39.7	44.1
A2	39.5	26.4	34.7	39.5
A3	40.1	28.2	32.4	90.1
A4	41.3	30.1	35.8	114.0
A5	38.5	27.6	35.2	99.5
A6	47.8	26.1	35.0	112.0
A7	45.4	37.6	41.8	45.3
A8	45.2	31.7	36.4	44.9
A9	42.3	33.6	37.0	41.9
A10	39.4	24.8	32.4	98.7



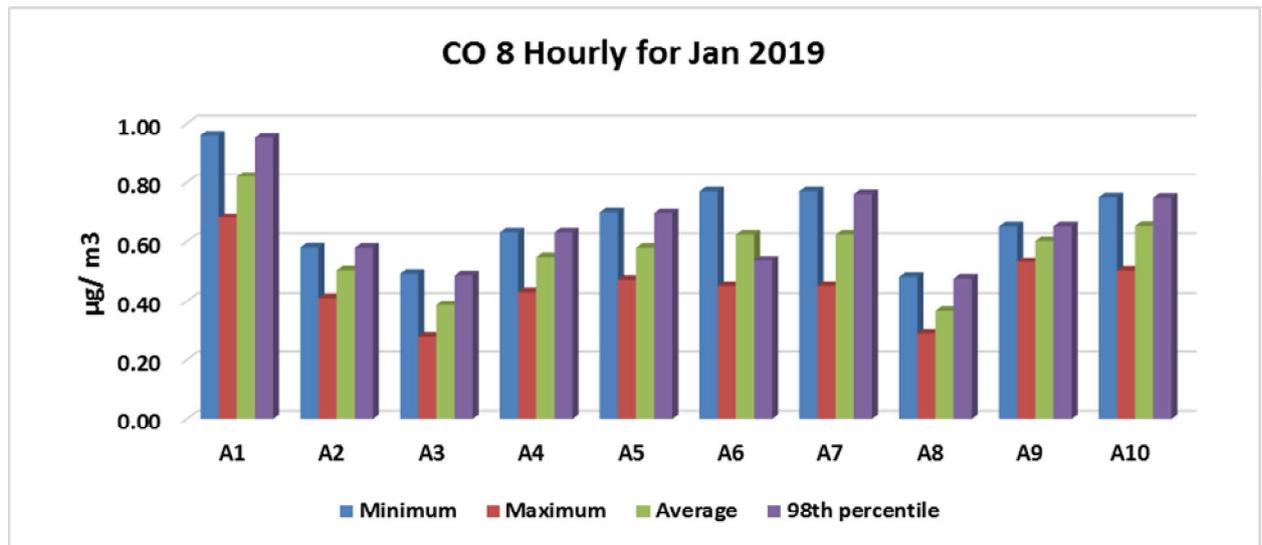
Location	Max	Min	Avg	98th Percentile
A1	8.34	6.34	7.42	8.31
A2	9.23	8.06	8.58	9.19
A3	8.69	7.59	8.05	8.65
A4	8.50	6.77	7.50	8.42
A5	8.94	7.07	8.25	8.90
A6	8.43	7.43	7.80	8.39
A7	9.89	7.12	8.49	9.80
A8	8.55	7.28	7.86	8.52
A9	8.81	7.40	8.16	8.78
A10	8.72	7.49	7.95	8.65



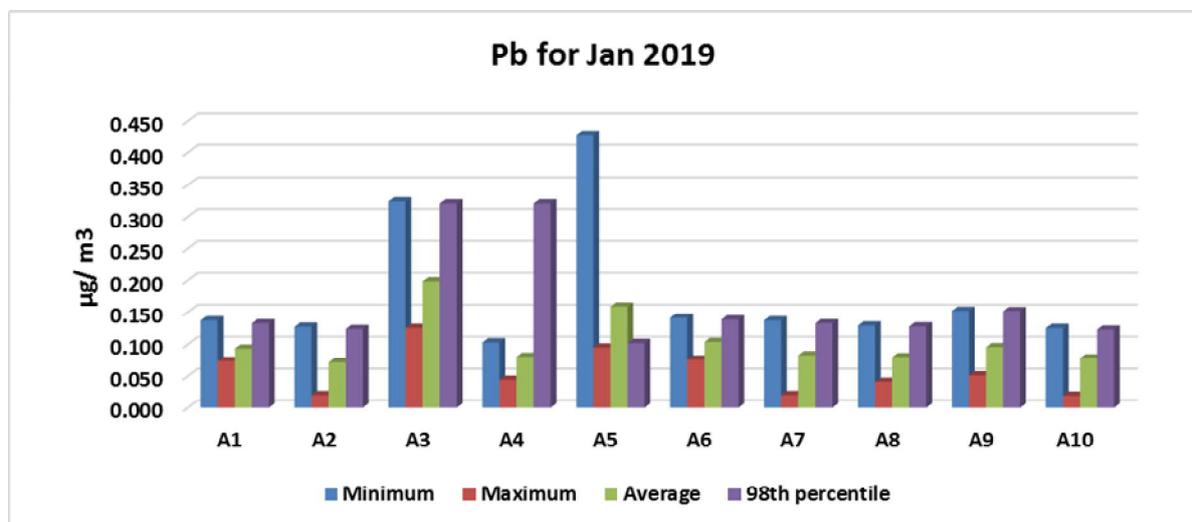
NOX for Jan 2019				
Location	Max	Min	Avg	98th Percentile
A1	32.15	27.61	29.41	32.02
A2	39.72	33.43	36.54	39.53
A3	28.65	24.78	26.53	28.46
A4	36.40	27.37	31.02	36.21
A5	29.58	23.67	27.06	29.39
A6	27.45	22.91	25.50	27.41
A7	29.49	21.48	24.85	29.21
A8	35.62	21.59	26.45	34.98
A9	37.33	20.61	30.16	37.14
A10	33.22	23.35	27.42	32.99



CO for Jan 2019				
Location	Max	Min	Avg	98th Percentile
A1	0.96	0.68	0.82	0.95
A2	0.58	0.41	0.50	0.58
A3	0.49	0.28	0.39	0.48
A4	0.63	0.43	0.55	0.63
A5	0.70	0.47	0.58	0.70
A6	0.77	0.45	0.62	0.53
A7	0.77	0.45	0.62	0.76
A8	0.48	0.29	0.37	0.47
A9	0.65	0.53	0.60	0.65
A10	0.75	0.50	0.65	0.75



Pb for Jan 2019				
Location	Max	Min	Avg	98th Percentile
A1	0.137	0.074	0.093	0.133
A2	0.127	0.020	0.072	0.124
A3	0.324	0.125	0.198	0.321
A4	0.103	0.044	0.081	0.321
A5	0.428	0.095	0.159	0.102
A6	0.141	0.076	0.104	0.138
A7	0.137	0.020	0.083	0.133
A8	0.129	0.041	0.080	0.128
A9	0.152	0.051	0.096	0.152
A10	0.125	0.019	0.078	0.123



4.5.1 Inferences on the Ambient Air Quality Analysis

Particulate Matter – PM₁₀

The average concentrations for PM₁₀ recorded were within the prescribed CPCB limits of 100µg/m³ at all the sampling locations.

The PM₁₀ monitored at following locations exceeded the prescribed standards.

- 100.5 µg/m³ in November 2018 at Minerva Circle (A-9);
- 101.6 µg/m³ in November 2018 & 100.6 µg/m³, 103.4 µg/m³, 101.3 µg/m³, 102.6 µg/m³ in December, 2018; 102.1 µg/m³ in January 2019 at Mekhri Circle (A-1);
- 102.6 µg/m³ in November 2018; & 122.7 µg/m³ in January 2019 at Lifestyle Junction, Richmond Road (A-5);
- 107.2 µg/m³ in January 2019 & 112.7 µg/m³ in January 2019 at Domlur SAARC Park (A-6);
- 115.7 µg/m³, 103.9 µg/m³, 100.4 µg/m³, 102.4 µg/m³ in January 2019 at Indian Express Circle (A-4) and
- 100.3 µg/m³ in January 2019 at Marathahalli Junction (A-7).

Particulate Matter – PM_{2.5}

The average concentrations for PM_{2.5} recorded were within the prescribed CPCB limits of 60µg/m³ at all the sampling locations. The minimum value for PM_{2.5} was recorded as 26.1 µg/m³ at Domlur SAARC park (A-6) in January 2019 and the maximum value was recorded as 53.9 µg/m³ at Marathahalli Junction (A-7) in November 2018.

Sulphur Dioxide (SO₂)

The average concentrations for SO₂ recorded were within the prescribed CPCB limits of 80µg/m³ at all the sampling locations. The maximum values of SO₂ of 9.89 µg/m³ were recorded at Marathahalli Junction (A-7) in January 2019 and minimum value of 5.62 µg/m³ is recorded at ITI Campus Junction(A-3) in November 2018.

Oxides of Nitrogen (NO_x)

The average concentrations for NO_x recorded were within the prescribed CPCB limits of 80µg/m³ at all the sampling locations. The maximum NO_x concentration was observed to be 30.93 µg/m³ at Deepanjalinagar (A-10) in November 2018 and minimum value of 20.61 µg/m³ was recorded at Minerva Circle (A-9) in January 2019.

Carbon Monoxide

The average concentrations for CO recorded were within the prescribed CPCB limits of 4µg/m³ at all the sampling locations. The maximum CO concentration was observed to be 1.07 µg/m³ at Mekhri Circle (A-1) in Decemeber 2018 and minimum value of 0.02 µg/m³ was recorded at Wheelers Road Junction (Opp to HQ MEG Centre) (A-2) in November 2018.

Lead (Pb)

The average concentrations for Pb recorded were within the prescribed CPCB limits of $1\mu\text{g}/\text{m}^3$ at all the sampling locations. The maximum Pb concentration was observed to be $0.149\mu\text{g}/\text{m}^3$ at Lifestyle Junction and Domlur SAARC park (A-5, A-6) in Decemeber 2018 and minimum value of $0.02\mu\text{g}/\text{m}^3$ was recorded at Wheelers Road Junction (Opp to HQ MEG Centre) (A-2) and Indian Express (A-4) in November 2018.

Figure 4-6: Photographs of Air Quality Monitoring





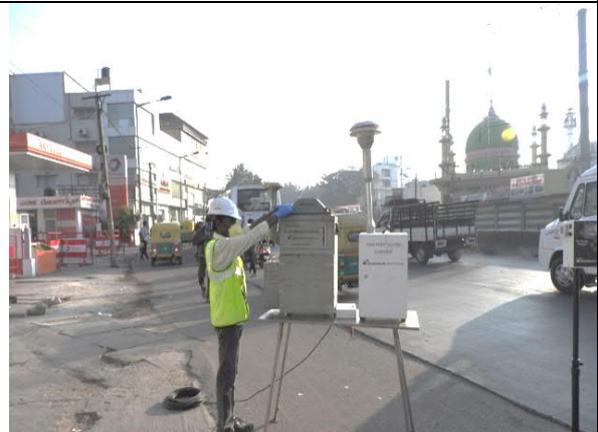
A7 - Marathahalli Junction



A8 - St. John's Medical College & Hospital



A9 - Minerva Circle



A10 - Deepanjalinagar, Mysore Road

4.5.2 Air Quality Modelling done for the project area:

Figure 4-7: Air Quality Modelling for PM 10 (Annual)

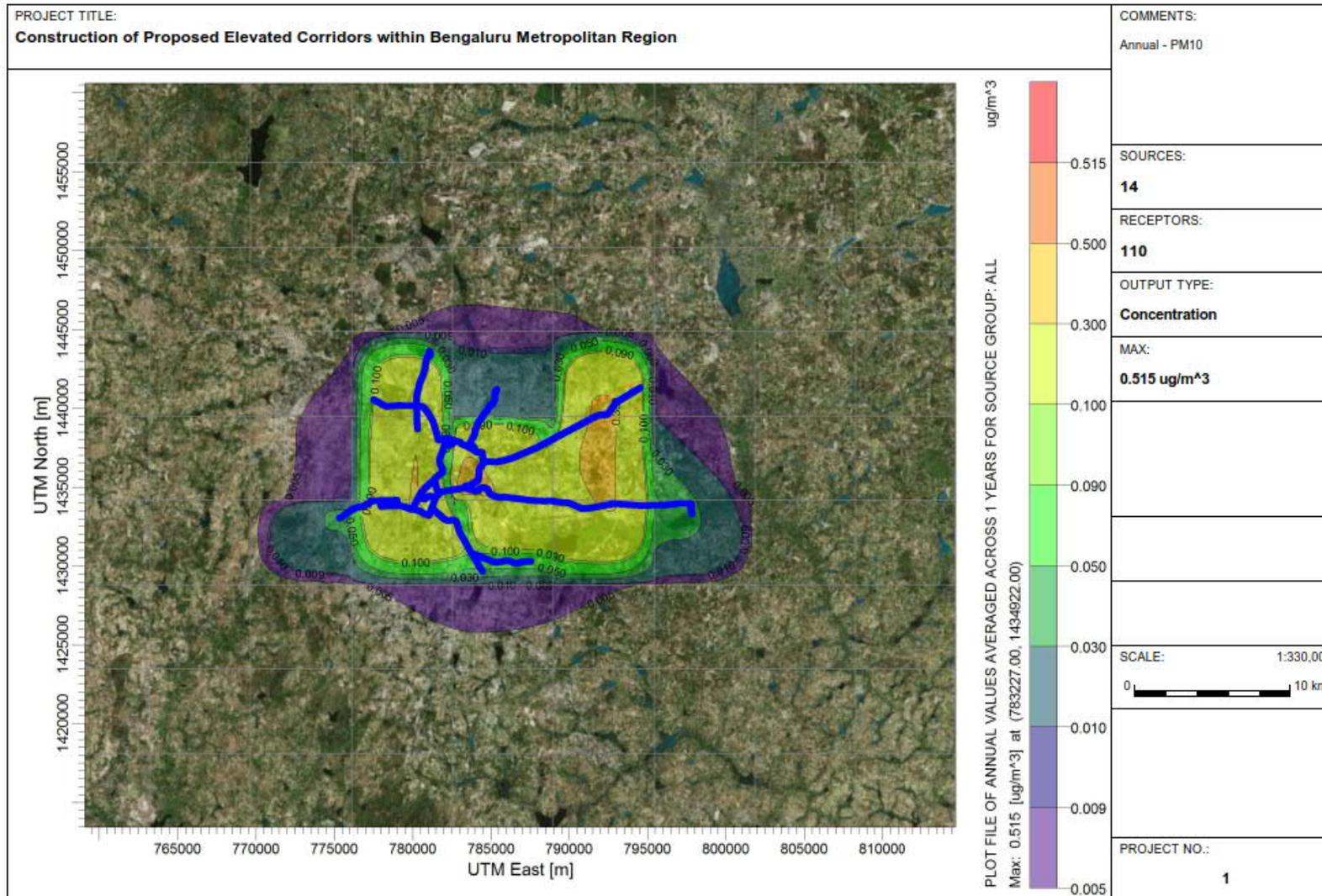


Table 4-18: Results of Air Quality Modelling for PM 10 (Annual)

Particulate Matter 10					
SI No	Receptor	Baseline in ($\mu\text{g}/\text{m}^3$)	Modeled results / Predicted Concentration ($\mu\text{g}/\text{m}^3$)	Cumulative ($\mu\text{g}/\text{m}^3$)	NAAQS ($\mu\text{g}/\text{m}^3$)
1	A1- Mekhri Circle	99.18	1.8768	101.0568	100
2	A2 - Wheeler Road Junction(Opp to HQ MEG Centre)	88.96	2.43771	91.39771	100
3	A3 - ITI Campus Junction along NH4	88.74	2.32568	91.06568	100
4	A4 - Indian Express/ Minsk Square	95.62	0.73446	96.35446	100
5	A5 - Marthalli Junction	91.71	2.24018	93.95018	100
6	A6 -Domlur SAARC Park	91.57	1.80165	93.37165	100
7	A7 - Life Style Juncton on Richmond Road	98.38	3.04753	101.42753	100
8	A8 - St.John's Medical College & Hospital (junction)	94.29	0.71492	95.00492	100
9	A9 - Minerva Circle	79.43	1.85682	81.28682	100
10	A10 - Deepanjalinagar ,Mysore Road	81.23	0.27048	81.50048	100

Figure 4-8: Air Quality Modelling for PM 2.5 (Annual)

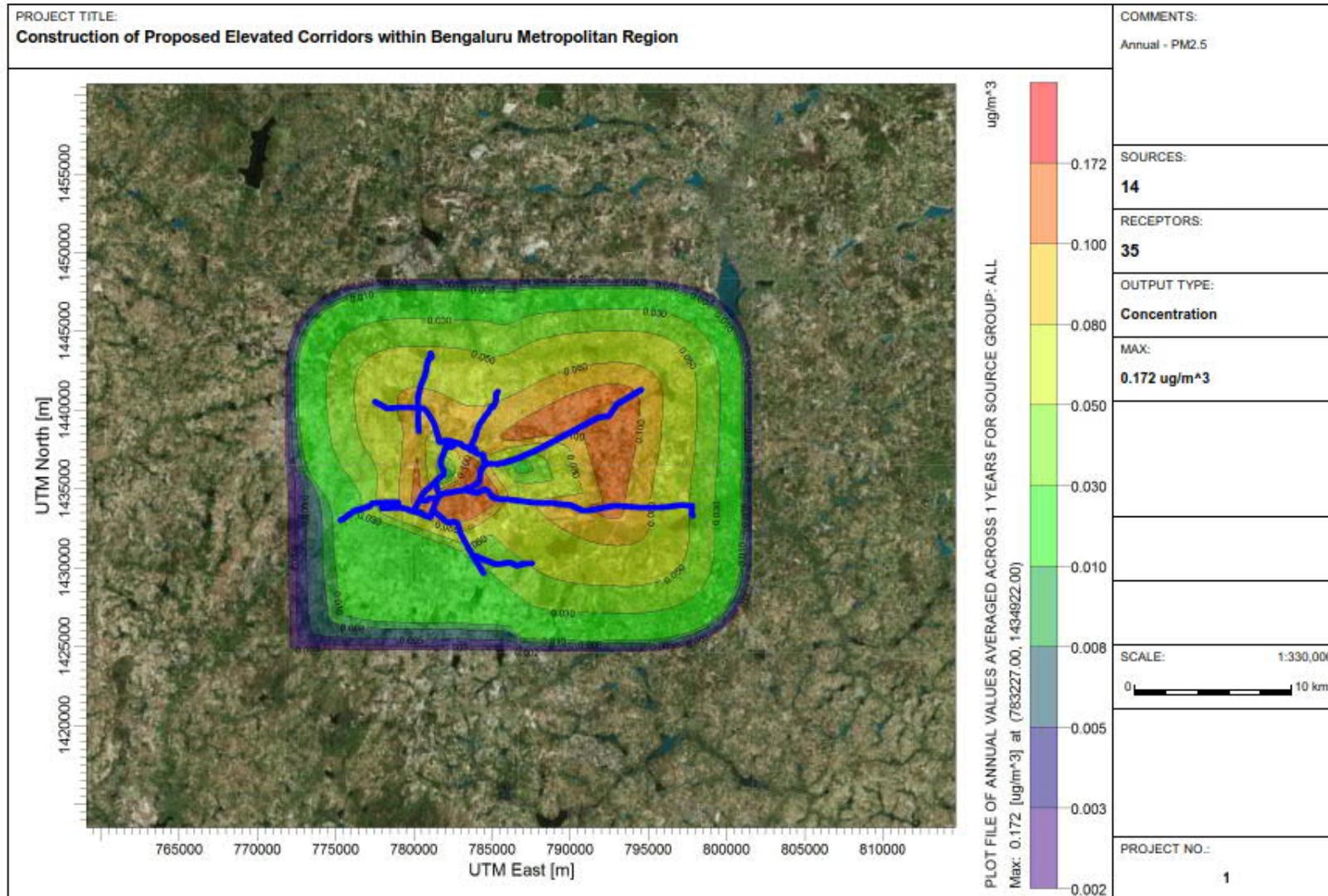


Table 4-19: Results of Air Quality Modelling for PM 2.5 (Annual)

Particulate Matter 2.5					
SI No	Receptor	Baseline in ($\mu\text{g}/\text{m}^3$)	Modeled results / Predicted Concentration ($\mu\text{g}/\text{m}^3$)	Cumulative ($\mu\text{g}/\text{m}^3$)	NAAQS ($\mu\text{g}/\text{m}^3$)
1	A1- Mekhri Circle	45.26	0.6256	45.8856	60
2	A2 - Wheeler Road Junction(Opp to HQ MEG Centre)	40.11	0.81257	40.92257	60
3	A3 - ITI Campus Junction along NH4	35.41	0.77523	36.18523	60
4	A4 - Indian Express/ Minsk Square	36.29	0.24482	36.53482	60
5	A5 - Marthalli Junction	38.42	0.74673	39.16673	60
6	A6 -Domlur SAARC Park	40.99	0.60055	41.59055	60
7	A7 - Life Style Juncton on Richmond Road	44.24	1.01584	45.25584	60
8	A8 - St.John's Medical College & Hospital (junction)	39.56	0.23831	39.79831	60
9	A9 - Minerva Circle	32.97	0.61894	33.58894	60
10	A10 - Deepanjalinagar ,Mysore Road	33.34	0.09016	33.43016	60

Figure 4-9: Air Quality Modelling for SO₂ (Annual)

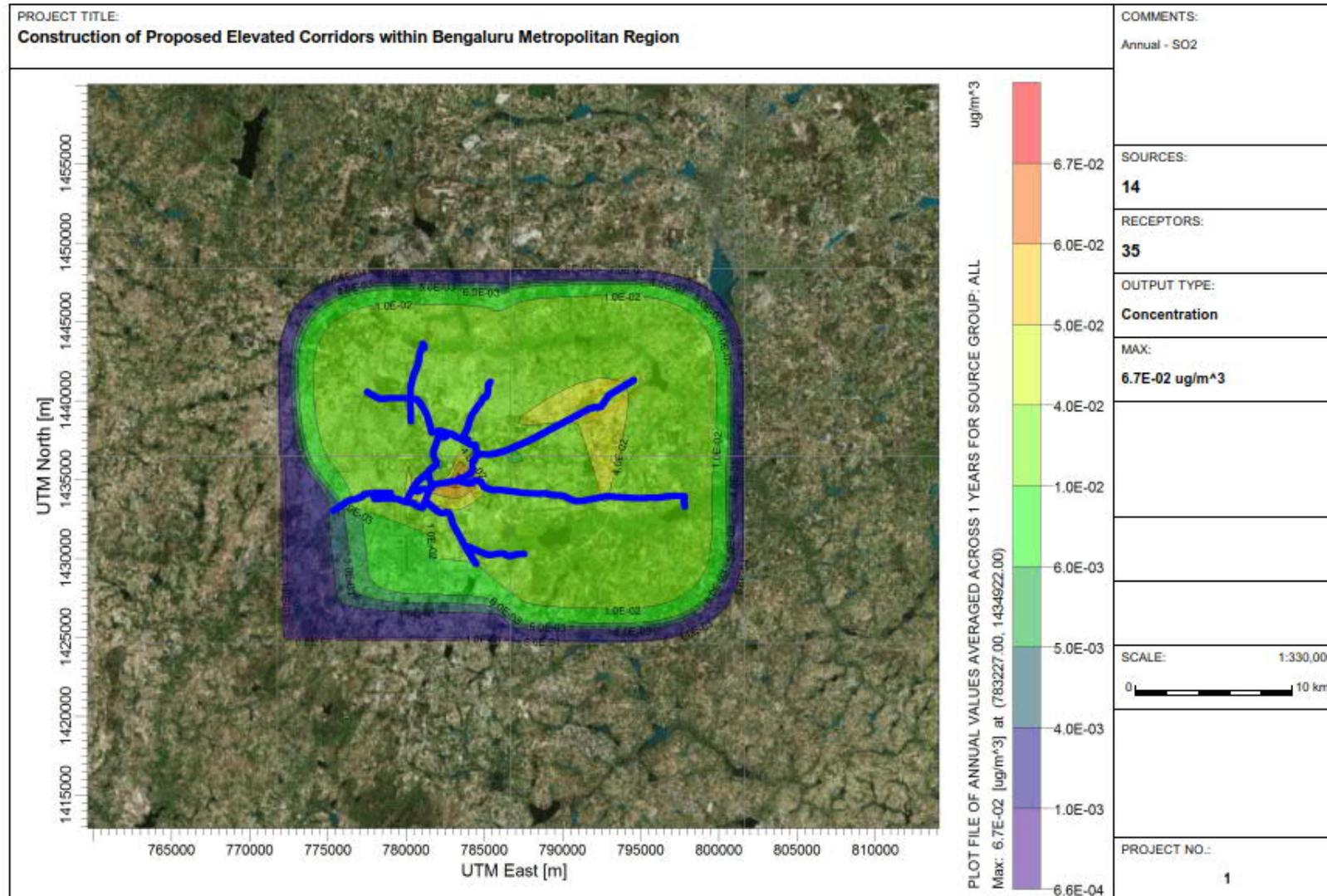


Table 4-20: Results of Air Quality Modelling for SO₂ (Annual)

SO ₂					
Sl. No.	Receptor	Baseline in (µg/m ³)	Modeled results / Predicted Concentration (µg/m ³)	Cumulative (µg/m ³)	NAAQS (µg/m ³)
1	A1- Mekhri Circle	7.72	0.11467	7.83467	80
2	A2 - Wheeler Road Junction(Opp to HQ MEG Centre)	7.86	0.12547	7.98547	80
3	A3 - ITI Campus Junction along NH4	7.06	0.1517	7.2117	80
4	A4 - Indian Express/ Minsk Square	6.73	0.03111	6.76111	80
5	A5 - Marthalli Junction	7.42	0.13041	7.55041	80
6	A6 -Domlur SAARC Park	7.15	0.09695	7.24695	80
7	A7 - Life Style Juncton on Richmond Road	7.82	0.204	8.024	80
8	A8 - St.John's Medical College & Hospital (junction)	7.82	0.0385	7.8585	80
9	A9 - Minerva Circle	6.48	0.12663	6.60663	80
10	A10 - Deepanjalinagar ,Mysore Road	6.51	0.01578	6.52578	80

Figure 4-10: Air Quality Modelling for NO2 (Annual)

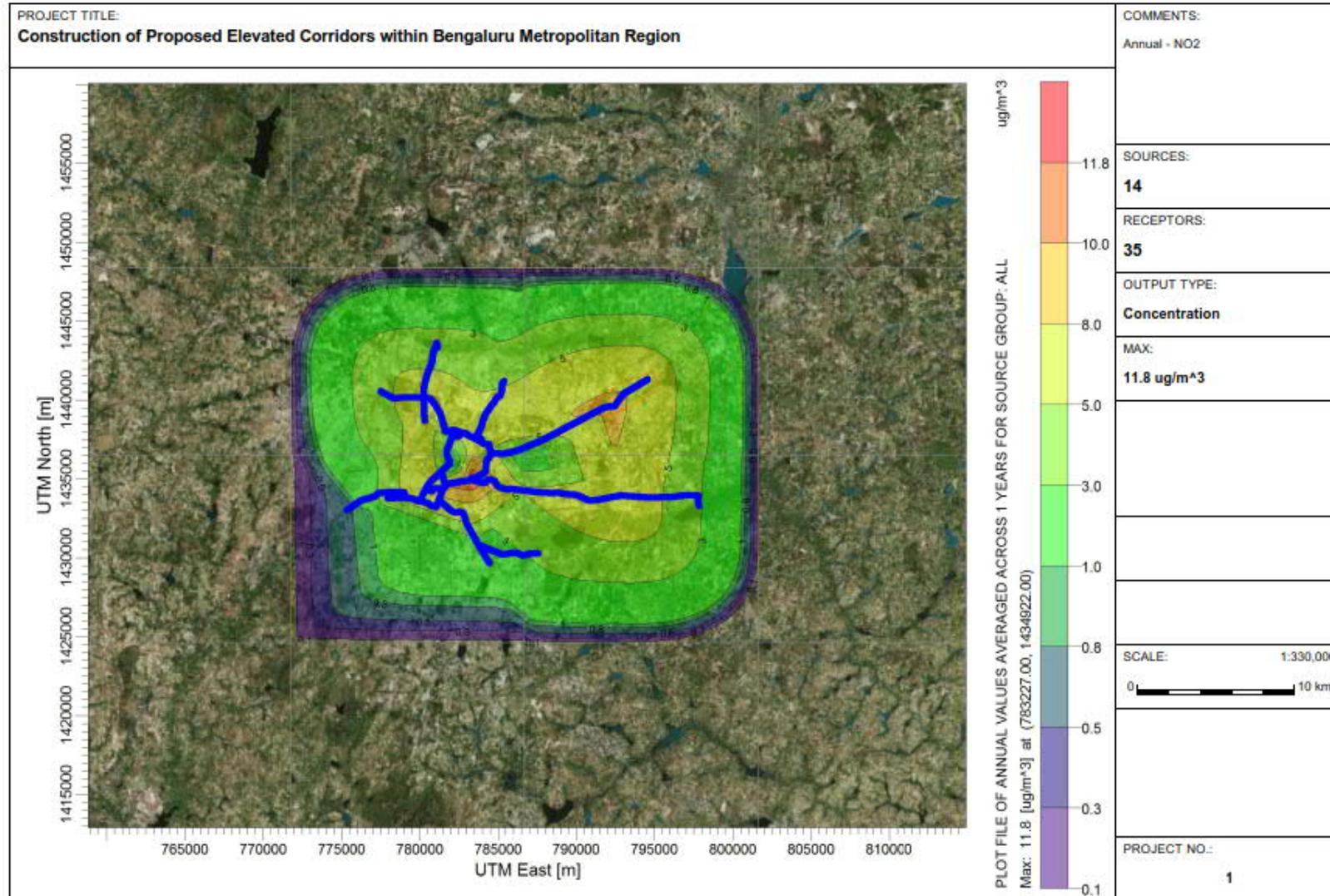


Table 4-21: Results of Air Quality Modelling for NO₂ (Annual)

NO ₂					
Sl. No.	Receptor	Baseline in (µg/m ³)	Modeled results / Predicted Concentration (µg/m ³)	Cumulative (µg/m ³)	NAAQS (µg/m ³)
1	A1- Mekhri Circle	28.78	20.44192	49.22192	80
2	A2 - Wheeler Road Junction(Opp to HQ MEG Centre)	30.46	22.17051	52.63051	80
3	A3 - ITI Campus Junction along NH4	26.82	26.82786	53.64786	80
4	A4 - Indian Express/ Minsk Square	28.11	5.50259	33.61259	80
5	A5 - Marthalli Junction	27.12	22.98981	50.10981	80
6	A6 -Domlur SAARC Park	27.35	17.09165	44.44165	80
7	A7 - Life Style Juncton on Richmond Road	24.9	35.93694	60.83694	80
8	A8 - St.John's Medical College & Hospital (junction)	28.11	6.70718	34.81718	80
9	A9 - Minerva Circle	24.24	22.62089	46.86089	80
10	A10 - Deepanjalinagar ,Mysore Road	24.67	2.70736	27.37736	80

Figure 4-11: Air Quality Modelling for CO (Anual)

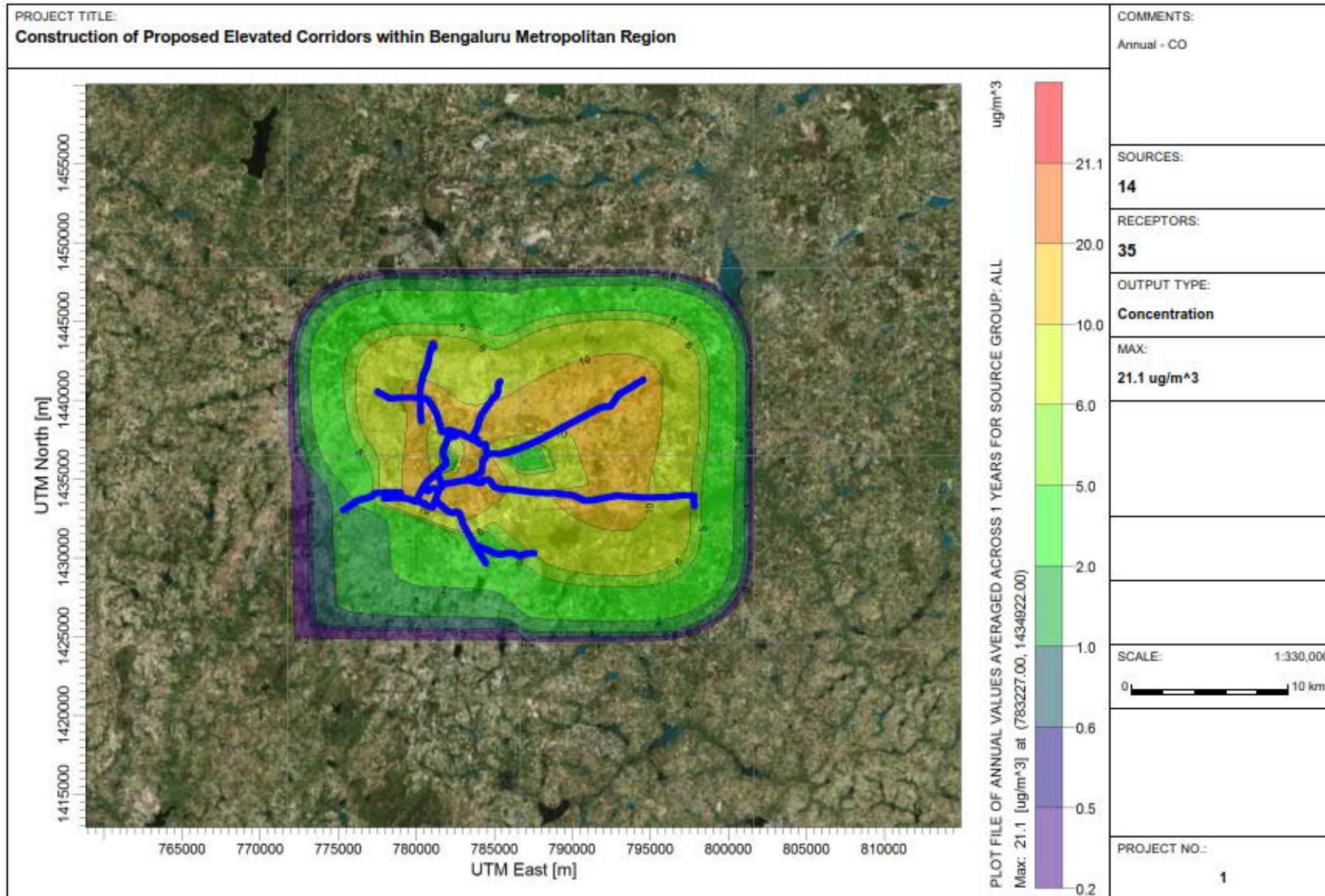


Table 4-22: Results of Air Quality Modelling for CO (Annual)

CO (Annual)					
Sl. No.	Receptor	Baseline in (mg/m3)	Modeled results / Predicted Concentration (mg/m3)	Cumulative (mg/m3)	NAAQS (mg/m3)
1	A1- Mekhri Circle	0.84	0.05011494	0.89011494	4
2	A2 - Wheeler Road Junction(Opp to HQ MEG Centre)	0.42	0.05552215	0.47552215	4
3	A3 - ITI Campus Junction along NH4	0.31	0.06797803	0.37797803	4
4	A4 - Indian Express/ Minsk Square	0.48	0.01342359	0.49342359	4
5	A5 - Marthalli Junction	0.63	0.05792516	0.68792516	4
6	A6 -Domlur SAARC Park	0.41	0.04283636	0.45283636	4
7	A7 - Life Style Juncton on Richmond Road	0.54	0.0887033	0.6287033	4
8	A8 - St.John's Medical College & Hospital (junction)	0.29	0.01669832	0.30669832	4
9	A9 - Minerva Circle	0.35	0.05700822	0.40700822	4
10	A10 - Deepanjalinagar ,Mysore Road	0.36	0.00626299	0.36626299	4

4.6 Noise Environment

Noise levels were monitored continuously for 24 hours at ten (10) locations within the study zone, using a spot noise measurement device. Noise level measurement locations were identified for assessment of existing noise level status, keeping in view the noise sensitive receptors, land use pattern, residential areas, etc.

Table 4-23: Noise Monitoring Location in the study area

Station	Location	Distance from the site, m	Direction from the site
N-1	Mekhri Circle	3.0	South West
N-2	Wheeler Road Junction	10.0	North & South
N-3	ITI Campus Junction along NH4	5.0	North
N-4	Indian Express	3.0	North West
N-6	Lifestyle Junction, Richmond Road	5.0	North
N-7	Domlur SAARC Park	5.0	South
N-8	Marathhalli Junction	5.0	South
N-9	St John Medical College & Hospital	3.0	East
N-10	Minerva Circle (Bangalore Medical College)	2.0	West

The results of the ambient noise level monitoring along with CPCB noise limits for day time and night time are presented in Error! Reference source not found..

Table 4-24: Noise Levels monitored at Mekhri Circle (N1)

Station Id.	Sample Location	Time Frequency	Parameters in dB(A)			CPCB Standards for Commercial Zone
			Max.	Min.	Leq	
N1	Mekhri Circle. GPS: 13°00'52.9"N, 77°35'01.25"E	6:01am to 10:00pm	88.5	52.3	69.65	65 dB(A) Day
		10:01pm to 6:00am	72.2	50.1	61.14	55 dB(A) Night

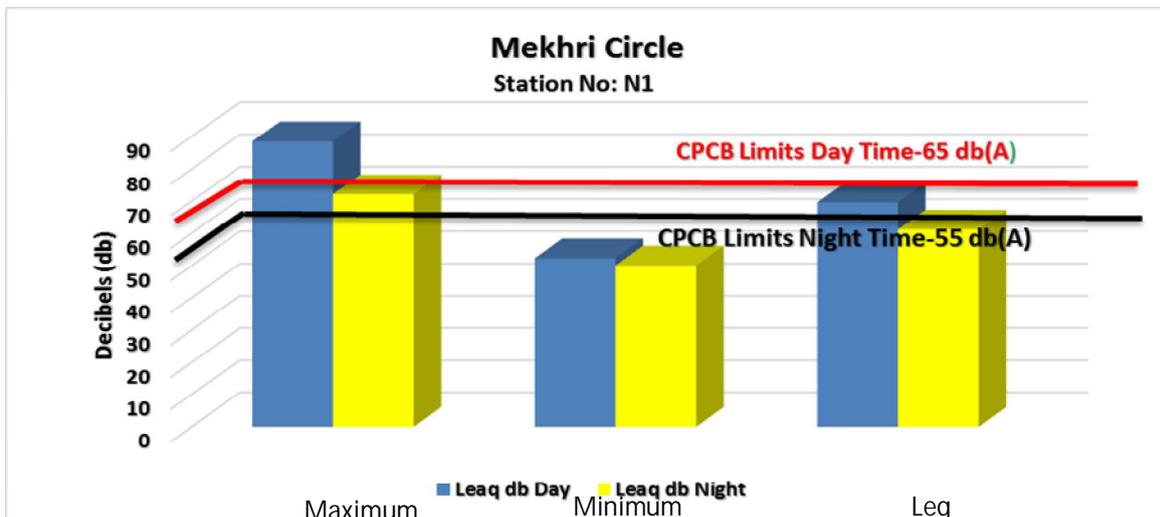


Table 4-25: Noise Levels monitored at Wheeler Road Junction (N2)

Station Id.	Sample Location	Time Frequency	Parameters in dB(A)			CPCB Standards for Commercial Zone
			Max.	Min.	Leq	
N2	Wheeler Road Junction (Opp to HQ MEG Centre) GPS: 12°59'28.2" N, 77°36'51.6" E	6:01am to 10:00pm	93.1	48.3	71.41	65 dB(A) Day
		10:01pm to 6:00am	71.0	35.1	59.38	55 dB(A) Night

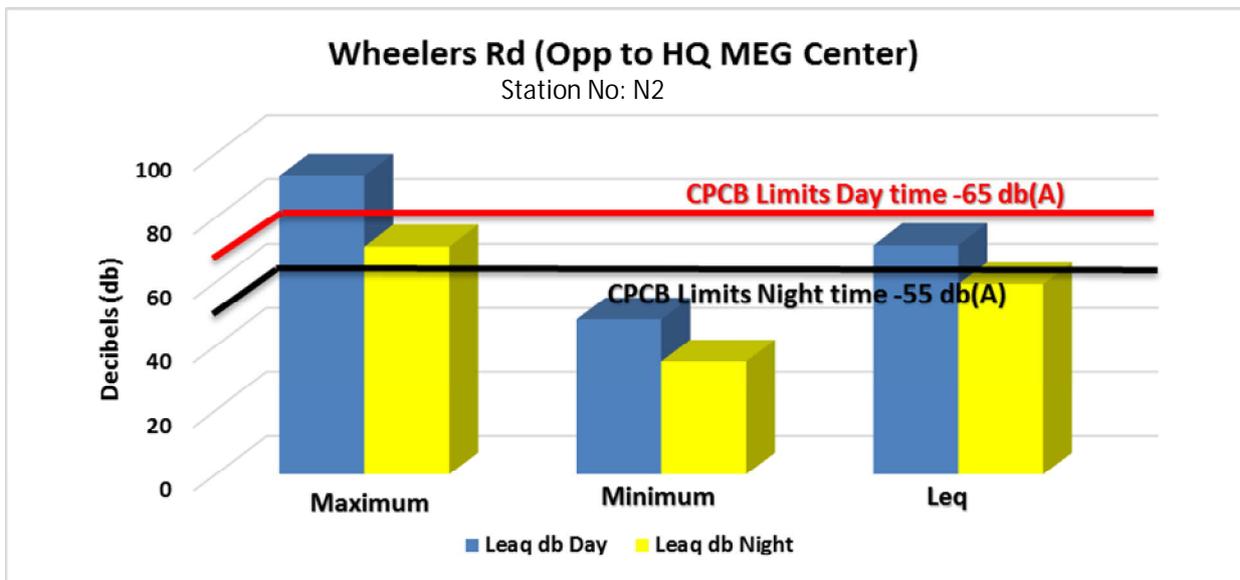


Table 4-26: Noise Levels monitored at ITI Campus Junction (N3)

Station No.	Sample Location	Time Frequency	Parameters in dB(A)			CPCB Standards for Commercial Zone
			Max.	Min.	Leq	
N3	ITI Campus Junction along NH-4. GPS: 13°00'29.44" N, 77°41'38.12" E	6:01am to 10:00pm	81.3	55.1	64.29	65 dB(A) Day
		10:01pm to 6:00am	86.4	43.5	62.98	55 dB(A) Night

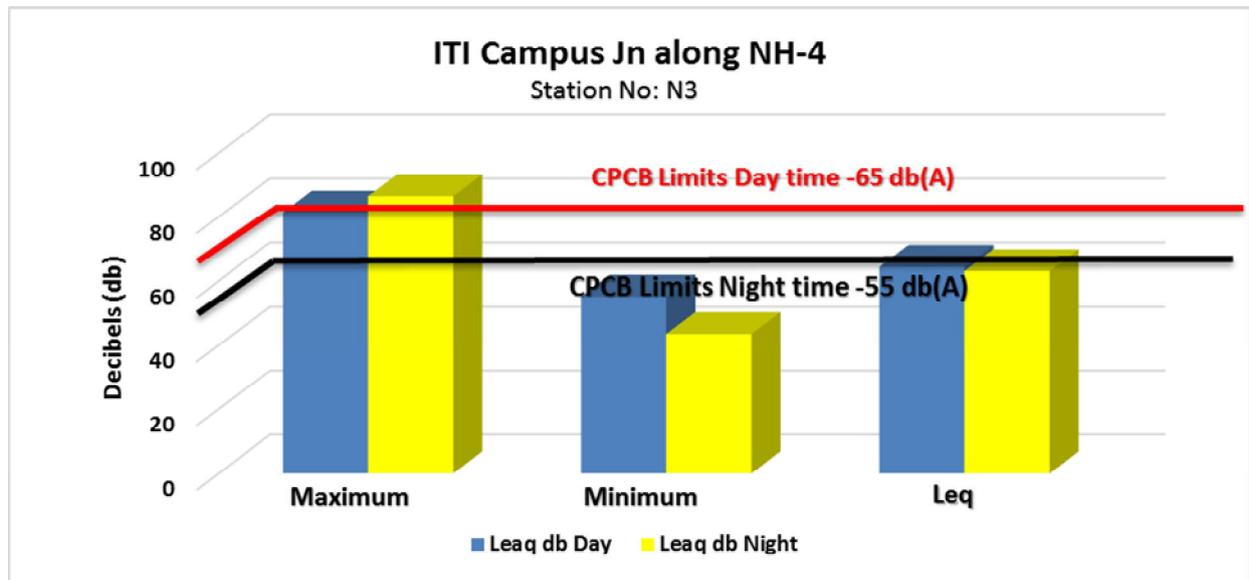


Table 4-27: Noise Levels monitored at Indian Express Circle (N4)

Station Id.	Sample Location	Time Frequency	Parameters in dB(A)			CPCB Standards for Commercial Zone
			Max.	Min.	Leq	
N4	Indian Express Circle GPS: 12°58'31.02" N, 77°36'6.12" E	6:01am to 10:00pm	84.7	50.5	69.54	65 dB(A) Day
		10:01pm to 6:00am	79.3	41.4	58.22	55 dB(A) Night

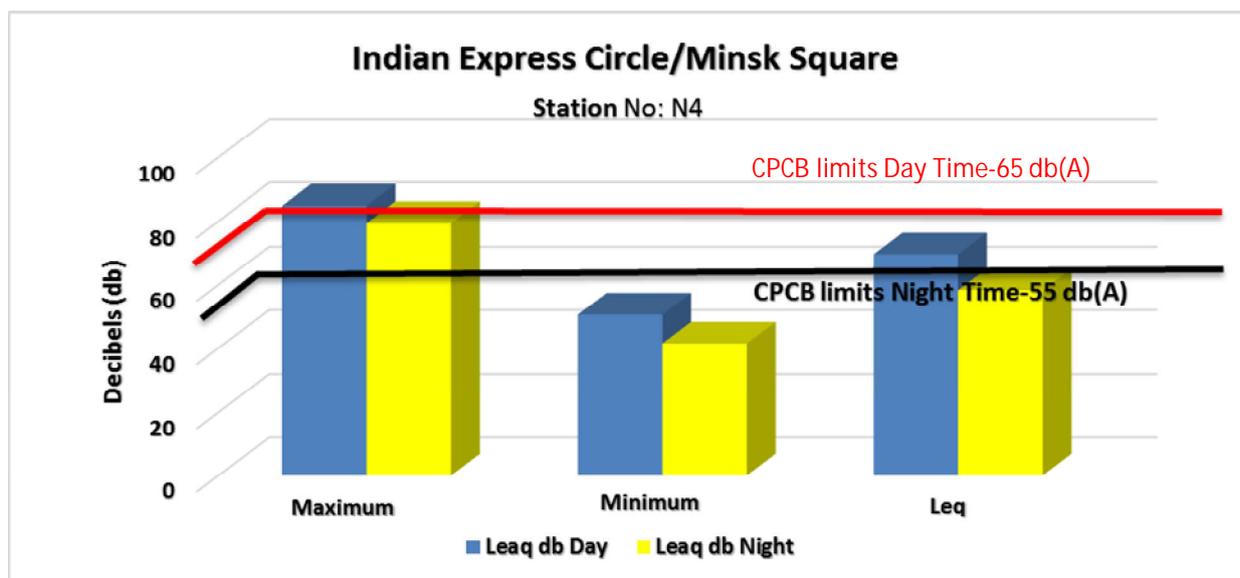




Table 4-28: Noise Levels monitored at Lifestyle Junction (N5)

Station Id.	Sample Location	Time Frequency	Parameters in dB(A)			CPCB Standards for Commercial Zone
			Max.	Min.	Leq	
N5	Lifestyle Junction on Richmond Road. GPS: 12°58'00.26" N, 77°36'38.23" E	6:01am to 10:00pm	83.1	48.6	67.85	65 dB(A) Day
		10:01pm to 6:00am	80.3	46.9	57.96	55 dB(A) Night

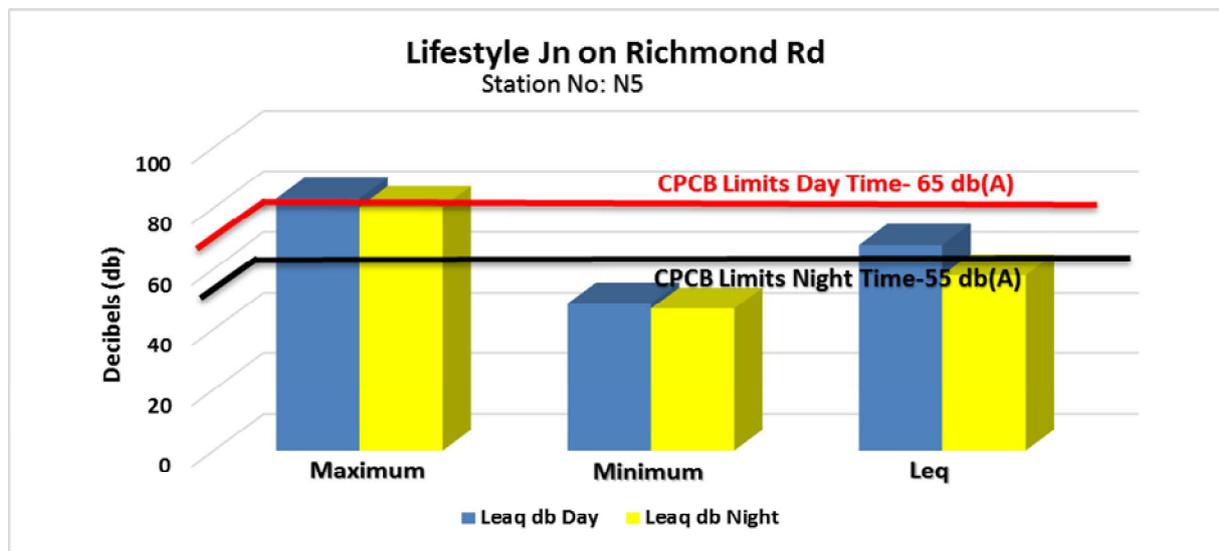


Table 4-29: Noise Levels monitored at Domlur SAARC Park (N6)

Station Id.	Sample Location	Time Frequency	Parameters in dB(A)			CPCB Standards for Commercial Zone
			Max.	Min.	Leq	
N6	Domlur SAARC Park. GPS: 12°57'37.89" N, 77°38'25.75" E	6:01am to 10:00pm	90.5	51.5	65.06	65 dB(A) Day
		10:01pm to 6:00am	70.5	54.9	61.54	55 dB(A) Night

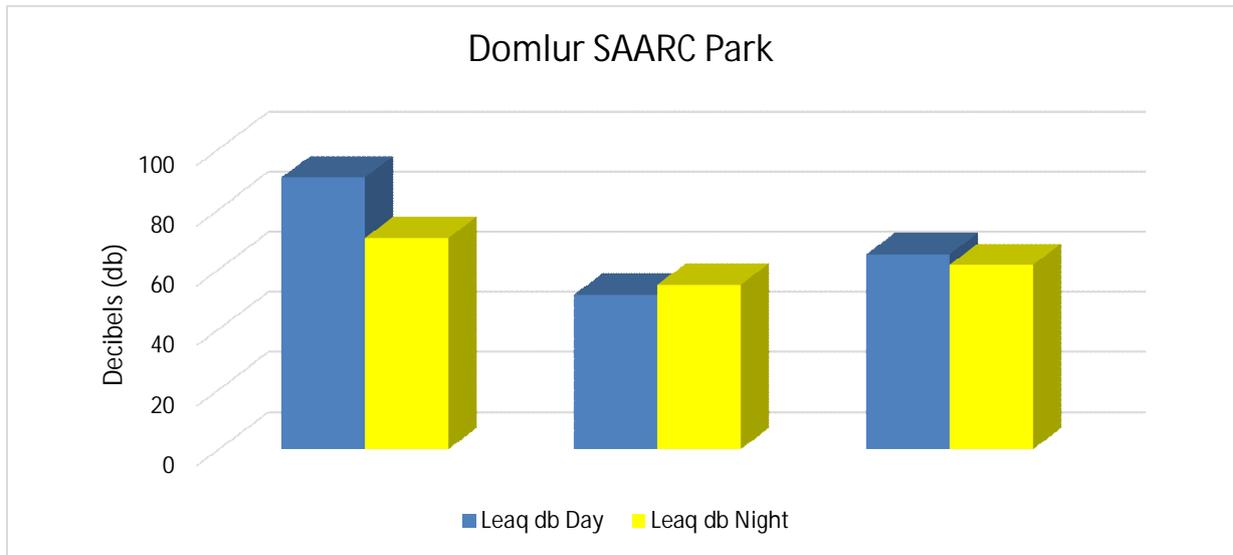


Table 4-30: Noise Levels monitored at Marathhalli Junction (N7)

Station Id.	Sample Location	Time Frequency	Parameters in dB(A)			CPCB Standards for Commercial Zone
			Max.	Min.	Leq	
N7	Marathhalli Junction. GPS: 12°57'24.05" N, 77°41'50.57" E	6:01am to 10:00pm	94.4	50.9	74.10	65 dB(A) Day
		10:01pm to 6:00am	86.7	62.6	72.24	55 dB(A) Night

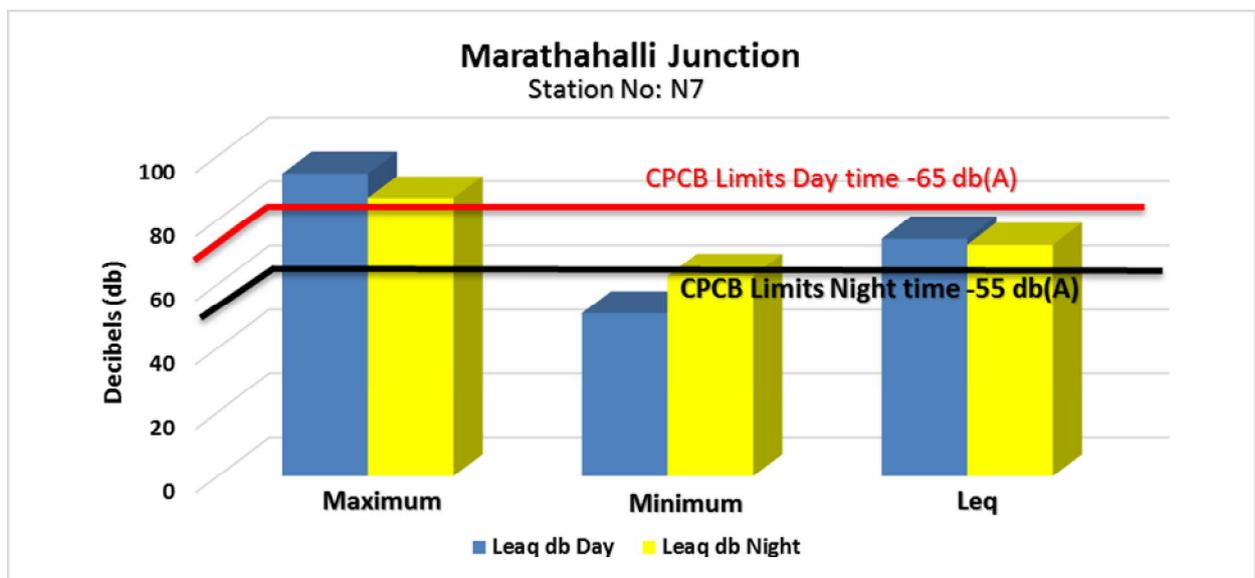




Table 4-31: Noise Levels monitored at St John’s Medical College (N8)

Station Id.	Sample Location	Time Frequency	Parameters in dB(A)			CPCB Standards for Commercial Zone
			Max.	Min.	Leq	
N8	St.John's Medical College & Hospital Junction. GPS: 12°55'48.69"N, 77°36'52.40"E	6:01am to 10:00pm	98.9	57.8	75.77	65 dB(A) Day
		10:01pm to 6:00am	81.1	50.0	74.30	55 dB(A) Night

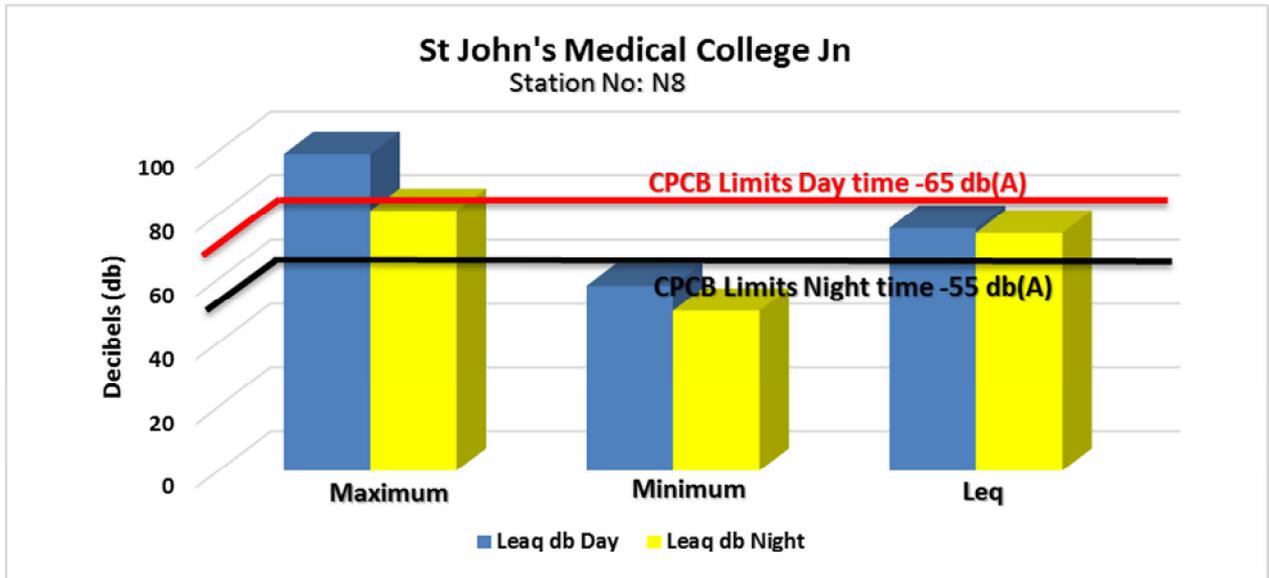


Table 4-32: Noise Levels monitored at Minerva Circle (N9)

Station Id.	Sample Location	Time Frequency	Parameters in dB(A)			CPCB Standards for Commercial Zone
			Max.	Min.	Leq	
N9	Minerva Circle. GPS: 12°57'32.02"N, 77°34'58.15"E	6:01am to 10:00pm	92.0	58.8	72.48	65 dB(A) Day
		10:01pm to 6:00am	84.2	47.5	69.06	55 dB(A) Night

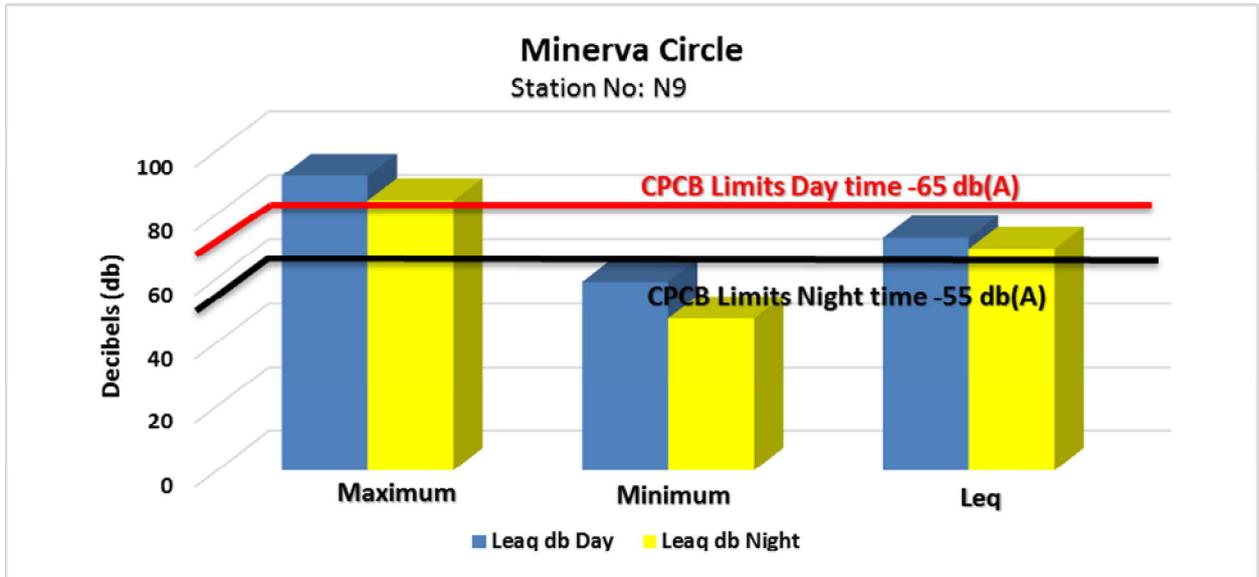


Table 4-33: Noise Levels monitored at Deepanjali Nagar (N10)

Station Id.	Sample Location	Time Frequency	Parameters in dB(A)			CPCB Standards for Commercial Zone
			Max	Min.	Leq	
N10	Deepanjalinagar, Mysore Road. GPS: 12°57'12.26"N, 77°32'31.74"E	6:01am to 10:00pm	89.6	42.9	75.34	65 dB(A) Day
		10:01pm to 6:00am	73.6	32.1	46.23	55 dB(A) Night

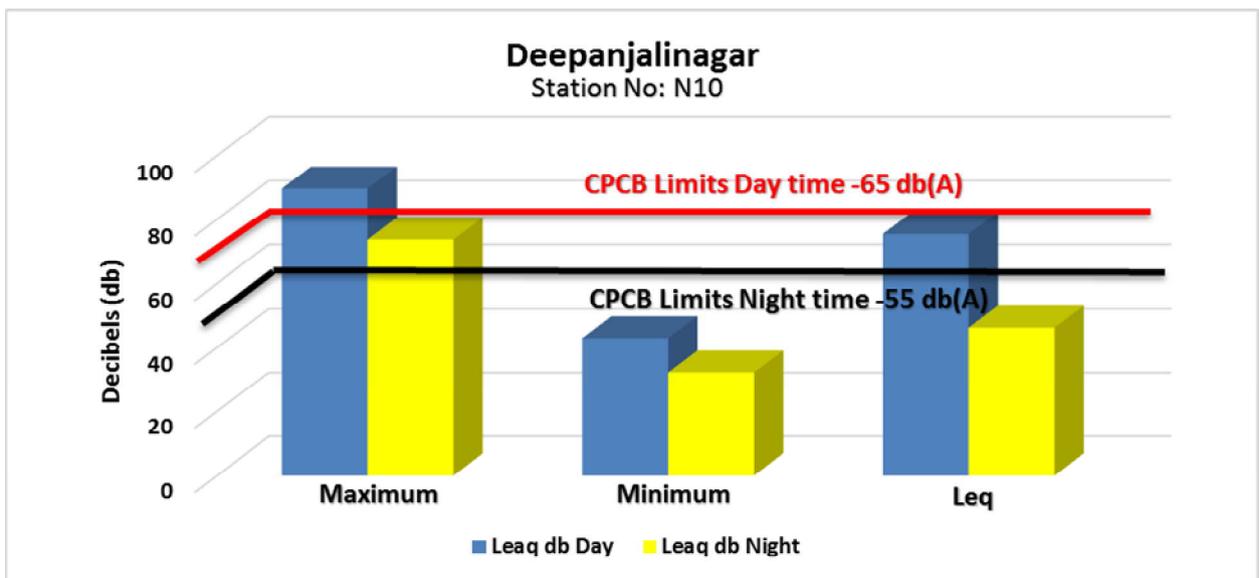
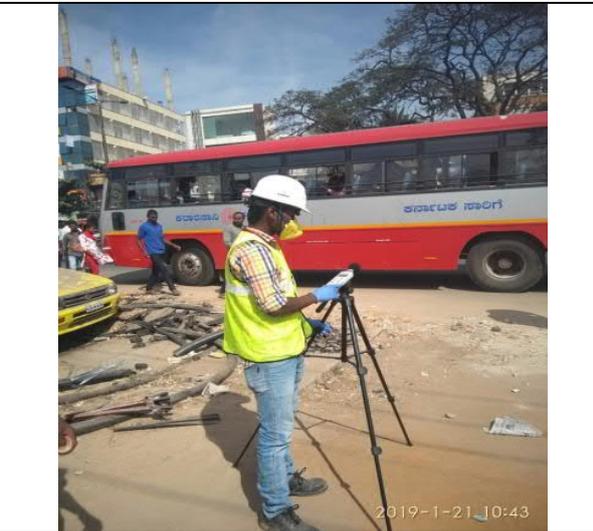
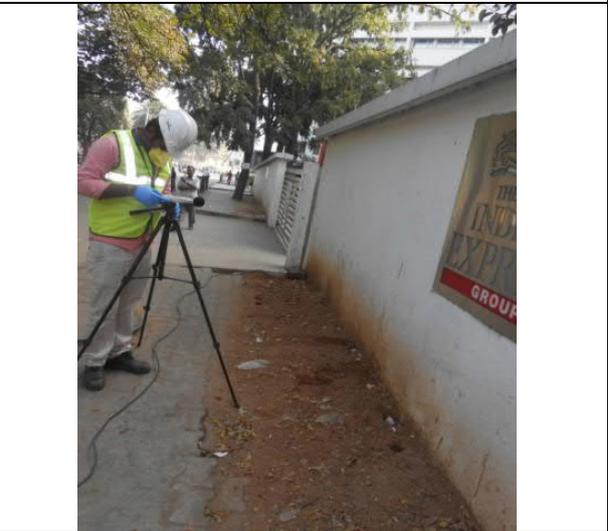
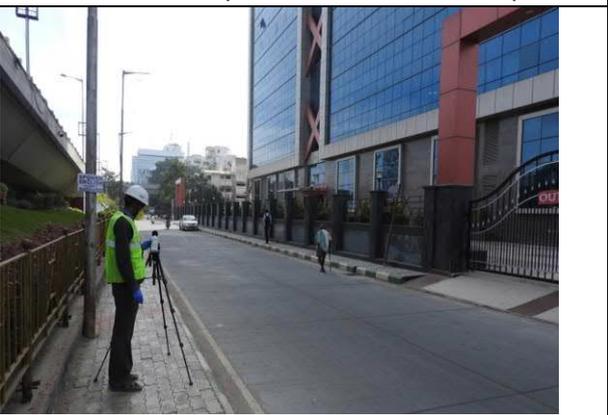


Figure 4-12: Photographs of Noise Levels Monitoring

	
A1 - Mekhri Circle	A2 - Wheelers Road Junction
	
A3 - ITI Campus Junction along NH4	A4 - Indian Express Circle/Minsk Square
	
A5 - Lifestyle Junction on Richmond Road	A6 - Domlur SAARC Park

	
<p>A7 – Marathahalli Junction</p>	<p>A8 - St. John's Medical College & Hospital</p>
	
<p>A9 - Minerva Circle</p>	<p>A10 - Deepanjalinagar, Mysore Road</p>

4.6.1 Inference on the monitored Noise levels

Noise levels were monitored at ten different locations along the project alignment. The noise levels at Mekhri Circle (N1) is 69.65 Leq, Wheeler Road (N2) is 71.41 Leq, Indian express (N4) is 69.54 Leq, Lifestyle Junction on Richmond road(N5) is 67.85 Leq, Marathahalli Junction (N7) is 74.1 Leq, St Johns medical college (N8) is 75.77 Leq, Minerva Circle (N9) is 72.48 Leq, Deepanjalinagar (N10) is 75.34 Leq are higher than the CPCB prescribed norms of 65 dB(A) during day. Noise levels at Mekhri Circle (N1) is 61.14 Leq, Wheeler Road (N2) is 59.38 Leq, ITI Campus (N3) is 62.98 Leq, Indian express (N4) is 58.22 Leq, Lifestyle Junction on Richmond road(N5) is 57.96 Leq, Domlur SAARC park (N6) is 61.54 Leq, Marathahalli Junction (N7) is 72.24 Leq, St Johns medical college (N8) is 74.3 Leq, Minerva Circle (N9) is 69.06 Leq have recorded noise levels higher than the CPCB prescribed limits of 55.8 dB (A) for night time. The details of maximum, minimum and Leq noise levels at all the ten noise monitoring stations are given in table along with respective graphical representations above.

4.7 Water Environment

No major rivers run through the city, though the Arkavathi and South Pennar cross paths at the Nandi Hills, 60 km to the north. River Vrishabhavathi, a minor tributary of the Arkavathi, arises within the city at Basavanagudi and flows through the city. The rivers Arkavathi and Vrishabhavathi together carry much of Bengaluru's sewage. There are two major river basins in the district namely Cauvery and South Pennar. Shimsha and Kanva River of the Cauvery basin is draining majority of the district and Anekal taluk is drained by South Pennar river of Ponnaiyar basin, which takes its birth from Nandi hills and flows towards south.

The city has a few freshwater lakes and water tanks such as Madivala tank, Hebbal tank, Ulsoor lake, Bellandur lake, Varthur lake and Sankey Tank. Groundwater occurs in silty to sandy layers of alluvial sediments and jointed quartzite.

Government after realizing the importance of waterbodies and the need for preservation and restoration of lakes transferred these lakes from Minor Irrigation Department to the Forest Department. The detail on lakes as per the Lake development working circle is given in Table 4-34 below.

Table 4-34: Abstract of tanks under Bengaluru Urban (Forest) Division

Sl. No.	Name of the Range / Unit	Number of Tanks	Extent In Ha
1	Bengaluru town unit	17	306.96
2	Banashankari unit	17	170.45
3	Rajajinagar unit	16	117.77
4	Tree unit	7	51.78
5	Kaggali pura range	7	54.97
6	K.R.Puram town unit	25	470.69
7	Ulsoor Unit	31	343.17
8	Yelahanka Range	6	60.30
	Total	126	1576.09

Table 4-35: Details of alignment passing near water bodies, lakes, rajakaluve, etc.

Sl. No.	Phase No.	Water bodies / Lakes	Name of the Corridor	LHS / RHS	Distance of pier foundation from Water body (m)	Location
1	Phase I Package - I	Hebbal Lake	NS	RHS	5	Near Hebbal Flyover
2	Phase II Package - I	KR Puram Lake,	EW-1	RHS	20	Along NH 4
3	Phase II Package - I	Benniganahalli Lake	EW-1	RHS	350	Swamy Vivekananda Road
4	Phase II Package - I	Pond near Sarvagna Nagar	EW-1	RHS	20	Swamy Vivekananda Road
5	Phase II Package - II	Ulsoor Lake	EW-1	LHS	5	Kensington Road

6	Phase V Package - I	Varthur Lake	EW-2	LHS/RHS	5	HAL Airport road and along SH 35 respectively
7	Phase V Package - I	Thubarahalli Lake	EW-2	RHS	120	Varthur road / HAL Airport road
8	Phase IV Package - I	Vrishabhavathi Nalla	EW-2	LHS / RHS	5	Mysore road
9	Phase I Package - III	Agara Lake	CC-1	LHS	30	Sarjapur main road
10	Phase II Package - II	Challkere	CC-3	RHS	30	100 ft. Ring road
11	Phase - II	Rajakaluve	CC-3		1	At Banasawadi
12	Phase I Package - II	Rajakaluve	NS		1	At Shathinagar Bus Depot

NGT's new no-development buffer zone order was issued on May 4, 2016. The NGT judgment, delivered on May 7, 2016 increased the buffer zone or no-construction zone around lakes and wetlands from 30 metres to 75 metres in the city. Para 3 of General Directions of NGT order stated that the distances in respect of buffer zone specified in the judgment shall be made applicable to all projects, and the authorities concerned are directed to incorporate such conditions in the projects to whom Environmental Clearance and other permissions are now granted not only around Bellandur lake, rajakaluves, Agara lake, but also all other lakes/wetlands in Bengaluru.

Examining the proposed elevated corridor project in the background of NGT Order, As mentioned in Table 4-35, it was found that some stretches of the proposed alignment passes within the prescribed buffer zones of some of the lakes. It is inevitable to take the alignment of proposed elevated corridor only on the existing major roads which have comparatively wider right of way (RoW) and are apparently located adjacent to the water bodies. The possible alternatives are limited as otherwise there will be severe impact on the buildings and structures.

Figure 4-13: Drainage map of Bengaluru Urban district

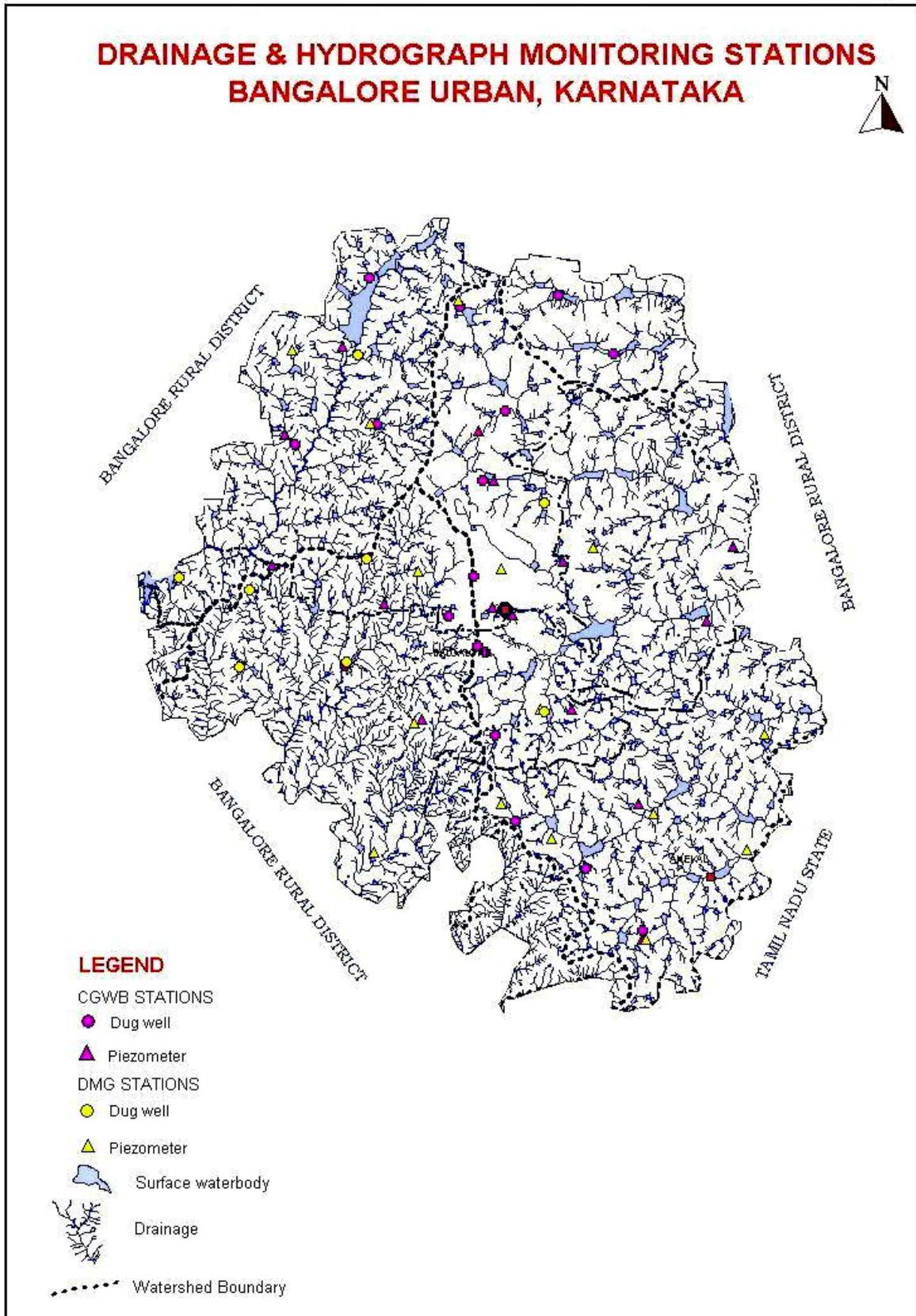
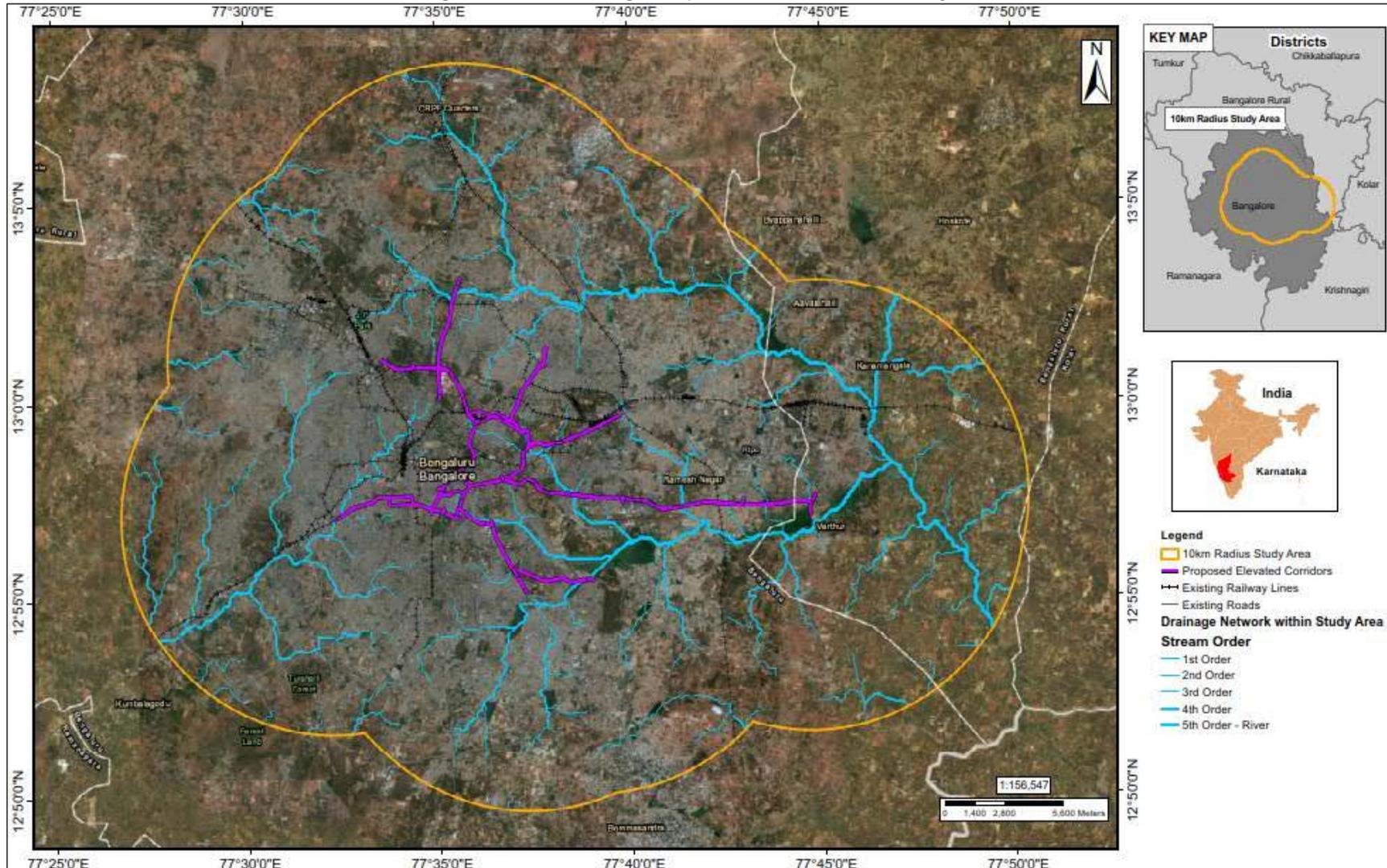


Figure 4-14: Drainage map for 10 km radius Study area



4.7.1 Water Environment

Seven surface water samples and three ground water samples were collected from the study area for analysis of water quality in the area (Table 4-36). Samples from Ponds and lakes were collected for surface water analysis while borewell water samples were collected to analyse the groundwater quality.

Table 4-36: Locations of Ground Water and Surface Water in Study Area

Sample Code	Name of the Location
SW-1	Hebbal Lake
SW-2	Ulsoor Lake
SW-3	Benneganahalli Lake
SW-4	KR Puram Lake
SW-5	Varthur Lake
SW-6	Agara Lake
SW-7	Vrishabhavathi Stream/River
GW-1	Bore Well along HAL Airport road
GW-2	Bore Well near GG Palya along Tumkur road
GW-3	Bore Well along Dodda Banaswadi Main Road

The surface water samples were analyzed for parameters as specified in IS: 10500 (2012) standards, "Drinking Water- Specifications" and analyzed as per methods specified in IS: 3025.

Table 4-37: Results of Surface Water Analysis

Sl. No	Parameters	Std. IS 10500:2012 (Second Revision)		Unit	SW1	SW2	SW3	SW4	SW5	SW6	SW7
		AL	PL								
1.	pH	6.5-8.5		-	8.64	7.91	8.87	7.66	7.91	8.66	7.73
2.	Colour	5	15	Hazen	<1	<1	<1	<1	<1	<1	<1
3.	Odour	Agreeable		--	Agreeable	Agreeable	Agreeable	Disagreeable	Agreeable	Agreeable	Agreeable
4.	Turbidity	1	5	NTU	8.04	25.4	3.35	35.1	19.7	3.38	2.15
5.	Total Dissolved Solids	500	2000	mg/L	1260	1140	810	904	525.0	342.0	780.0
6.	Dissolved Oxygen	Not Specified		mg/L	4.8	4.9	4.0	4.2	4.4	Nil	4.3
7.	Total Hardness as CaCO ₃	200	600	mg/L	312	280	168.0	244	96.0	100	188
8.	Alkalinity as CaCO ₃	200	600	mg/L	484	512	140	432	88.0	124	224
9.	Nitrate as NO ₃	45		mg/L	9.86	19.05	6.48	32.74	9.03	4.48	18.28
10.	Phosphate as PO ₄	Not Specified		mg/L	26.37	4.25	0.45	24.24	BDL	0.12	BDL
11.	Chloride as Cl	250	1000	mg/L	218.37	182.63	115.14	127.05	156.83	63.52	160.80
12.	Sulphate as SO ₄	200	400	mg/L	59.04	26.72	78.79	46.02	51.04	7.99	47.73
13.	Sodium as Na	Not Specified		mg/L	246	156	98	144	104	39.66	107.77
14.	Potassium as K	Not Specified		mg/L	24.76	22.17	14.20	20.38	13.70	12.96	17.91
15.	Calcium as Ca	75	200	mg/L	65.6	92.8	38.4	57.6	24.0	20.8	44.8
16.	Magnesium as Mg	30	100	mg/L	35.96	11.66	17.49	24.3	8.74	11.66	18.46
17.	Fluoride as F	1	1.5	mg/L	0.28	0.22	0.70	0.34	0.94	0.17	0.93
18.	Iron as Fe	0.3		mg/L	0.10	0.36	0.26	0.65	0.48	0.21	0.28
19.	Manganese as Mn	0.1	0.3	mg/L	0.110	0.113	0.067	0.134	0.022	0.040	0.261
20.	Copper as Cu	0.05	1.5	mg/L	0.003	0.005	0.004	0.041	BDL	BDL	0.004
21.	Zinc as Zn	5	15	mg/L	0.005	0.014	0.009	0.189	0.007	0.005	0.007
22.	Mercury as Hg	0.001		mg/L	BDL	BDL	BDL	0.020	BDL	BDL	BDL
23.	Total Chromium as Cr	0.05		mg/L	BDL	BDL	BDL	0.020	BDL	BDL	BDL
24.	E-coli	Not Specified		MPN Index/10	920	2100	240	110 x 10 ⁴	170	1700	920



Detailed Feasibility Report

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Sl. No	Parameters	Std. IS 10500:2012 (Second Revision)		Unit	SW1	SW2	SW3	SW4	SW5	SW6	SW7
		AL	PL								
				0ml							

Table 4-38: Results of Ground Water Analysis

Sl. No.	Parameters	Std. IS 10500:2012 (Second Revision)		Unit	GW1	GW2	GW3
		AL	PL				
1.	pH	AL	PL	-	8.04	6.68	6.70
2.	Colour	6.5-8.5		Hazen	<1	<1	<1
3.	Odour	5	15	--	Agreeable	Agreeable	Agreeable
4.	Turbidity	Agreeable		NTU	0.15	0.38	0.40
5.	Total Dissolved Solids	1	5	mg/L	790	1025	1030
6.	Dissolved Oxygen	500	2000	mg/L	5.1	4.9	5.0
7.	Total Hardness as CaCO ₃	Not Specified		mg/L	192	468	348
8.	Alkalinity as CaCO ₃	200	600	mg/L	352	228	296
9.	Nitrate as NO ₃	200	600	mg/L	35.15	35.40	25.95
10.	Phosphate as PO ₄	45		mg/L	0.70	BDL	BDL
11.	Chloride as Cl	Not Specified		mg/L	101.24	180.65	166.75
12.	Sulphate as SO ₄	250	1000	mg/L	31.29	106.09	79.25
13.	Sodium as Na	200	400	mg/L	120	39.62	107.59
14.	Potassium as K	Not Specified		mg/L	0.99	8.26	4.74
15.	Calcium as Ca	Not Specified		mg/L	36.8	108.8	92.8
16.	Magnesium as Mg	75	200	mg/L	24.3	47.62	28.18
17.	Fluoride as F	30	100	mg/L	0.92	0.70	0.62
18.	Iron as Fe	1	1.5	mg/L	BDL	BDL	BDL
19.	Manganese as Mn	0.3		mg/L	0.008	BDL	0.137
20.	Copper as Cu	0.1	0.3	mg/L	0.003	0.003	BDL
21.	Zinc as Zn	0.05	1.5	mg/L	0.026	0.019	0.874
22.	Mercury as Hg	5	15	mg/L	BDL	BDL	BDL
23.	Total Chromium as Cr	0.001		mg/L	BDL	0.003	BDL
24.	E-coli	0.05		MPN Index/10 0ml	<1.8	<1.8	<1.8

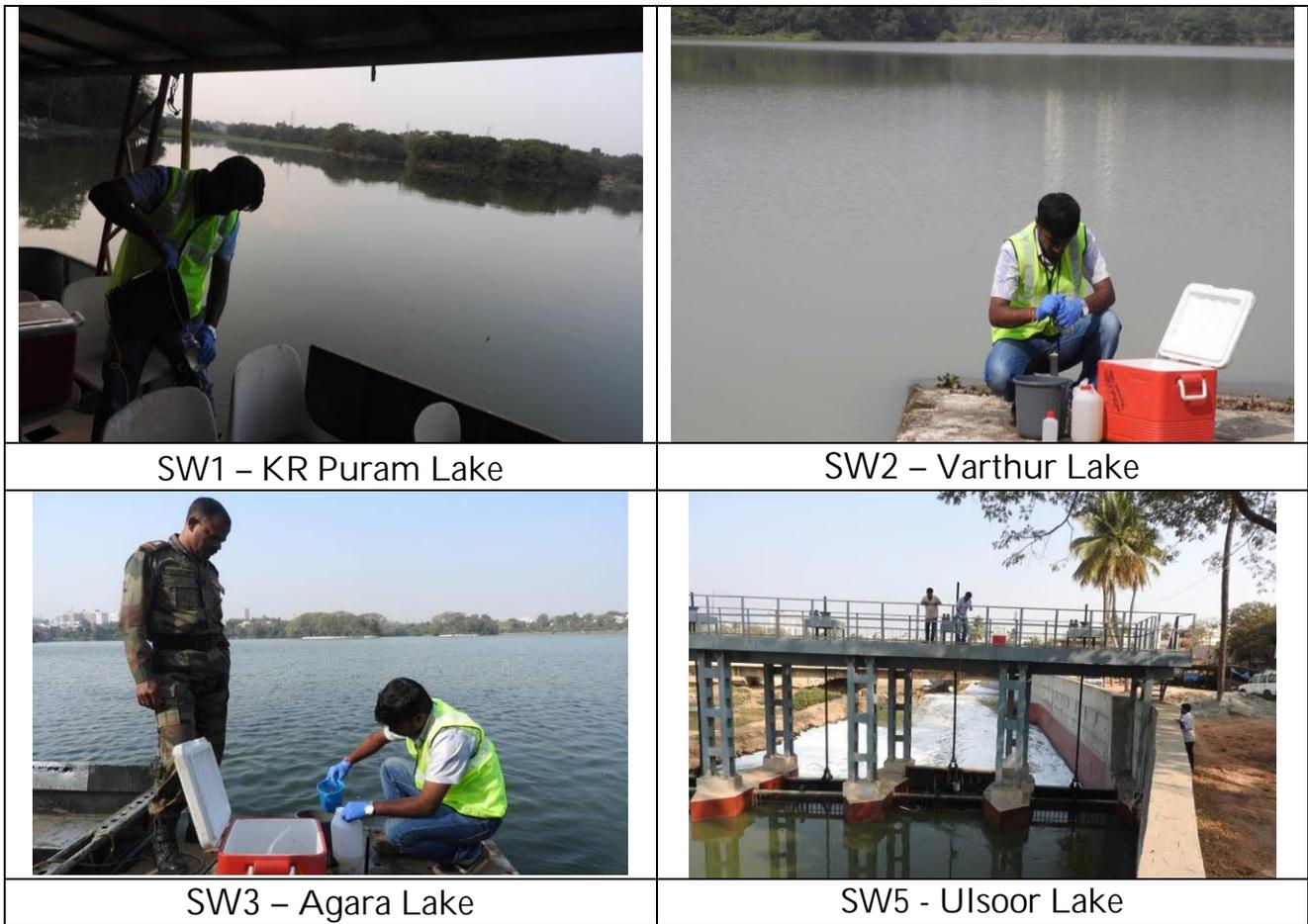
AL – Acceptable Limit, PL – Permissible Limit, BDL: Below Detectable Limit

Table 4-39: Water Quality Standards by CPCB for Best Designated Usage

Designated-Best-Use	Class of water	Criteria
Drinking Water Source without conventional treatment but after disinfection	A	Total Coliforms Organism MPN/100ml shall be 50 or less
		pH between 6.5 and 8.5
		Dissolved Oxygen 6mg/l or more
		Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
Outdoor bathing (Organized)	B	Total Coliforms Organism MPN/100ml shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more
		Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Drinking water source after conventional treatment and	C	Total Coliforms Organism MPN/100ml shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more
		Biochemical Oxygen Demand 5 days 20°C 3mg/l or less

Designated-Best-Use	Class of water	Criteria
disinfection		
Propagation of Wild life and Fisheries	D	pH between 6.5 to 8.5 Dissolved Oxygen 4mg/l or more Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	pH between 6.0 to 8.5 Electrical Conductivity at 25°C micro mhos/cm Max.2250 Sodium absorption Ratio Max. 26 Boron Max. 2mg/l
-	Below-E	Not Meeting A, B, C, D & E Criteria

Figure 4-15: Photographs of Water Sampling



	
<p>SW6-Vrishabhvati River</p>	<p>GW1 - Borewell along HAL Airport road</p>
	
<p>GW2- Borewell near GG Palya along Tumkur road</p>	<p>GW3 - Bore well along Dodda Banaswadi</p>

4.7.2 Inference on the water quality analysis

The inferences of the analysis of water samples are as follows:

SW-1 - KR Puram Lake:

The measured values for the above parameters for those standards have been specified, were observed to be within the prescribed IS 10500 Standard of 2012 (2 Rev), except pH & Turbidity.

SW-2 - Varthur Lake:

The measured values for the above parameters for those standards have been specified, were observed to be within the prescribed IS 10500 Standard of 2012 (2 Rev), except Turbidity & Iron.

SW-3 - Agara Lake:

The measured values for the above parameters for those standards have been specified, were observed to be within the prescribed IS 10500 Standard of 2012 (2 Rev), except pH.

SW-4 - Vrisabhavati River:

The measured values for the above parameters for those standards have been specified, were observed to be within the prescribed IS 10500 Standard of 2012 (2 Rev), except Odour, Turbidity & Iron.

SW-5 - Hebbal Lake:

The measured values for the above parameters for those standards have been specified, were observed to be within the prescribed IS 10500 Standard of 2012 (2 Rev), except Turbidity & Iron.

SW-6 - Ulsoor Lake:

The measured values for the above parameters for those standards have been specified, were observed to be within the prescribed IS 10500 Standard of 2012 (2 Rev), except pH.

SW-7 - Bennganahalli Lake:

The measured values for the above parameters for those standards have been specified, were observed to be within the prescribed IS 10500 Standard of 2012 (2 Rev).

GW-1 - Bore hole along HAL Road:

The measured values for the above parameters for those standards have been specified, were observed to be within the prescribed IS 10500 Standard of 2012 (2 Rev).

GW-2 - Near GG Palya Tumkur Road:

The measured values for the above parameters for those standards have been specified, were observed to be within the prescribed IS 10500 Standard of 2012 (2 Rev).

GW-3 - Borehole along Doddabanasawadi Main Road:

The measured values for the above parameters for those standards have been specified, were observed to be within the prescribed IS 10500 Standard of 2012 (2 Rev).

4.8 Land Environment

Bengaluru (Urban) district consists of Charnokites and peninsular gneisses complex. The peninsular gneiss is the dominant group of rocks and covers two-thirds of the area and includes granites, gneisses and migmatites. Small patches of porphyritic granite are also seen in Bengaluru South and Bengaluru North taluks.

Bengaluru falls under the expanse of Peninsular Gneissic Complex. The main rock type in the district is gneissic rock and intrusions of granites and migmatites. Bangalore district lies over a hard and moderately dense gneissic basement which dates back to Archean era (2500-3500 million years). They recorded the principal rock formations namely upper Vindhyan super group, Deccan traps and Inter-trappean beds, alluvium and laterite. These rock types represent different time segments within Archean era.

The analysis of the soil type reveals that the study area is predominantly covered by red loamy and sandy soils, laterite soil. Red loamy and sandy soils generally occur on hilly to undulating land slope on granite and gneissic terrain. The soils are light textured and are highly leached in nature with good infiltration rate. It is mainly seen in the eastern and southern parts of Bangalore North and South taluks. Laterite soils occur on undulating terrain forming plain to gently sloping topography of peninsular gneissic region. It is mainly covered in Anekal taluk and western parts of Bangalore North and South taluks.

Table 4-40: Details of Soil Sampling Locations

Location Code	Soil Sampling Locations
S-1	Lalbagh Park
S-2	Cubban Park
S-3	ITI Campus, NH4
S-4	Kendriya Vidyalaya near Mekhri Circle
S-5	SAARC Park, Domlur
S-6	St John Medical College Grounds, Sarjapur Main Road
S-7	MV Garden, Ulsoor
S-8	Park near Banasawadi Fire Station
S-9	Coles Park
S-10	HAL Airport Road



Table 4-41: Results of Soil Quality Analysis

Sl. No	Parameters	Unit	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
1.	pH	-	6.90	7.06	7.12	6.85	7.02	7.10	7.26	6.61	7.04	7.40
2.	Electrical Conductivity	µs/cm	103.1	109.9	126.9	171.5	118.3	161.7	147.8	108.7	1080	286
3.	Organic Carbon	Percent	0.35	0.29	0.23	0.29	0.35	0.17	0.23	0.29	0.17	0.11
4.	Sand	Percent	62.96	58.96	54.96	60.96	66.96	60.96	64.96	56.96	62.96	70.96
5.	Silt	Percent	27.28	29.28	31.28	31.28	21.28	25.28	23.28	29.28	27.28	21.28
6.	Clay	Percent	9.76	11.76	13.76	7.76	11.76	13.76	11.76	13.76	9.76	7.76
7.	Porosity	Percent	41.43	28.5	44.58	25.25	53.46	36.53	45.41	41.55	39.41	56.6
8.	Texture	-	Sandy Loam									
9.	Available Nitrogen as N	kg/ha	235.79	215.25	150.99	223.91	174.48	141.59	234.82	174.42	199.44	122.93
10.	Available Potassium as K	kg/ha	441.16	220.52	100.55	585.76	202.38	201.48	205.52	326.36	306.09	192.86
11.	Available Phosphorus as P ₂ O ₅	kg/ha	184.87	100.59	135.93	386.05	116.90	367.02	342.2	133.21	187.58	122.34
12.	Calcium as Ca	meq/L	7.2	5.0	6.4	5.9	6.6	2.5	7.0	5.1	4.2	5.5
13.	Magnesium as Mg	meq/L	0.9	2.7	1.6	1.9	2.3	1.1	1.1	0.9	1.3	0.7
14.	Sodium as Na	mg/100gm	4.50	1.96	3.07	3.91	1.40	5.73	3.70	2.34	25.21	3.78
15.	Boron as B	mg/100gm	18.43	17.25	13.16	19.52	5.99	24.51	BDL	3.13	8.12	BDL
16.	Iron as Fe	mg/kg	7147.1	4508.5	4629.2	6035.1	4265.8	4462.3	5053.0	5301.9	5453.1	2930.2
17.	Zinc as Zn	mg/kg	16.2	9.6	16.6	10.9	30.8	4.5	20.0	13.2	13.5	6.7
18.	Molybdenum as Mo	mg/kg	BDL									
19.	Copper as Cu	mg/kg	9.1	3.7	7.3	7.3	10.2	3.1	7.8	5.0	5.0	4.5
20.	Aluminium as Al	mg/kg	3106.9	2449.8	2330.0	3479.6	1992.3	1431.2	2148.0	2630.3	2587.8	1735.0

BDL: Below Detectable Limit.

Figure 4-16: Photographs of Soil Sampling



S7 - Makkala Koota Park (Near KIMS)	S8 - St John Medical College Grounds
	
S9 - MV Garden, Ulsoor	S10 - Park Near Banasawadi Fire Station

4.9 Hydrogeology

Granites and Gneisses of peninsular gneissic group constitute major aquifers in the urban district of Bangalore. Laterites of Tertiary age occur as isolated patches capping crystalline rocks in Bangalore north taluk and ground water occur in phreatic condition. Alluvium of limited thickness of 20 to 25m and aerial extent occur along the valley portions, possess substantial ground water potential. Ground water occurs in phreatic conditions or unconfined conditions in the weathered zone and under semi confined to confined conditions in fractured and jointed rock formations. The occurrence of Ground water movement and recharge to aquifers are controlled by various factors like fracture pattern, degree of weathering, geomorphological setup and amount of rainfall received. Generally the depth of weathering varies, being more in the valley, and often extending up to 30 m in the dug wells. However the yield in the bore well is dependent upon factors like degree of weathering, presence of joints and fractures and its connectivity and the presence of intrusive bodies (Figure 1-9).

Studies have been done on the ground water quality for Bengaluru Urban district by Central Ground Water Board based on hydro-chemical data of network hydrograph stations wells and exploration bore wells. Results show wide variations in its chemical composition. The shallow and deep groundwater is alkaline with pH value ranging from 7.8 to 8.5. Total hardness varies from 100 to 600 ppm. Fluoride content in general is less than 1 ppm. Major part of the district is having fresh water with EC ranging from 250 to 2000 micro mhos/cm at 25° C.

In urban area of Bengaluru district, main problems affecting ground water are sewage pollution and industrial pollution; high Nitrate concentration in ground water and over exploitation of ground water resources². This is further attributed to factors like urbanization in the last two decades paving way for commercial buildings, layouts and industries. The green cover, tanks and lakes have also diminished leading to depletion of water levels. Rapid urbanization, IT boom, related economic activities, trade and commerce have exerted pressure and this has increased the sewage waste into the lakes. Improper

² Central Ground Water Board Ground Water Information Booklet, Bangalore Urban District, 2012.

environmental planning has given room for establishment of new residential layouts without proper sewerage network and even if such systems have been provided, they are mostly not functional or connected to trunk sewers of BWSSB. The municipal effluents from natural drains leading to tanks and lakes deteriorate the quality of the water. Sedimentation of pollutants has not only reduced the surface area of the water, but has also reduced ground water levels on account of poor permeability with more and more silt, clay deposits, trash and toxic waste accumulation in the lakes year after year.

Sewage pollution as observed in the western part of Bengaluru city where all the sewage is let into Vrishabhavathi River valley and most of the tanks are also polluted from sewage source due to unplanned urbanization. As per CGWB studies, most of the open wells/bore wells situated in the vicinity of Vrishabhavathi River is polluted due to sewerage discharging into the river. Study of CGWB shows that, in Industrial belt of Peenya, Rajajinagar and Hosakote area, Ground water is slightly alkaline and indicated high concentrations of chloride and magnesium in ground water and high nitrate in all the industrial belts of Peenya, Hosakote, Rajajinagar and Kanakapura road. However water is free from bicarbonates.

Rapid and unplanned urbanization has taken its toll on ground water resource of the district, with increased exploitation by bore wells dug up in all possible terrains. The only solution is building up of ground water resource through artificial recharge and rainwater harvesting.

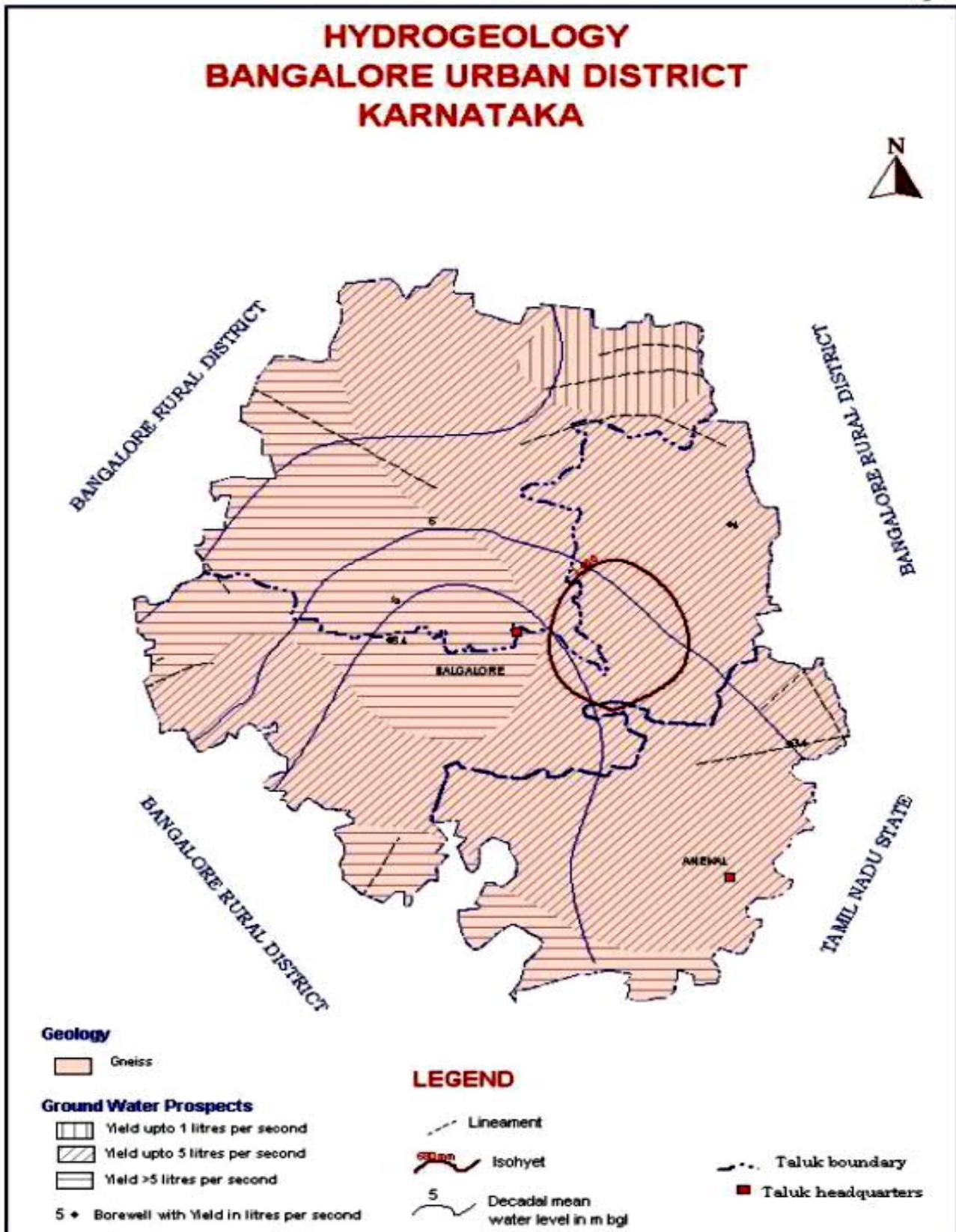


Figure 4-17: Hydrogeology of Bengaluru Urban district

4.10 Land use pattern

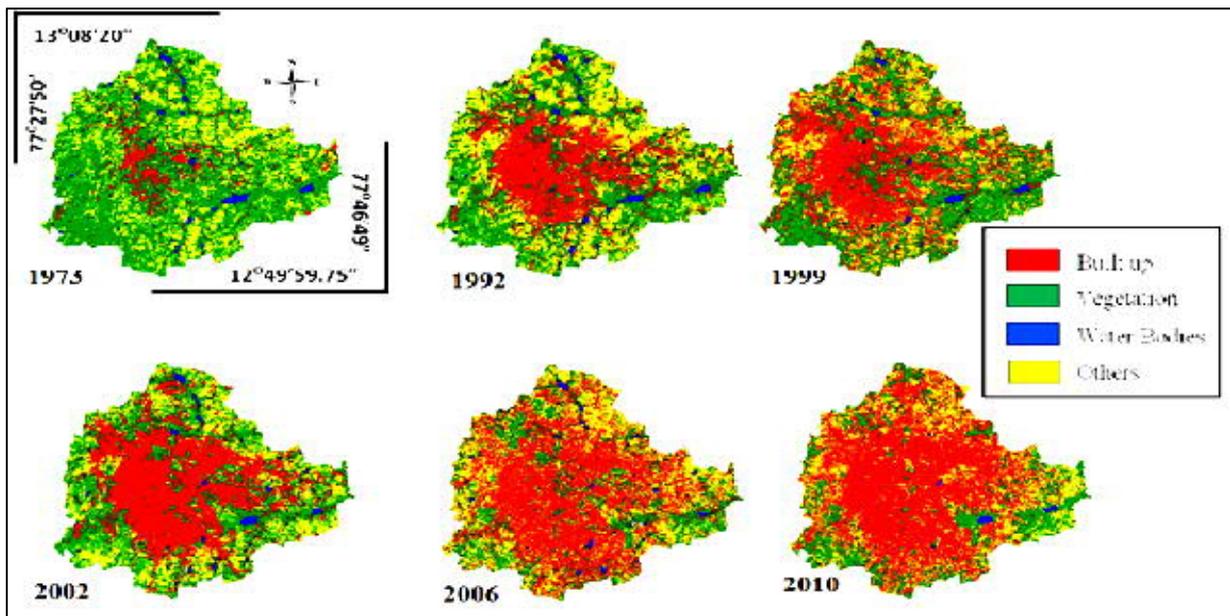
Bengaluru is one of the fastest growing cities in India. The city is a part of Bengaluru district, which is situated in the south- eastern part of Karnataka state. The city is being heavily flooded with public investment in industry and infrastructure.

Major contributors for rapid land use changes in Bengaluru are increase in population, rapid urbanization, industrialization, commercial establishments, political influences, tourism, etc. leading to an unplanned growth of the city. The change in land use is leading to expansion of urban sprawl consuming productive agricultural land, vegetation cover and water bodies. Functioning of city has hampered due to over-crowding, inadequate housing, development of slums, social polarization, traffic congestion and environmental pollution, ill-health, etc. This land-use change has complex interactions with the ecosystem, hydrological cycle and atmospheric circulation leading to modification of micro-climate ultimately affecting the quality of life. Category wise land use change in the city of Bengaluru is outlined from 1973 to 2013 is given in the following Table 4-42 and Figure 4-18.

Table 4-42: Land use changes in Bengaluru during 1973 to 2013

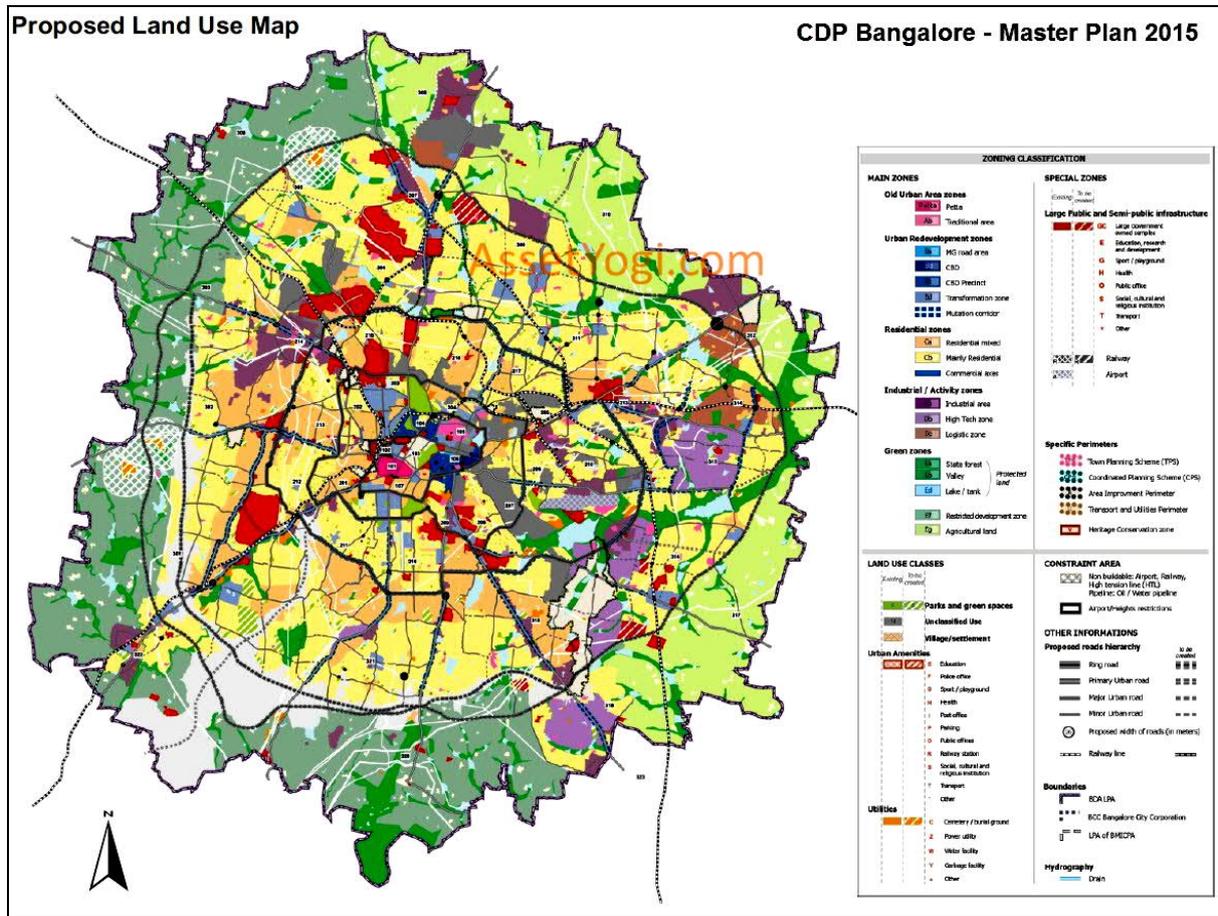
Land use Class	Urban		Vegetation		Water		Others	
	Ha	%	Ha	%	Ha	%	Ha	%
1973	5448	7.97	46639	68.27	2324	3.40	13903	20.35
1992	18650	27.30	31579	46.22	1790	2.60	16303	23.86
1999	24163	35.37	31272	45.77	1542	2.26	11346	16.61
2002	25782	37.75	26453	38.72	1263	1.84	14825	21.69
2006	29535	43.23	19696	28.83	1073	1.57	18017	26.37
2010	37266	54.42	16031	23.41	617	0.90	14565	21.27
2013	50440	73.72	10050	14.69	445.95	0.65	7485	10.94

Figure 4-18: Land use changes in Bengaluru city (1973 to 2010)³



³ Source: Ramachandra T V, Vinay S and Bharath H.Aithal, 2015. Detrimental land use changes in Agara-Bellandur wetland, ENVIS Technical Report 95, CES, IISc, Bangalore, India.

Figure 4-19: Proposed land use map from CDP Bangalore Master Plan 2015



An attempt is made to prepare land use map covering 10 km radius around the project site. Analysis is made based on using ESRI latest satellite imagery. The Land Use Land Cover graph is shown in Figure 4-20. LULC mapping is done using guidance from BDA master plan and NRSC LULC from 2011/12 and analysis is performed on latest satellite imagery from ESRI, HERE, DeLorme, MapmyIndia, OpenStreetMap contributors and the GIS user community.

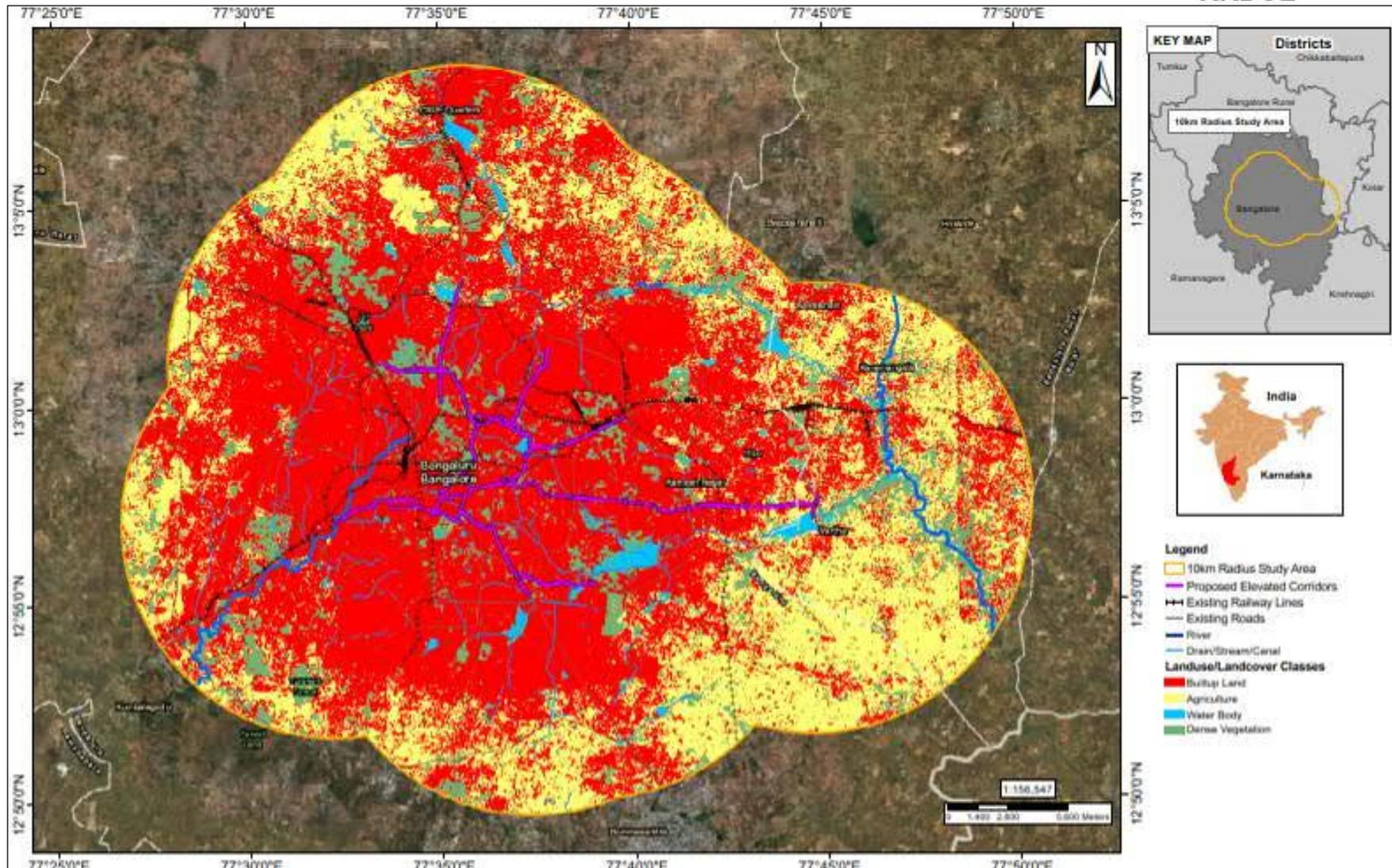


Figure 4-20: Landuse/Landcover Classes Map for 10km Radius Study Area



Class	Total Area (ha)
Agriculture	302912.57
Builtup Land	618205.69
Vegetation	115210.54
Water Body	12319.71
Grand Total	1048648.51

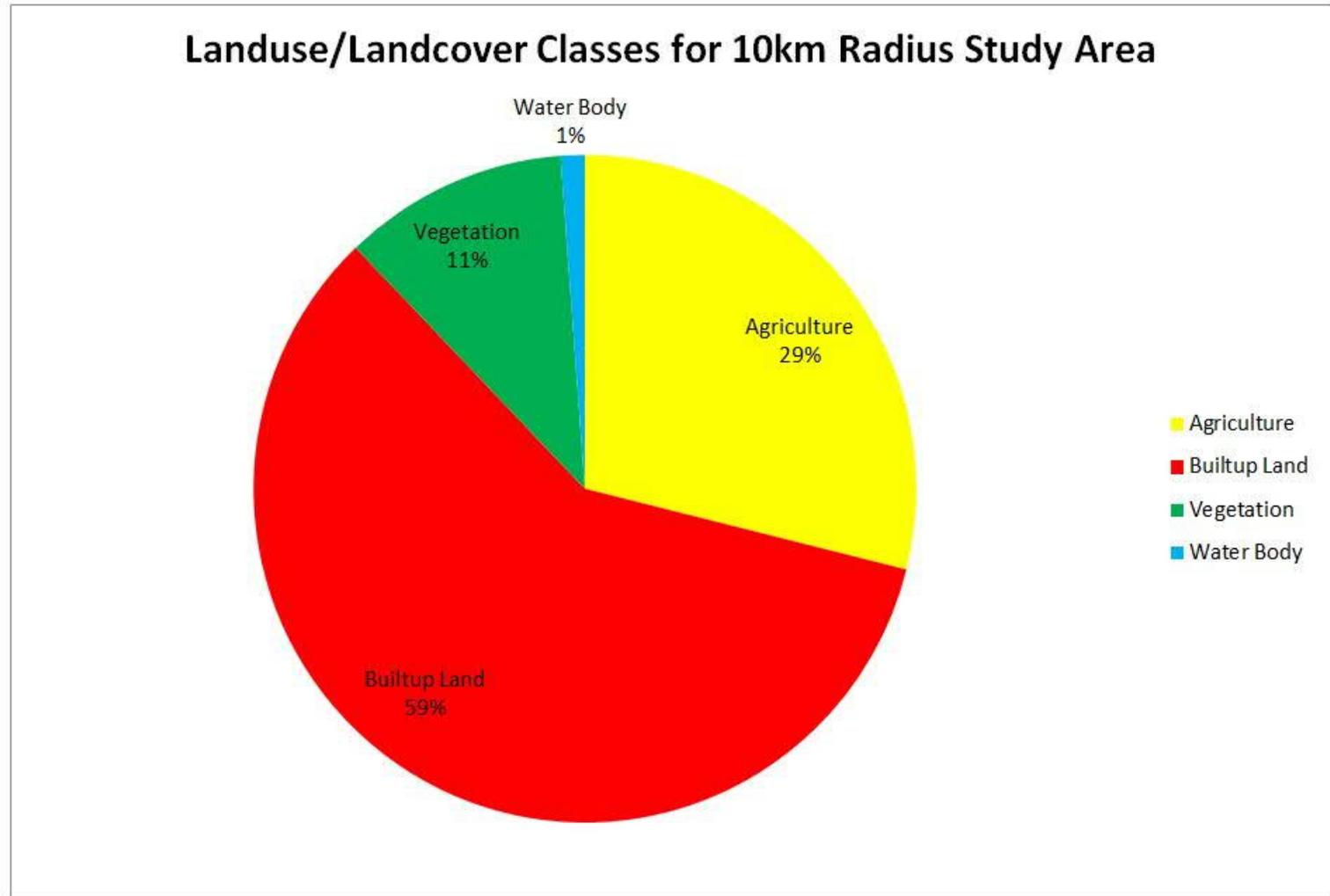


Figure 4-21: Landuse/Landcover Classes for 10km Radius Study Area

4.11 Environmental Pollution

About 4000 metric tonnes of Municipal Solid Waste (MSW) is currently being generated daily within the area under the jurisdiction of Bruhat Bengaluru Mahanagara Palike (BBMP). Handling and management of this huge quantity of municipal waste is a challenge for the Urban Local Body with regard to environmental, social and techno-financial aspects. Of the total quantity of municipal solid waste being generated, about 3,000 tonnes is collected and sent to composting units such as the Karnataka Composting Development Corporation and other common municipal waste handling facilities which were established recently. The remaining solid waste collected by the municipality is dumped in open spaces or on roadsides outside the city.

The pollution level in Bengaluru city's air has deteriorated over the recent years to an alarming level. The city suffers significantly with dust pollution, hazardous waste disposal, and disorganized, unscientific waste retrievals. The IT hub, Whitefield region is the most polluted area in Bengaluru. Recently a study found that over 36% of diesel vehicles in the city exceed the national limit for emissions.

Status of baseline air quality in Bengaluru city during the year 2015-16 is presented in the Table 4-43 below.

Table 4-43: Status of baseline air quality in Bengaluru city during the year 2015-16

Sl. No.	Name of the Station	SO ₂ µg/m ³	NO ₂ µg/m ³	RSPM µg/m ³	PM 2.5 µg/m ³	NH ₃ µg/m ³	lead (Pb) µg/m ³
1	Export Promotional Park ITPL	3.8	21.1	189.0	80.0	19.0	0.046
2	K.H.B Industrial Area	3.6	15.5	109.0	*	14.0	0.080
3	Peenya Industrial Area - RO	3.9	20.2	127.0	69.0	25.0	0.091
4	Swan Silk Peenya Industrial Area	2.0	36.0	117.0	66.0	30.0	0.056
5	Yeshwanthpura Police Station	3.6	22.6	105.0	49.0	21.0	0.040
6	Amco Batteries	4.0	20.2	119.0	57.0	20.0	0.018
7	Central Silk Board	3.9	21.1	165.0	*	28.0	0.059
8	DTDC House	3.7	17.5	135.0	*	14.0	0.061
9	CAAQM City Railway Station	9.0	45.6	104.0	*	*	*
10	CAAQM S.G. Halli	3.7	25.7	72.0	*	*	*
11	Kajisonnenahalli	3.6	12.6	75.0	*	13.0	0.088
12	Victoria Hospital	4.0	23.0	102.0	60.0	24.0	0.038
13	Indira Gandhi Children Care	3.8	17.5	113.0	35.0	16.0	0.069
	CPCB Standards	50.0	40.0	60.0	40.0	100.0	0.500

Source: <http://kspcb.gov.in/AQI-DATA-Bangalore-CITY-2015-16.pdf>

Air quality monitoring of representative land uses and environmentally sensitive zones of the project area will be carried out as per the Terms of Reference (ToR) issued by SEAC (State Environmental Appraisal Committee) as a part of detailed feasibility study through an approved agency to know the background quality of ambient air.

4.12 Biological Environment

Bengaluru has been well known for its green spaces and lakes. In recent years, city has witnessed accelerated and unplanned growth leading to transformation of green lung spaces like forests, orchards, pastures and fertile agricultural fields into a concrete jungle flats and commercial agglomerations. The Bengaluru city, is called as the Garden City of India has an abundance of fauna and flora. The city has two nationally renowned botanical gardens Cubbon Park and Lal Bagh. The Cubbon Park has a history of over 100 years. It was established in the year 1870 by John Meade, the then acting Commissioner of Mysore. The vast landscape of the park was conceived by Major General Richard Sankey, the then Chief Engineer of the State. As a mark of honor to John Meade, the park was initially named as "Meade's Park" and subsequently it was called the Cubbon Park. Lalbagh, is a botanical garden and has been a treasure house of plants. The rich floral wealth of Lalbagh extends over an area of 97 hectares (240 acres) accommodating 1854 species 673 genera and 890 cultivars of plants.

In 1982 a Forest Division was created under the name Bangalore Green Belt Division which was entrusted with the job of greening of Bengaluru Metropolitan Region and later on, the same has been enlarged to cover the Bengaluru Urban District. The natural vegetation consists species like Albizzia amara, Albizzia lebbek, Anogiessus latifolia, Acacia species, Shorea talura and Santalum album,

Home gardens within the city have been critical for enhancing green cover and biodiversity support in Bengaluru city. These gardens constitutes ubiquitous coconut trees, jackfruit, mango and drumstick, and plants such as papaya, banana and other ornamental flowering plants

The geographical area of Bengaluru Urban (Forest) division is 2,17,410 ha. The extent of forestlands within the division is 4,298.43 ha which includes both notified and other Government lands constituting 1.97 % of the geographical area. The forests in the division are of tropical dry deciduous type mostly containing Acacias, Albizzia, Wrightia tinctoria, Zizyphus, Pongamia, etc.

As per the Working Plan of Bengaluru Urban forest division, total area has been divided into five territorial ranges comprising of reserved forests, protected forests and other Government lands. The details of ranges, reserved and protected forests, other Government lands and lakes are given in Table 4-44.

Table 4-44: Details of various categories of forests, range wise abstract (Area in ha)

Sl. No.	Name of the range	Total area of notified forests	Other Govt. Lands (in ha.)	Total tanks Extent in ha.	Total forest Area in ha.
1	Anekal	34.07	112.00	-	146.07
2	Bengaluru	504.33	86.67	646.96	1237.96
3	Kaggalipura	1831.24	252.97	54.97	2139.18

4	K.R. Puram	395.70	701.45	813.86	1911.01
5	Yelahanka	380.00	-	60.30	440.30
	Total	3145.34	1153.09	1576.09	5874.52

Source: Working Plan for Bengaluru Urban Forest Division (period - 2002-03 to 2011-12), 2003

The government lands in the division are not notified forests but are under the control of the Forest Department. These lands include revenue kharab lands, gomal lands and other areas where the department has raised plantations over the years. Besides, the Revenue Department quite often grants these lands, hence the extent of these lands is decreasing day by day. In addition to the above areas Social Forestry wing of the Forest department also own government lands that have not been notified as forests.

Other government lands (C & D class lands, Gomals, tanks, etc. district forests) under the control of Bangalore Urban Division, Forest Department can be utilized for compensatory afforestation in lieu of trees being cut for implementation of elevated corridor project

The following table (Table 4-45) shows the details on the name of the forests and their extent in the jurisdiction of Bengaluru Urban Division.

Table 4-45: Various types of forests with extent in Bengaluru Urban Division

Sl. No.	Name of the forest	Forest area in Ha.
1	Jarakabande Reserved Forest	199.92
2	Marasandra Reserved Forest	380.00
3	Kumbaranahalli Reserved Forest	34.07
4	Govindapura Reserved Forest	19.42
5	Arkavathi Reserved Forest	42.89
6	Madappanahalli Plantation	62.29
7	Jarakabande Sandal Reserved Forest	129.81
8	Sulikere Reserved Forest	210.01
9	Turahalli Gudda Protected Forest	238.97
10	Basavanathara Reserved Forest	566.80
11	Doresanipalya Reserved Forest	54.88
12	Jyothipura Reserved Forest	228.00
13	Mandoor Reserved Forest	129.60
14	B.M.Kaval Reserved Forest	562.87
15	Kadugodi Reserved Forest	38.10
	Total	2897.63

As per the statement of mixed plantation raised in Bengaluru Urban Forest Division Nilagiri, Bevu, Sirude, Kamara, Sissoo, Acacia auriculiformis, Kamara, Jali, Karijali, Hunise, Nerale, Honge, Hippe, Gulmohar, Spathodia, Mavu, Sampige, Malemara, Ala, Mathi, Bamboo, Salle, Saruli, Thore Mathi, Sakke, Agala tharis, Peltophorum, Basavanapada, Thangadi, Sarve, S. mahagony, Subabul, Atti, Arali, Bage, Halasu, Nelli, Muthuga, Dalchinni, Kadhembe, Badami, Uvalli, Huvarasi, Nelli, Biudire, Peltophorum, Antuvala, Cherry, Bottlebrush, Holemathi, Kanagal, Silver Oak, Swietenia mahagony, Teak, Kumkum (Mallotus philippensis), Sita, Ashoka, Shivani (Gmelina arborea), Jakaranda, etc.

The nearest wildlife sanctuary which is adjacent to Bengaluru Urban District is Bannerghatta National Park. Most of the animals found in these protected areas are also found in the forests of Bengaluru urban division. Wild animals like elephant, wild boar, bear from the sanctuary destroy agricultural crop raised by farmers in and around their habitations. There are also instances of human beings and domestic cattle being killed by wild animals. Often elephants are found migrating from adjacent forests of Bannerghatta National Park.

The list of birds found in and around Bangalore in addition to Nandi hills, Bannerghatta forest ranges and Kaveri sangam area roughly extending 40 km around the city center are included. Some of the important birds found are Common quail, Grey jungle fowl, Indian peafowl, Lesser whistling-duck, Bar-headed goose, Spot-billed duck, Northern shoveler, Common teal, Greater flamingo, Lesser flamingo, Painted stork, Asian open bill, Black-headed ibis, Red-napped ibis, Eurasian spoonbill, Little egret, Grey heron, Purple heron, Intermediate egret, Cattle egret, Indian pond heron, Spot-billed pelican, Great white pelican, Little cormorant, Indian cormorant, Great cormorant, Oriental darter, Crested honey buzzard, Brahminy kite, Grey-headed fish eagle, Egyptian vulture, Indian vulture, Crested serpent eagle, Marsh harrier, Montagu's harrier, Eurasian sparrow hawk, Indian spotted eagle, Common buzzard, Red-necked falcon, Laggar falcon, Great Indian bustard, White-breasted water hen, Water cock, Grey-headed swamp hen, Common moorhen, Eurasian coot, Barred buttonquail, Pacific golden plover, Common ringed plover, Yellow-wattled lapwing, Grey-headed lapwing, Red-wattled lapwing, Pheasant-tailed jacana, Bronze-winged jacana, Eurasian woodcock, Marsh sandpiper, Common sandpiper, River tern, Whiskered tern, Painted sandgrouse, Chestnut-bellied sandgrouse, Rock pigeon, Spotted dove, Red turtle dove, Yellow-footed green pigeon, Rose-ringed parakeet, Pied cuckoo, Indian cuckoo, Common cuckoo, Grey-bellied cuckoo, Asian koel, Barn owl, Oriental scops owl, Indian scops owl, Mottled wood owl, Jungle owlet, Common kingfisher, White-throated kingfisher, Stork-billed kingfisher, Blue-bearded bee-eater, Blue-tailed bee-eater, Chestnut-headed bee-eater, Indian grey hornbill, Brown-capped woodpecker, Yellow-crowned woodpecker, White-cheeked barbet, Coppersmith barbet, Indian golden oriole, Black drongo, White-bellied drongo, Indian paradise flycatcher, White-bellied tree pie, House crow, Red-whiskered bulbul, White-eared bulbul, Yellow-throated bulbul, Paddy field warbler, Common starling, Common myna, Jungle myna, Indian blue robin, House sparrow, Yellow-throated sparrow, Red munia, Forest wagtail, Common rose finch, etc.

Snakes such as Cobra, Russels Viper, Common Krait, Saw Scaled Viper, Checkered Keel back, Common Verm or Blind Snake, Russell's Earth Boa, Trinket Snake, Rat Snake, Indian Python, etc. and many types of lizards and insects.

4.13 Social Economic Environment

Bengaluru had population of 9,621,551 in 2011. Of which male and female were 5,022,661 and 4,598,890 respectively. In contrast, as per 2001 census, Bengaluru had a population of 6,537,124 of which males were 3,426,599 and remaining 3,110,525 were females. The census data shows that population density of 4,381 people per sq. km in 2011 in the district as against 2,985 people per sq. km in 2001.

Average literacy rate of Bangalore in 2011 were 87.67 compared to 82.96 of 2001. If things are looked out at gender wise, male and female literacy were 91.01 and 84.01 respectively. For 2001 census, same figures stood at 87.92 and 77.48 in Bangalore District. Total literate in Bangalore District were 7,512,276 of which male and female were 4,078,041 and 3,434,235 respectively. In 2001, Bangalore District had 4,782,565 in its district.

With regards to Sex Ratio in Bangalore, it stood at 916 per 1000 male compared to 2001 census figure of 908. The average national sex ratio in India is 940 as per latest reports of Census 2011 Directorate. In 2011 census, child sex ratio is 944 girls per 1000 boys compared to figure of 943 girls per 1000 boys of 2001 census data.⁴

Infrastructure: Annual average power consumption by Bengaluru district is about 14,225 MU and 28% of it is industrial requirement and 33 % is for domestic consumption. Power transmission in the district is being done by Bengaluru Electricity Supply Company Limited (BESCOM) Bengaluru is being supplied with 1480 MLD of water which is being managed by Bengaluru Water Supply and Sewerage Board. Water is sourced from Arkavathi River and Cauvery for drinking purpose. Bengaluru Urban has 46- water tanks of various capacities serving the irrigation needs and has 52 reservoirs and 118 ground level reservoirs.

Bengaluru district has a total length of 147 km NH. NH 4, NH 7 and NH 209 passes through the district. District has a total railway route of 148.32 km. Bengaluru International Airport is fourth busiest airport in India. Bengaluru Metro (Namma Metro) – Mass Rapid Transit System extends for a total length of 137 Km under different phases of execution (Figure – 1-10).

Bengaluru is the highest contributor of the State's economy. Its total Gross Domestic Product (GDP) is INR 993.25 billion contributing 33.3% to Gross State Domestic Product (GSDP) with the per capita annual income in the district being INR. 2,02,340. However, the Gross District Domestic Product (GDDP) trend is 5.5% Compound Annual Growth Rate (CAGR) from 2007-8 to 2012-13; with the services sector reigning supreme at INR 683.30 billion with 39.5% contribution to the state.⁵ Bengaluru has 14.09% of its land for cultivation. Amongst this, cereals and pulses occupy 66.36% and 9.94% of the land respectively. Best known for Ragi, especially, in Anekal Taluk which is called 'Ragi Bowl' in the State. Bengaluru Urban is recognized as Class A destination for floriculture projects. Major crops grown are Paddy, Ragi, Maize, Horse gram and Oilseeds along with Horticultural crops like Banana, Grapes, Papaya, Mango Sapota, Pomegranate and Plantation crops like Coconut and Rose. The district also has 649 milk co-operatives that annually produce 119 Million liters of Milk, 34.7 million Eggs, and 5,880 tonnes of Meat.

Bengaluru Urban district is a vital business hub with 315 large scale industries with an investment of INR 147.9249 billion; 211 medium scale industries with an investment of INR 134.233 billion and 74,282 small-scale industries with a massive investment of INR 412.13 billion. The District has 16 odd industrial areas and Peenya has the largest industrial cluster in Asia; 13 industrial estates and 14 notified operational SEZ in Bengaluru forms the framework to the rich industrial landscape in the region.

⁴ Source: <http://www.census2011.co.in/census/district/242-bangalore.html>

⁵ <http://www.investkarnataka.co.in/district-profiles-bangaloreurban>

needs of the population. Bengaluru is a hub for medical tourism, with super-specialty hospitals boasting state-of-the-art treatment facilities.

4.14 Sites of Tourist and Archaeological Interest

Bengaluru Palace: Constructed by Chamaraja Wodeyar in 1887, the palace carves a niche for its architecture. Besides, the Gothic windows and fortified towers of this palace are worth viewing. Bengaluru Palace is a minor replica of the Windsor Castle in England.

HAL Aerospace Museum: Located 11 km from the city, it is the first aerospace museum in India. The museum is home to equipment for navigation and communication, and many model aircraft.

Cubban Park: has been serving as a lung space of Bengaluru city in the central administrative area. It has a rich recorded history of abundant flora and fauna plantation coupled with numerous impressive and aesthetically located buildings and statues of famous personages.

Lal Bagh: One of the popular botanical gardens of India, Lal Bagh is home to approximately 1,000 species of rare herbs and plants. Sprawled across 2,400 acres, the garden is well secured with stone walls. Visitors can visit this park anytime between 6 am in the morning to 7 pm in the evening. Lalbagh botanical garden was commissioned by the ruler of Mysore, Hyder Ali.

Bannerghatta National Park: Located 22 km from Bengaluru, this national park is famous for its picturesque natural beauty. Besides, the park is also home to Indian tigers, lions, and crocodiles. Bannerghatta National Park is a rich natural zoological reserve which also hosts first butterfly park of India.

Bull Temple: is a magnificent pilgrimage of Nandi which is 15 ft tall and over 20 ft long.

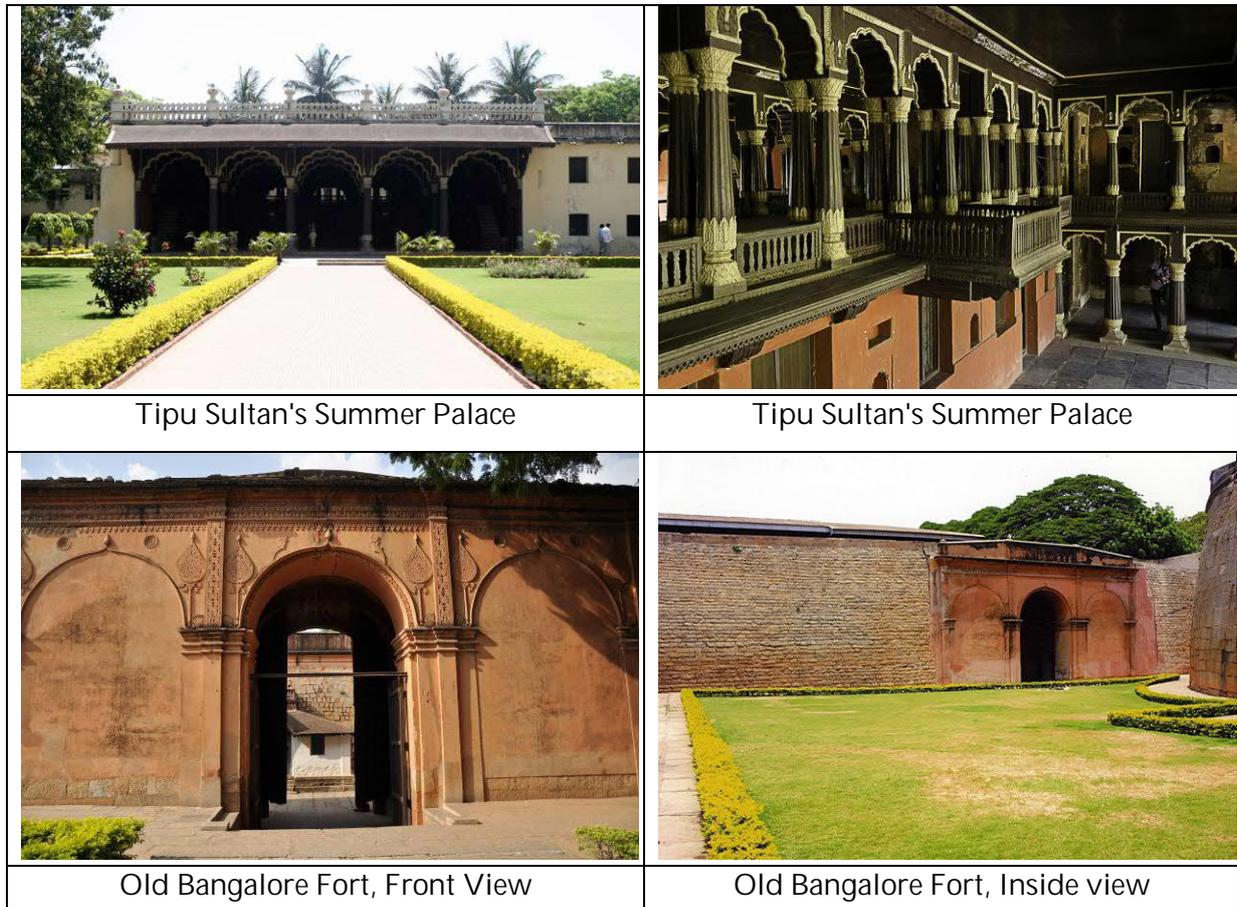
Visvesvaraya Industrial and Technological Museum: is famous for its interactive exhibits.

There are two structures of archaeological interest near the EW 2 Corridor alignment.

Tipu Sultan's Palace: Though the construction of the palace was initiated by Hyder Ali in 1781 AD, Tipu Sultan completed the construction of the same in 1791. Formerly one of the summer retirements of Tipu Sultan, today the palace has been transformed into a museum. The palace is a beautiful two storied ornate wooden structure with exquisitely carved pillars arches and balconies built in 1791 and were Tipu Sultan's summer retreat. This is a splendid structure now present within the old fort. It has a large open courtyard in the front with a fountain and small, ornamental garden.

Old Dungeon Fort & Gates: Old Dungeon Fort & Gates or Bengaluru Fort began in 1537 as a mud fort by Sri Kempe Gowda I, a vassal of the Vijaynagar Empire and the founder of Bengaluru. Haider Ali in 1761 replaced the mud fort with a stone fort. The army of the British East India Company, led by Lord Cornwallis on 21 March 1791 captured the fort in the siege of Bengaluru during the Third Mysore War (1790-1792). Today, the fort's Delhi gate, on Krishna Rajendra Road and two bastions are the primary remains of the fort in Figure 4-23.

Figure 4-23: Tipu Sultan's Palace & Old Dungeon Fort & Gates



4.15 Seismicity

Bengaluru Urban district lies in a seismically stable region, Zone III. Bengaluru has been untouched by major seismic events but only mild tremors have been recorded in the past. The Indian Peninsular region was once considered to be seismically stable is experiencing many earthquakes recently. As a part of micro-zonation programme, Department of Science and Technology, Government of India has carried out seismic hazard analysis of Bengaluru region considering the regional seismo-tectonic activity based on faults, lineaments, shear zones and historic earthquake events of more than 150 events in about 350 km radius around Bengaluru city. About 21 numbers of faults and lineaments are identified as a vulnerable sources as a first step. The vulnerable source for Bangalore city is identified as Mandya – Channapatna – Bengaluru lineament with an earthquake moment magnitude of 5.1.⁶

⁶ TG Sitaram, and P Anbazhagan, 2006, Seismic Hazard Analysis for the Bangalore Region

5. ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

The proposed elevated corridor project aims to ease the traffic nuisance being faced by Bengaluru dwellers and contributes towards better infrastructure and improved connectivity. Improved access to job locations, education, health facilities, market centers, tourist places and other essential services for the public of the city in the region; reduced sufferings during monsoons and adverse climatic conditions; improved public safety and security; productive use of time which influences and improves the income patterns; the quality of life and human dignity; opens up opportunities for social interaction; etc. All these factors improve economic and social welfare of communities in the vicinity and the state as a whole.

For all the positive impacts, road improvement projects could also generate some adverse impacts on environment. The direct environmental impacts are usually due to activities that are directly related to construction and rehabilitation activities, while indirect environmental impacts are usually related to the operation of improved roads. Such indirect environmental impacts include cumulative impacts due to improved access to certain geographic areas.

The environmental impacts caused by the development of the project corridor/road can be categorized as primary and secondary impacts. Primary impacts are induced directly by the project, whereas secondary impacts are indirectly induced, and typically include the associated investment and changing pattern of social and economic activities in the region. The generic impacts of the project on the environment are presented below. Impacts of the elevated corridor project can be appropriately discussed under following heads.

- Impacts during Pre-construction Phase.
- Impacts during Construction Phase.
- Impacts during Operation Phase.

5.1 IMPACTS DURING PRECONSTRUCTION PHASE

5.1.1 Change of Land use:

The proposed elevated corridor project requires acquiring private residential, commercial, government and Army lands. It is difficult to avoid acquiring land as the scope for alignment alternatives are located within Bengaluru city and finalization of the alignment is much influenced by traffic induced obligatory factors. However, all attempts have been made to restrict the width of the elevated structure after taking into consideration the traffic projections for each proposed corridor to minimise the impact and land acquisition required for the project. It is estimated that about total of 56.89 Ha of land have to be acquired for the project. Acquisition of land adjacent to the proposed corridor will lead to change in the land use. Apart from main corridor which runs across Bengaluru city, large area of land is also required for construction of access ramp structures which connect elevated corridor with at-grade roads, junction improvements, grade separators and associated developments. Further, during construction phase additional land is required, for establishing construction camps, casting yards, material storage and labour camps including space for meeting the requirements of construction works.

Transfer of land and involuntary resettlement will cause adverse social, economic and cultural impacts on families and communities who are dependent on them.

Table 5-1: Land to be acquired (Source: DFR Study)

Type of Ownership	North - South Corridor	East West Corridor - 1	East West Corridor - 2	Connecting Corridor - 1	Connecting Corridor - 2	Connecting Corridor - 3	Total (Ha)
Private land	3.14	10.65	3.21	0.03	0.31	0.42	17.76
Defence Land	0.08	0.54	1.87	0.00	0.05	0.00	2.54
Central Govt.	2.00	1.00	0.06	0.00	0.00	0.00	3.07
State Govt.	10.54	21.36	0.28	0.47	0.72	0.15	33.52
Total Land (Hectares)	15.77	33.55	5.42	0.50	1.08	0.57	56.89

Mitigation measures:

- The land acquisition has been avoided or minimized to reduce the impact on owners owning the adjacent properties and lands. Alternative engineering designs has been attempted to avoid or minimize land acquisition.
- Where land acquisition is unavoidable, resettlement of Project Affected Persons (PAPs) shall be implemented as an integral part of the project.
- All temporary land acquisition will be preferably Government lands and away from Bengaluru city to reduce the impact of these construction establishments.
- The temporarily acquired lands for construction establishments shall be transferred back after suitable rehabilitation before the completion of construction works.

5.1.2 Structures Affected

Social screening survey along all the project corridors has identified social impact especially impact on buildings or structures. Survey covered major structures like residential, commercial and Altogether, Corridor wise impact are illustrated in below sections and summary is presented in table

Approximately 1130 structures are affected by the proposed elevated corridor especially at those stretches where available right of way (ROW) is narrow. The type of structures impacted includes residential, commercial, religious and other structures like compound wall, sheds, bathrooms, abandoned structures, etc. Rehabilitation and Resettlement (R&R) of displaced structures and families is important and is addressed in Social Impact Assessment report.

Table 5-2: Impact on structures

Phase Nos.	Residential	Commercial	Residential/ Commercial	Religious	Govt./ Community	Education	Others	Total
I	169	48	1	6	8	1	64	297
II	8	143	10	9	2	2	47	220
III	32	339	5	14	2	5	146	543
IV	0	47	5	3	1	1	13	70
Total	209	577	21	32	13	9	270	1130

*Includes room, shed, under construction, toilet, abandoned etc.

A total of 47 religious structures like small temples, mosque, shrines etc., were identified as affected religious structures. Category wise religious structures under all the corridors are summarized in the below table.

Table 5-3: Category wise Religious Properties

Phase Nos.	Temple	Church	Mosque	Total
I	5	3	2	10
II	20	1	0	21
III	7	2	1	10
IV	6	0	0	6
Total	38	6	3	47

Mitigation measures:

- The alignment shall be planned in such a way that impact on the adjacent structures is minimized. Alternative engineering designs shall be attempted to avoid or minimize land acquisition.
- Project-affected persons, families, households and groups shall be compensated as per the statutory provisions before the commencement of project. The impact shall be addressed as per the KIADB Act with compensation at par with Land Acquisition, Rehabilitation and Resettlement Act, 2013.

5.2 IMPACTS DURING CONSTRUCTION PHASE

5.2.1 Impact on Topography

The significance of the impact on the topography is based on the spread of the impact of cutting and the embankment construction along the corridor alignments. Hence there is no significant impact on the topography along the elevated stretch of the project except at location of ramps where (both up ramp & down ramp) earth will be filled and retained with the help of retaining structures to access the elevated structures. There are about 53 such ramp locations in the proposed elevated corridor project. In addition, there will be significant change in topography at the locations of material storage yards, gravel & sand quarries and murrum borrow areas.

5.2.2 Impact on Soil

The soil/debris will be generated during foundation excavations for pile construction which needs to be carefully and safely disposed of. Lot of waste slurry is also generated during pile foundation construction which causes serious soil pollution if it is not disposed properly. However, soil contamination is not considered to be a significant concern from this proposal looking at the nature of land uses in the project areas.

The debris generated (approximately 5,88,678 cum) at the pile foundation location will be partially utilized for construction of ramps and rehabilitation of quarries and borrow pits.

Table 5-4: Quantity of Debris generated

Phase Nos.	Length of Project Corridor (km)	Quantity of Debris generated (Cum)
Phase I	24.47	1,77,171
Phase II	41.20	2,08,881
Phase III	27.12	1,36,348
Phase IV	9.25	66,278
Total	102.04	5,88,678

The run off from unprotected excavated areas during construction results in excessive soil erosion. Periods of prolonged rainfall or heavy downpours during construction phase may increase the risk of erosion and subsequent sedimentation of local storm water drains. Similarly, periods of dry and windy weather may increase the potential for soil erosion near the project area.

Land clearing for the project will involve removal of trees which have a very important role in binding the soil intact. Stripping of topsoil at the project and construction site to level the ground will lead to the loss of developed and stable soil. However the impact on the soil is not of importance as the land use pattern in project area is urban and uncultivable. It is necessary to limit the removal of ground cover, trees or shrubs only to the area needed for permanent works to minimize the impact on soil. Alteration of storm water drainage along the corridor alignment may lead to soil erosion. The hard impervious bituminous/concrete pavement of the elevated road will have the surface runoff and if this runoff is not drained off properly by means of drains, may lead to flooding and accelerated soil erosion on the at grade roads.

Scarification of existing bituminous pavement at grade for preparatory works of pile foundation and indiscriminate disposal would cause soil pollution. These wastes could be managed well, by careful handling, storing and disposal.

Unplanned disposal of the soil generated from the pile foundation excavation and other project activities during the project implementation will cause the loss of productive top soil and at the same time will lead to erosion of soil. For such locations where soil erosion is evident, exposed surface area shall be limited to minimum and duration of construction shall be scheduled immediately after completing land clearing.

Proposed project involves construction of as many as 11,705 pile foundations which requires soil to be excavated and disposed of elsewhere safely. Phase wise details of pile foundations and ramps (both up and down ramps) are given in the following table. On an average each ramp will have length of approximately 250 m.

Table 5-5: Pile foundations and ramp locations along the proposed project corridor

Phase Nos.	Pile Foundations (Nos.)	Ramps (Nos.)
Phase I	806	23
Phase II	417	10
Phase III	699	19
Phase IV	275	-
Total	2197	52

Mitigation measures:

- Soil erosion can be effectively controlled by careful planning, timing of cut and fill operations and safe disposal of excess excavated unserviceable soil, especially during monsoon season.
- The soil erosion can best be mitigated by removing vegetative cover only from the specific site on which construction is to take place and by disturbing the vegetation in adjacent areas as little as possible.
- Bituminous wastes should not be disposed nearby water bodies, open spaces and parks and wastes should not be left unmanaged on the road sides. The scarified bitumen shall be disposed of in clay lined bitumen disposal pits.
- The excavated soil from the pile foundations shall be stockpiled and covered such that the soil are not eroded away and they should be transported securely to disposal sites.
- At borrow pits, the depth of the pit should be regulated so that the sides of slope are not steeper than 1 vertical to 4 horizontal.
- Location of borrow areas should be preferred on infertile soils. The top soil shall be stripped and stored. The stored topsoil shall be spread back to maintain the original characteristics of the soil.
- The topsoil from all areas of cutting, shall be stripped to a specified depth of 150 mm and stored in stockpiles of heights not exceeding 2 m. If borrow areas are located on agricultural lands, it shall be ensured that the topsoil be preserved & reutilized during rehabilitation of borrow areas.
- Borrow pits shall be redeveloped by dumping of unserviceable soils and debris and by leveling elevated or raised earth mounds.
- Adopting waste minimization technologies would minimize the generation of waste materials to be disposed and thereby the cost incurred for transportation and handling will be reduced.
- Demolition and Construction waste should be dumped in pre-identified and approved pits, developed on infertile land.

5.2.3 Impact on Water Quality, Drainage and Hydrology

There are a few important water bodies along the proposed elevated corridors which may be impacted during construction phase of elevated corridor. The lakes which are within 100 m

from the proposed corridors are considered to be impacted directly by the project. Water bodies adjacent to the corridor are shown in the Annexure.

Table 5-6: Details of water bodies adjacent to proposed elevated corridor

Sl. No.	Phase No.	Water bodies / Lakes	Name of the Corridor	LHS / RHS	Distance of pier foundation from Water body (m)	Location
1	Phase I Package - I	Hebbal Lake	NS	RHS	5	Near Hebbal Flyover
2	Phase II Package - I	KR Puram Lake,	EW-1	RHS	20	Along NH 4
3	Phase II Package - I	Benniganahalli Lake	EW-1	RHS	350	Swamy Vivekananda Road
4	Phase II Package - I	Pond near Sarvagna Nagar	EW-1	RHS	20	Swamy Vivekananda Road
5	Phase II Package - II	Ulsoor Lake	EW-1	LHS	5	Kensington Road
6	Phase V Package - I	Varthur Lake	EW-2	LHS/RHS	5	HAL Airport road and along SH 35 respectively
7	Phase V Package - I	Thubarahalli Lake	EW-2	RHS	120	Varthur road / HAL Airport road
8	Phase IV Package - I	Vrishabhavathi Nalla	EW-2	LHS / RHS	5	Mysore road
9	Phase I Package - III	Agara Lake	CC-1	LHS	30	Sarjapur main road
10	Phase II Package - II	Challkere	CC-3	RHS	30	100 ft. Ring road
11	Phase - II	Rajakaluve	CC-3		1	At Banasawadi
12	Phase I Package - II	Rajakaluve	NS		1	At Shathinagar Bus Depot

There is a possible impact on the water bodies like KR Puram Lake, Ulsoor Lake and Agara Lake. As the East-West corridor alignment passes over Ulsoor Lake, and two piers may have to be established within the water body and the water body may get affected by the construction activities during construction phase if proper precautions are not taken.

This can be avoided by careful planning of the construction methodology to avoid the spill of the soil and debris into the water body. Construction works shall not be taken up during monsoon season.

The establishment of temporary construction camps and labour camps during the construction of project corridor will cause water pollution due to oil spills from construction equipment, sewage and garbage from the camps. If these wastes are let into the river without proper treatment, they will lead to water pollution which may spread

communicable diseases further down the stream. Precaution shall be taken to treat and dispose the wastes in a proper manner to prevent and minimize the impact.

There are many bore wells along the sides of the road implemented through various schemes by the state Government which will be impacted by widening of at-grade roads. Alternative arrangement of water supply shall be made for the day to day house activities to those people who are living adjacent to the project road. The affected water resources shall be rehabilitated at the earliest.

The establishment of temporary construction camps will generate environmental impacts due to inappropriate sewage and disposal of garbage, spills from construction equipment operations, conflicts related to the use of existing facilities and disseminating communicable diseases.

Construction of elevated corridor requires total 266 M litres of water. Water required for construction shall not be sourced from public water resources and supplies. Contractor shall source water from ground water resources like bore wells and tube wells dug after obtaining all necessary permissions from concerned authorities. Contractor shall source treated water from local Sewage Treatment Plants to use in the construction.

Mitigation measures:

- Batching plants, hot mix plants, labour camps, stone crushers, and other heavy machinery should be located away from the water bodies. Domestic and sewage wastes from labour camps shall be treated to the standards as per the CPCB standards and disposed.
- Arrangement for the supply and storage of water shall be made by the contractor, in such a way that the water availability and supply to nearby communities remains unaffected. If a new tube-well is to be bored, proper sanction and approval from local authorities and Central Ground Water Board.
- The impacted community water resource such as taps, stand posts tube-wells, along the at-grade road shall be relocated immediately.
- The excavated earth, stones or any other construction material, shall be properly disposed of so as not to choke the drainage system and block the flow of water.
- All required precautions shall be taken up to ensure no silt, soil, construction material reaches and silt up the adjacent waterbodies by constructing suitable retaining barricades.
- Construction works close to water bodies and streams shall be avoided, especially during the monsoon period.
- The required permissions from Forest Department/Lake Development Authority /National Green Tribunal (NGT) as required shall be obtained.
- To avoid contamination from fuel and lubricants, the vehicles and equipment shall be properly maintained and repaired. Oil interceptors shall be installed at the construction camps, vehicle service areas, fuel storage areas to ensure oils and oil based product do not pollute the soil or reach nearby waterbodies.

- Fuel storage and refilling sites should be kept away from cross drainage structures and water bodies.

5.2.4 Traffic Diversions

During construction of pile foundations, complete or partial traffic diversions on at grade road will be required. Traffic shall have to be diverted into alternate roads which not only creates traffic nuisance but also inconveniences with respect to emission of dust pollutant gases, increased noise levels to the adjacent inhabitants.

As most of the construction activities are on the existing roads but most of the proposed alignment passes through double lane roads. Hence, rather than completely blocking the roads it will be advisable to make these roads as one way to allow for operation of traffic together with construction activities. Moreover, on both sides of the at-grade roads, a clear passage shall be maintained for smooth operation of traffic, emergency and local movements. Dissemination of information on traffic diversions in advance will be an advantage to commuters of affected routes.

Traffic diversion arrangements are required to be done at all major junctions and existing narrow project stretches to avoid traffic chaos. Phase wise details of major junctions and the narrow project stretches where traffic control shall be a task. The details of junctions and narrow stretches in each phase of project execution are given in the table below.

Table 5-7: Major & Minor Junctions along the proposed project (At-grade)

Phase Nos.	Major Junctions	Minor Junctions
Phase I	61	66
Phase II	23	29
Phase III	27	34
Phase IV	17	25
Total	128	154

5.2.5 Impact on Air Quality

Dust generation is the main air quality issue associated with construction of the proposed elevated corridor. Primary sources of dust during construction phase include activities like site preparatory earthworks; demolition of existing structures; foundation excavation works; erection and use of heavy equipment & machinery; loading, transporting and unloading soil and construction materials and material handling; traffic diversion; etc. In addition, dust and gaseous emissions are released from the batching plants, hot mix plant and diesel generators; stone crushing unit operations in the stone quarries. Main pollutants released during construction are suspended particulate matter (SPM) and obnoxious gaseous pollutants like Carbon Monoxide, oxides of Nitrogen, Sulphur dioxide, Lead deteriorating quality of ambient air along the project corridor and at construction establishments.

As the project construction works occur close to residential dwellings and commercial possessions, dust may be a nuisance to the community. However, the degree of dust nuisance would depend on the nature of works at the particular section, duration of construction time and the local meteorology (like humidity, wind speed and direction) at the time of construction.

In addition to dust, it is also expected that project activities release air pollutants like SO₂, NO_x, CO, Lead, Benzene and Volatile Organic Compounds (VOC). Air pollutants adversely impact on human health, vegetation and materials. Human beings exposed to air pollutants will have higher incidence of cough, shortness of breath, bronchitis, chronic fibrosis, emphysema, bronchopneumonia, colds of long duration and fatigue. Most of the SO₂ and NO_x in the atmosphere are converted to acid, thereby making rain water acidic. Air pollution has damaging effect on vegetation depending upon their chemical nature, level of concentration and duration of exposure. Air pollutants cause physical and chemical change in materials and results in their damage and destruction. The most destructive air pollutants to materials are smoke, grit, dust and oxides of sulphur.

Air sensitive receptors (ASRs) such as inhabited stretches, commercial zones, schools, hostels, hospitals, office occupancies, place of public worship, sports stadium are considered as ASRs. The boundary of air quality impact considered to be adjacent (50m) to the project alignment and boundaries of all associated construction establishment areas under the project. More than 60 ASRs (Schools, Colleges & Hospital), are considered to be most likely to be affected by the construction of the project. The representative stretches of inhabited stretches (ASRs) are listed in Table 5-8 and their locations are illustrated in Annexure.

DG sets will be used at construction camps and construction sites for various construction activities. Particulate and gaseous emissions are expected from DG sets. The impacts will be short term and limited in nature. Proper site selection, appropriate location of plant and regular maintenance and monitoring shall minimize such impacts. However suitable mitigation measures such as using chimneys of required height will be ensured as per the KSPCB norms. There will not be use of DG sets during operation phase of the project.

Table 5-8: Details of Air Sensitive Receptors (ASRs) along the proposed corridor

Sl. No.	Location of Air Sensitive Receptors (Inhabited stretches)	Chainage	Length impacted (M)	LHS/RHS
Phase I				
1	Jayamahal Road	1+200 to 1+600	400	RHS
2	Jayamahal Road	1+900 to 2+400	500	RHS
3	Millers Road	3+400 to 3+800	400	RHS
4	Millers Road	3+450 to 3+690	240	LHS
5	Cock Burn Road	4+750 to 5+400	650	LHS
6	Hosur Road Elevated Express way	12+100 to 12+400	300	RHS
7	Hosur Road	12+600 to 12+700	100	LHS
8	100 Feet Ring Road	0+000 to 0+250	250	LHS
9	100 Feet Ring Road	1+300 to 1+410	110	LHS
10	Sarjapur Main Road	1+570 to 2+200	730	RHS
11	Sarjapur Main Road	2+480 to 3+310	830	RHS
12	Sarjapur Main Road	2+600 to 3+000	400	LHS
13	District Office Road	Exit Ramp	300	LHS
14	Shamanna Main Road	10+700 to 11+200	500	RHS
15	Raja Ram Mohan Roy Road	17+160 to 17+390	230	LHS
	Total		5940	

Sl. No.	Location of Air Sensitive Receptors (Inhabited stretches)	Chainage	Length impacted (M)	LHS/RHS
Phase II				
1	NH-4 Road	1+100 to 1+300	200	RHS
2	NH-4 Road	1+300 to 1+400	100	LHS
3	NH-4 Road	2+100 to 3+000	900	RHS
4	NH-4 Road	2+500 to 3+040	540	RHS
5	D Bhaskaran Road	10+600 to 10+700	100	RHS
6	D Bhaskaran Road	10+600 to 10+700	100	LHS
7	St Johns Church Road	12+800 to 13+300	500	LHS
8	Promenade Road	12+800 to 13+000	200	RHS
9	CV Raman Road	18+100 to 18+500	400	LHS
10	CV Raman Road	18+600 to 18+900	300	LHS
11	Ramamurthinagar Main Road	3+600 to 5+600	2000	RHS
12	Ramamurthinagar Main Road	3+600 to 5+400	1800	LHS
13	General KS Thimaiah Road	0+700 to 1+000	300	RHS
14	Kensington Road	2+000 to 2+200	200	LHS
15	Wheeler Road	0+000 to 0+500	500	LHS
16	Kensington Road	0+700 to 1+000	300	LHS
17	Kensington Road	0+580 to 1+120	540	RHS
	Total		8980	
Phase III				
1	Lal Bagh Fort Road	19+500 to 19+800	300	RHS
2	Lal Bagh Fort Road	19+470 to 19+800	330	LHS
3	Armugam Mudaliar Road	19+100 to 19+600	500	RHS
4	Alur VenkataRao Road	20+700 to 21+090	390	LHS
5	Alur VenkataRao Road	21+100 to 21+700	600	RHS
6	Alur VenkataRao Road	21+300 to 22+950	1650	LHS
7	Mysore Road	23+100 to 23+400	300	LHS
8	Mysore Road	23+800 to 24+200	400	RHS
9	Mysore Road	24+690 to 25+100	410	LHS
10	5th Main Road (Rajagopalanagar)	20+850 to 22+450	1600	RHS
11	5th Main Road (Rajagopalanagar)	20+850 to 21+930	1080	LHS
12	5th Main Road Ramachandra Agrahara	22+200 to 22+450	250	LHS
13	HAL Airport Road	0+500 to 1+100	600	LHS
14	HAL Airport Road	4+600 to 4+800	200	LHS
15	HAL Airport Road	4+900 to 5+200	300	RHS
16	HAL Airport Road	5+400 to 6+300	900	LHS
17	Old Airport Road	9+450 to 9+650	200	LHS
18	Old Airport Road	9+700 to 9+900	200	LHS
19	Old Airport Road	10+050 to 10+110	60	LHS
20	Old Airport Road	12+290 to 12+600	310	RHS
21	Old Airport Road	12+400 to 12+600	200	LHS
22	Richmond Road	16+070 to 16+250	180	LHS

Sl. No.	Location of Air Sensitive Receptors (Inhabited stretches)	Chainage	Length impacted (M)	LHS/ RHS
	Total		10960	
Phase IV				
1	Dodda Banaswadi Main Road	1+300 to 1+810	510	RHS
2	Dodda Banaswadi Main Road	1+990 to 2+240	250	RHS
3	Dodda Banaswadi Main Road	2+300 to 2+810	510	RHS
4	Dodda Banaswadi Main Road	2+500 to 2+800	300	LHS
5	Dodda Banaswadi Main Road	3+000 to 3+800	800	RHS
6	Dodda Banaswadi Main Road	3+600 to 4+100	500	LHS
7	8th Main East Road	4+600 to 5+500	900	LHS
8	8th Main East Road	4+600 to 5+500	900	RHS
	Total		4670	

Mitigation measures:

During construction, the following mitigation measures should be employed in order to minimise the impact on air quality.

- All construction sites, material haulage roads and the traffic diversion routes shall be sprayed with water two to three times a day. Water spraying is needed to compact the soil properly and prevent dust.
- The materials transported to and from the construction site should be properly covered with tarpaulin;
- Temporary stockpiles of soil or other material should be covered or sprayed with water on a regular basis, particularly during dry or windy conditions;
- All stockpiles should be located far from residences and businesses where possible, prevent placing dusty material storage piles near ASRs;
- Water sprinkling should be done regularly to suppress dust on at grade roads, temporary traffic diversion roadways and other exposed areas;
- Dust-generating activities should be minimised during windy conditions, particularly when dust is visible in the air.
- Additionally, all plant, equipment should be maintained and operated to specifications to minimise emissions of other gaseous pollutants.
- Construction vehicles used for the construction shall be serviced regularly to ensure that the air pollutants emissions are not exceeding the norms prescribed by CPCB and shall obtain the Pollution Under Control Certificate.
- Siting of all construction establishments such as hot mix plants, batching plant, crusher plant, construction camps and offices shall ensure compliance to all legal requirements and strictly adhered conditions stipulated in the consent.

- Human settlements should be at least 500 m down windward of hot (asphalt) mix plants, batching plants, crushers, etc. These construction establishments should be compulsorily fitted with dust suppression units.
- Dust generation during construction would be managed well through the implementation of Environmental Management Plan.
- Ambient air quality monitoring shall be done regularly at all the representative sensitive locations to ensure that all the emissions from construction activities are within the National Ambient Air Quality Standards by CPCB and implement required mitigation measures if any of the air pollutant exceeds the limit.

5.2.6 Impact on Noise Quality

The community living adjacent to the project corridor and those involved in construction of project corridor will be adversely affected by increase in ambient noise levels due to construction activities. Various construction activities such as demolition of structures within the proposed right of way, grading of the site, excavation and drilling operations for pile foundations, construction of structures and facilities, movement of heavy construction vehicles, loading, transportation and unloading of construction materials, equipment & machineries to construction site and unserviceable materials from construction site to disposal sites. Further, activities such as blasting at stone quarry sites, crushing plants, asphalt production plants, produce significant noise during the construction stage. Traffic diversions during construction also contribute to the increase in noise.

Table 5-9 summarizes the noise emissions from different construction equipment which may be used in the elevated corridor project. Equipment and operation noise levels are expressed in terms of L_{Max} noise levels

Table 5-9: Average noise levels generated from equipment used in construction⁷

Sr. No.	Equipment	Noise Level in dB(A) (L_{max} @ 50 feet (DBA, slow))
1	Batching Plant	83
2	Concrete Pump Truck	82
3	Dumpers	84
4	Cranes	85
5	Dozer	85
6	Generators	82
7	Excavator	85
8	Trailer	84
9	Jackhammer	85
10	Hydraulic Hammer	90
11	Compactor (ground)	83
12	Compressor (air)	78
13	Impact Pile Driver	95
14	Vibratory Concrete Mixer	80
15	Auger Drill Rig	85

⁷ These values represent the default values for use in the Roadway Construction Noise Model (RCNM), Federal Highway Administration's (FHWA), national model for the prediction of construction noise.

Increase of noise around 90 dB (A) creates fatigue of the hearing organs. Prolonged living in an area infested with noise pollution may gradually induce deafness. Increased noise may induce in human body various types of temporary physiological changes, such as hypertension, change of the rate of heart-beat, high respiratory rates, excessive perspiration, vomiting tendency, vertigo, exhaustion and disturbs sleep. If the noise is intolerable, it can tend people to shift to far off places.

It is expected that the increase in noise levels on the elevated roads depends on several factors like type of vehicle, age of the vehicle, type of pavement (rigid and flexible) speed of the vehicle, distance of sensitive receptor from the source of noise generation, height of the super structure (crash barrier) on the elevated roads.

All the identified inhabited stretches are prone to increased noise. Further, noise sensitive receptors like schools, hostels, hospitals, libraries, civil courts are largely impacted from project activities both during construction and operation phase. Some of the noise sensitive receptors along the proposed corridors are tabulated in the Table 5-10 below.

Table 5-10: Noise sensitive receptors along the proposed corridors

Chainage		Schools/Colleges/Hostels/Hospitals	
From	To	LHS	RHS
NS Corridor			
Starting from Airport road flyover near Columbia Asia Hospital			
0+250	0+300	Columbia Asia Hospital, Hebbal	
3+950		R S College of Management & Science	
Starting from Mekhri Circle			
1+600			Indian Institute of Ayurvedic Medical and Research
3+100		United Theological College	
4+250		HKBK Degree College, Cantonment Railway Station Road	
4+400		Church of South India Hospital, Hazarat Kambal Posh Road	
4+830			Shifaa Hospital
			Hope Medical Centre, Queen's Road, Vasanthanagar
6+670		British Library, Kasturaba Road, Richmond Town, Bengaluru,	
8+200	8+300	United Mission High School	
8+600	8+700	Government College of Pharmacy	
10+000	10+100	Outreach School	
11+900	12+000	Shanthigiri Ayurveda & Siddha Hospital	
EW1 Corridor			
	2+100		Vidyarthi Education Academy
2+400	2+500		Sri Ramakrishna Hospital
2+900	3+000		Sri Ram Hospital
3+100	3+200	ESI Hospital	Government Hospital
5+400		Apple Kids	
12+300	12+400	Lakeside Medical Centre & Hospital	
12+900	13+000		Conrad Higher Primary School

Chainage		Schools/Colleges/Hostels/Hospitals	
From	To	LHS	RHS
13+200	13+400		St. Germain PU College
14+500	14+600		United Theological College
16+100	16+200		Eches Boys Hostel
16+300	16+400		H R H A Primary High School
18+100	18+200		Air Force School Hebbal
19+300	19+400		JRD Tata Memorial Library
20+000	20+100		New Boys Hostel
20+300	20+400		Kendriya Vidyalaya,
21+300			Indian Institute of Sciences
EW2 Corridor			
1+100	1+300	Government School	
1+600	1+700	Royal English School, Siddapura	
2+390		Prishti Pre-school	
3+000	3+100	Government Primary School	
3+400	3+500		Picasso Animation College
3+900	4+000		Sankara Eye Hospital
4+100	4+200	Yashoda Medicare and Research Center	
4880		MGA Hospital	
6+400		Deepa Nursing Home	
9+450	9+600	M Visvesvaraya College	
9+700			Cloud 9 Hospital
10+500		Manipal Hospital	
10+900		Seventh-day Adventist English High School & Pre-University College	
11+370			Manipal Global Education Services (P)
13+600	13+700		Command Hospital
15+300	15+400	Vardhaman Mahaveer Jain School	Kedriya Vidyalaya
15+900		All Saints Church and Cathedral High School	
17+300		St. Joseph College	
17+700		Kalakusuma Film Institute and Studio, Lalbagh Main road	
17+900	18+000	Govt. College of Pharmacy, Subbaiah Circle	
18+500		Jain University & Sri Bhagawan Mahaveer Jain College	
18+600		St Thomas Church,	School of Graduates
19+900	20+000	Bangalore Medical College	BMCRI Ladies Hostel & ENT Government Hospital
20+200	20+300	Minto Eye Hospital	Vanivilasa Hospital
20+400	20+500	Jnana Jyothi College of Business	
20+800	20+900	Wisdom International School	
21+000	21+100	Sri Morarji Desai Model School	JJ Ramanagar Referral Hospital
CC 1 Corridor			
1+200	1+300		Asia Pacific World School
1+400	1+500	Government Middle School	
1+900	2+400	Krupanidhi PU College	

Chainage		Schools/Colleges/Hostels/Hospitals	
From	To	LHS	RHS
2+300			St Francis High School & College
2+700	2+800		Amity Global Business School
2+800	2+900	CGHS Wellness Centre Hospital	
2+900	2+950		Greenwood High Pre School
3+000	3+100		The Freethinking School
3+200	3+300		Dr. Agarwal's Eye Hospital
3+300		Indian Institute of Astro Physics	
3+600	3+700		St. John's Hospital
CC 2 Corridor			
0+200	0+500		Kendriya Vidyalaya
1+650			Sri Guru Harkrishan High School
CC 3 Corridor			
0+100	0+200	RTC Girls High School	
1+000	1+100		Government School
1+100	1+200		Ambedkar Girls Hostel
2+600	2+700		Apple Hospital
3+450		Paul's Primary High School	
3+700	3+800		Dewan's Hospital
5+700		Parankushachar Institute of Vedic Studies	

Construction workers are affected by the construction noise. It is true that intermittent and impulse noises are less dangerous than continuous noise due to the short exposure duration except under the situation when the level exceeds 115 dB (A).

Mitigation measures:

- The effective control of construction noise can be achieved by using a three-part approach consisting of control of the noise at the source; control along the path of the noise and control at the receptor. During construction, the following mitigation measures should be employed in order to minimise the impact from increased noise levels during the construction of elevated corridor project.
- The type of pavement on the elevated corridor affects the noise generated from the roads. Rigid pavements are known to generate more noise than the flexible asphalt roads.
- Properly designed and maintained equipment & machinery with in-built silencers, mufflers and enclosures and shock absorbing pads shall be used in construction. This would reduce their noise by 5 to 10 dB (A)
- Locating noise emitting stationary equipment away from noise sensitive receptors would decrease the impact of noise.
- All construction establishments such as batching plants, hot mix plants, casting yards, construction camps shall be sited away from the human habitations. In addition, greenbelts around the construction establishments shall be planned to obstruct the noise transmission. Further, The plant and equipment used in construction shall strictly conform to CPCB noise standards.

- Generally, piling is driven using an impact hammer which often produces excessive noise levels. This noise can be reduced by various dampening and shielding methods. Further, an alternative to driving piles, vibration or hydraulic insertion can be used. Drilled holes for cast in place piles are another alternative that may produce noise levels significantly lower than the traditional driving method.
- A large part of the noise emitted is from the intake and exhaust parts of the engine. A remedy for controlling much of the engine noise is the specification and use of muffler systems. Muffler requirements shall be made as contract specifications.
- Poor maintenance of equipment causes high noise. Faulty or damaged mufflers, loose engine parts, rattling screws, bolts or metal plates contribute to increase in the noise level from a machine. Poor maintenance, improper handling and operation of equipment also increase noise levels. Specifications / instructions shall be included to the Contractors to ensure all equipment are regularly inspected.
- Noise levels may be regulated by stopping all the noise generating construction works at night time near the inhabited localities. Noisier construction and demolition activities to be limited between 6 AM and 10 PM would comply to reduce construction noise impacts during night hours.
- Turning off construction equipment during the prolonged periods of non-use would eliminate noise from construction equipment during those periods. Continuous loud noises around noise sensitive receptors such as schools, hospitals, etc., are disturbing at all times. Restriction of construction activity to limited time periods can be effective in reducing noise induced impacts.
- Construction equipment and vehicles carrying spoil, concrete or other materials can be routed over those streets that could cause least disturbance to residents in the vicinity of the project. The contractor shall propose and get the approval for such proposed hauling routes prior to the construction.
- Dissemination of information to the public and adjacent property owners of upcoming noise impacts related to the construction activity. The scope of the proposed work and when possible, the time span of the activity should be spelt out in order to allow residents to plan their activities accordingly.
- Efforts shall be made to reduce truck trips by increasing load size, decreasing fill requirements, or combining trips would reduce noise levels.
- Ensure proper personal protective devices to all the persons working in high noise zones.
- Regular monitoring of noise levels shall be done at noise sensitive locations along the construction sites and associated construction establishments to monitor and have a control over increase in noise.
- IS 4954 - Recommendations for Noise Abatement in Town planning, 1968 (reaffirmed 2006) shall be considered during design of corridors.

- Increased noise and its transmission to sensitive receptors from the vehicles can be controlled and regulated by providing suitable noise barriers. Noise barriers are constructed to suit the acoustic requirements and aesthetic considerations as well.
- Sign boards on restricting use of horns and speed limit shall be erected at all the noise sensitive receptors.

5.2.7 Impact on Biological Environment

Removal of these trees will impact the quality of air. Trees are major sources of air purification in urban areas making cities socio-economically and environmentally more sustainable. Trees clean air by absorb CO₂ from atmosphere and play an important role in climate change mitigation. Trees in cities will help to control temperature and keeps the air cool, thus reducing the urban heat island effect.

Loss of trees: The impact on the trees is unavoidable as the alignment of the corridor is taken almost along the existing roads which have substantial width to accommodate lanes for the projected traffic. There will be a significant impact on trees by construction of elevated corridors. Space of about one meter beyond actual corridor of impact is required on both sides to carryout construction activities and for safety reasons. This requires tree branches obstructing the construction of elevated structures to be pruned.

Not all the trees along the elevated corridor are to be cut. Trees along some of the stretches are to be pruned as the height of the elevated structure is much higher than the height of the trees. Hence, the trees impacted are grouped under two headings i.e. trees to be cut and trees to be pruned. Phase wise details of impacted trees are as shown in Table 5-11.

Table 5-11: Trees impacted along the proposed project corridors

Trees to be Cut / Trimmed	Phase I	Phase II	Phase III	Phase IV	Total
Trees to be cut (within Col)	940	710	983	376	3009
Trees to be trimmed/ pruned	212	120	241	28	601
Total	1152	830	1224	404	3610

There are a few identified environmentally sensitive thickly wooded stretches which are affected by the project. These are mainly located along North-South corridor, East –West Corridors 1 & 2 as detailed in the following table and shown in Annexure.

Table 5-12: Environmentally sensitive wooded stretches

Sl. No.	Location of Sensitive wooded Stretches	Approximate Length impacted (M)	Approximate number of trees (Nos.)	Phase No.	Corridor Name
1	Cubban Park, Kasturabha Road	876	120	Phase I	NS
2	Near Bengaluru Palace, Jayamahal	1100	356	Phase I	NS

Sl. No.	Location of Sensitive wooded Stretches	Approximate Length impacted (M)	Approximate number of trees (Nos.)	Phase No.	Corridor Name
	Road				
3	Coles Park, Promenade Road	350	47	Phase II	EW 1
4	IISc Campus to Mekhri circle, CV Raman Road	1350	195	Phase II	EW 1
5	IISc Campus to Yeshwanthpur circle, CV Raman Road.	900	32	Phase II	EW 1
6	Raja ram Mohan Roy Road	960	108	Phase I	EW 2

The proposed elevated corridors are within Bangalore Metropolitan Region and does not pass through any forests and wildlife sensitive zones.

Mitigation measures:

- Trees cutting and felling shall be done only after the confirming that the tree comes in the way of construction.
- Trees cleared shall be replaced with minimum of 10 trees per tree cut or according to Compensatory Afforestation Policy under Forest Conservation Act-1980.
- No damage shall be caused to the trees other than trees to be felled along the proposed during construction activities. No paint thinner, paint, plaster or other liquid or solid excess or waste construction materials or wastewater shall be dumped on the ground or base of the tree.
- Wherever cuts are made in the ground near the roots of trees, appropriate measures shall be taken to prevent exposed soil from drying out and causing damage to tree roots.
- Where feasible all possible efforts shall be made to transplant the trees to a safer and preapproved location. Transplanting of tree depends on general health, form and structure of the tree; size and quality of root system; size of trees, species and conservation status of a tree; availability and suitability of a receptor site, time for preparation, cost effectiveness, etc.
- Vertical garden shall be grown on the piers to enhance the aesthetic value and to address the vehicular pollution.
- Suitable ornamental plants shall be planted in medians of at grade roads all along the proposed alignment of elevated corridors.

5.2.8 Impact on Water Bodies

There are many water bodies along the proposed route of elevated corridors which are brought out in Table 5-13. Construction of the project corridor and the associated activities

will impact on the water bodies and its ecology. The debris generated from the demolition of structures and excavation for pile foundation could potentially find its way to the nearby water bodies adjacent to the project corridor. This will not only silt up the lakes but also impact the aquatic life in these waterbodies.

Table 5-13: Details of waterbodies adjacent to the project corridor

Sl. No.	Phase No.	Water bodies / Lakes	Name of the Corridor	LHS / RHS	Distance of pier foundation from Water body (m)	Location
1	Phase I Package - I	Hebbal Lake	NS	RHS	5	Near Hebbal Flyover
2	Phase II Package - I	KR Puram Lake,	EW-1	RHS	20	Along NH 4
3	Phase II Package - I	Benniganahalli Lake	EW-1	RHS	350	Swamy Vivekananda Road
4	Phase II Package - I	Pond near Sarvagna Nagar	EW-1	RHS	20	Swamy Vivekananda Road
5	Phase II Package - II	Ulsoor Lake	EW-1	LHS	5	Kensington Road
6	Phase V Package - I	Varthur Lake	EW-2	LHS/RHS	5	HAL Airport road and along SH 35 respectively
7	Phase V Package - I	Thubarahalli Lake	EW-2	RHS	120	Varthur road / HAL Airport road
8	Phase IV Package - I	Vrishabhavathi Nalla	EW-2	LHS / RHS	5	Mysore road
9	Phase I Package - III	Agara Lake	CC-1	LHS	30	Sarjapur main road
10	Phase II Package - II	Challkere	CC-3	RHS	30	100 ft. Ring road
11	Phase - II	Rajakaluve	CC-3		1	At Banasawadi
12	Phase I Package - II	Rajakaluve	NS		1	At Shathinagar Bus Depot

None of the proposed corridors are passing over the water bodies. However, as the elevated corridor alignments are proposed along the existing roads which are parenthetically adjacent to the waterbodies, except Thubarahalli Lake all other water bodies mentioned in table are within the buffer zone established by NGT Order.

It is also important to mention that looking at the feasibility and other parallel project developments from various department like BDA, BMRCL, BBMP, etc. there are some changes in the proposed lengths. Significant changes which reduce the impact on water bodies are as follows.

The start point of North-South Corridor will start from Baptist Hospital instead of Esteem Mall. Now, the start point is at a distance of almost 1 km

Vehicles operating on the elevated road release engine oil which are carried by surface runoff during monsoon, which is ultimately thrown in to the nearest waterbodies. Over the time accumulated oil forms a thin layer on the surface of the water and lead to eutrophication.

There is no significant impact on either ground water or water table by the project activities. The elevated corridor is proposed along the existing paved roads which are not making significant impact on the ground water percolation and ground water potential.

Mitigation measures:

- Rain water harvesting will be proposed to collect the surface runoff from the elevated paved surfaces and made to recharge ground water in the available median space after the required treatment to remove the oil.
- Proper and regular maintenance shall be carried out to clear the debris on the elevated road which otherwise choke the drains.
- To prevent these impacts effective mitigation measures shall be ensured to control the spillage of debris / construction materials into water bodies particularly where the project corridor is passing adjacent to waterbodies.

5.2.9 Impact on Land Environment

Construction of projects in urban areas involves both cut and fills activities and requires use of construction materials from quarries and excavations of soil from borrow pits. From a resource perspective, there are benefits from using excavated soil and rock as a construction material, particularly in the construction of ramps used to access the elevated corridors.

Construction of elevated corridors requires about 12 Lakh cum of borrow earth which have to be sourced from the nearby approved murrum borrow pits. The earth excavated from pile foundations shall be used for

Sl. No.	Project Phases	Quantity of excavated earth generated (Cum)	Reuse of construction excavated soils & debris (Cum)	Unserviceable construction waste to be disposed (Cum)
1	Phase I	154030	123224	30806
2	Phase II	58278	46622	11656
3	Phase III	83555	66844	16711
4	Phase IV	1863	1488	375
	Total	297726	238178	59548

The unserviceable debris generated from project construction activities shall be disposed of in a scientific and sustainable manner in the abandoned quarries located in and around

Bangalore city. Though the lead and lift is incidental to the civil works, contractor will be paid to handle the debris in a sustainable manner.

5.2.10 Impact on Structures (Religious, Community structures and Historical and Cultural Monuments)

Construction of corridor project will directly impact on structures residential, commercial, residential cum commercial, religious, community and others which are directly under Col of elevated structure and needs to be demolished. List of impacted structures are given in Table 5-14. Further, during construction access to these centres to the public will be impacted temporarily.

These impacted structures need suitable resettlement and rehabilitation in consultation with the local public.

Table 5-14: The structures under impact in the project area (Nos)

Sl. No.	Corridor Name	Residential	Commercial	Res/Com	Religious	Govt./Community	Educational	Others	Total
1	NS Corridor	169	48	1	6	8	1	62	295
2	EW 1 Corridor	0	155	15	8	3	2	42	225
3	EW 2 Corridor	32	339	5	14	2	5	146	543
4	Connecting Corridor 1	0	0	0	0	0	0	2	2
5	Connecting Corridor 2	4	1	0	2	0	0	6	13
6	Connecting Corridor 3	4	33	0	2	0	1	12	52
	Total	209	576	21	32	13	9	270	1130

There are two notified archaeological structures along the East West Corridor - 2. Tipu Sultan's Summer Palace being a protected monuments as per the Ancient Monuments and Archaeological Sites and Remains (Amendment & Validation) Act, 2010(prohibited area), is within a distance of 100 metres from the proposed East West Corridor - 2. Another notified structure Old Dungeon Fort & Gates is at a distance of 330 m from, beyond regulated area (200 meters further beyond prohibited area as per the latest circular). The vibrations induced by piling activity typically influence the zone stretching 10 – 50 m from the operation. Hence, there is no significant impact on the notified structure.

Mitigation measures:

- Compensation has to be settled before the start of project for all the structures being impacted as per the KIADB Act with compensation at par with the Land Acquisition, Rehabilitation and Resettlement Act, 2013.
- All the impacted cultural and community structures are to relocated and rehabilitated to proper location in consultation with the local community.
- All necessary and adequate care should be taken to minimize the impact on cultural properties.

- If valuable or invaluable articles such as fabrics, coins, artefacts, structures or other geographic or archaeological rarities are discovered, the excavation should be stopped and the archaeological department to be contacted.
- Permission from National Monument Authority shall be obtained before the start of construction in the area falling within protected area notified by the authority.
- The press-in method, an alternative technique of pile installation, which allows pre-formed piles to be installed with minimal noise and vibration.
- Pre-formed steel piles shall be preferred within the notified prohibited area.
- Mini or Baby rollers shall be used for compaction to reduce the vibration

5.2.11 Impact on Livelihood, Public services, Health and Safety of Community and Labourers

There will be lot of inconveniences and nuisance to the public temporarily during construction of the project. Inconveniences will be caused by utility shifting, excavations, unplanned stacking of excavated earth and traffic diversions in the vicinity of project corridors. Construction activities causes disturbance to traffic along the proposed alignments resulting congestion, traffic diversions, increased dust generation, emission of air pollutants by slow moving traffic. The commercial activities along the proposed alignment will be affected and incurs loss to the retailers and businessmen. Increase in noise along the corridors will impact inhabitants particularly old age community and school children and the patients.

The construction of proposed elevated corridors will impact on utilities both on the road and under the ground. Utilities such as electricity, telephone, optical cables, storm water drains, UGD, water supply resources, optical cables, etc. are common utilities to be affected during the construction stage. The inventory on the number of affected utilities above the ground is in progress.

In addition to the above concerns, there will be regional labour issues, safety of children and the elders, possibility of spread of communicable disease, etc. The issues related to safety shall be addressed by properly locating the labour camps and construction establishments sufficiently away from thickly populated areas to avoid the pressure on the local resources facilities. Construction zone should be separated by providing appropriate barricading, providing personal protective equipment (PPE) to labourers, educating and training the labourers and local community, and establishing labour camps quite far from the inhabited areas.

These impacts are temporary in nature, however, it needs planning, coordination and management to reduce the intensity of the impact and sustainable completion of the project.

Mitigation measures:

- All the utilities shall be shifted properly to safe and pre-planned locations before the start of construction such that the impact on livelihoods is not affected much.

- Contractor shall prepare traffic management plan addressing all the traffic issues in the project corridor alignment and get the approval of engineer concerned.
- Semi-skilled and unskilled labourers would be recruited from nearby areas to create some employment opportunities and sense of well-being among local people. This will also reduce social tension of migration and the necessity establishing labour camps within the city thus alleviating impacts associated with establishment of labour camps.
- All the labourers engaged in the construction works are provided with proper camp facilities including sanitation, drinking water supply, washing facilities, cooking facilities and primary health facilities.
- Construction workers are ensured adequate safety measures complying as per the occupational safety requirements to prevent accidents and hazards. Safety of workers during construction should be ensured by providing them with helmets, masks, safety goggles etc.
- The workplace shall have proper medical facilities approval by the local medical health or municipal authorities. At every work place, a readily available first aid unit, including an adequate supply of dressing materials, a mode of transport (ambulance), nursing staff and an attending doctor, to be provided.
- To ensure safe construction, the temporary accesses during construction, lighting devices and safety signals shall be installed and traffic rules and regulations to be strictly followed.
- The electrical equipment should be checked regularly to avoid risks to workers.

5.2.12 Impact on Economy

During construction phase, local people involving construction activities earn their livelihood in the form of wages and salaries. Local retail shops get their business by construction workers, making everyday purchases. This is likely to give a short-lived stimulus to daily commercial activities till the completion of project. Broader, flow-on economic impacts will be experienced in other sectors of economy as a result of purchase of construction materials. During operation stage, after the construction is complete, there will be a few long-term benefits in the economic structures of the Bengaluru city due to improved access to the different parts of city and suburban areas in the periphery.

5.2.13 IMPACTS DURING OPERATION STAGE

During operation phase no significant adverse impact is envisaged on the environment. However, Ambient air quality will be improved compared to present condition as the at grade traffic congestion will be reduced. However increase in number of vehicles over the period of design life may increase the air pollution along these corridors. Reduction in traffic congestion will reduce the air pollutant emissions due to reduction in acceleration and deceleration and also reduces the dust generated from the operating vehicles. Noise levels along the corridors will be reduced considerably as the use of horn will be reduced. However, speeding vehicles will generate the noise by the friction of tyres with the pavement which may be annoying to the inhabitants adjacent to the corridors especially during nights.

5.2.14 POSITIVE IMPACTS OF ELEVATED CORRIDOR PROJECT

Construction of elevated corridor in a city like Bengaluru will also yield tangible benefits such as better accessibility, less atmospheric air pollution, less travel time, comfort and improved quality of life. The impact on the economic growth of the city, improved quality of life, reduced air pollution and its impact on health and wellbeing of city dwellers which are difficult to quantify. Some of the positive impacts have been listed and discussed below.

Employment Opportunities - The project during construction is expected to generate employment in the secondary and tertiary sector during construction and operation phases respectively. During the construction phase, there will be requirements for unskilled labourers.

Safety – The proposed corridor will be safer, efficient and faster compared to the present roads. Also reduction in traffic congestion will make the roads safer and will reduce the incidence of accidents.

Traffic Congestion Reduction – Proposed elevated corridors are aimed to provide quick access and reduce traffic congestion on the main roads in the city.

Less Fuel Consumption – The proposed elevated corridors are signal free and planned to give access to all important peripheral roads leading suburban areas and Bengaluru International airport. Ease of traffic movement on the elevated corridors and reduction of vehicles on at grade roads will help in reduction of fuel consumption in the city.

Reduced Air Pollution – Implementation of elevated corridor will reduce the traffic congestion on the at grade roads. Vehicle users prefer elevated corridor as it will serve as faster and convenient alternative to congested at grade roads. This eases the traffic on the roads and reduces traffic jams leading to reduction of gaseous emissions and improves the air quality in the city.

Traffic Noise Reduction - Any reduction in traffic and traffic congestion will also contribute for reduction in the noise levels.

5.2.15 Environmental Impact Matrix

The proposed elevated corridor project requires acquisition of valuable land abutting the proposed alignment. At some locations, it also requires to acquire land for construction of ramps and grade separators. The major environmental impact is due to felling of trees abutting the proposed alignment. Some stretches of the proposed corridor passes through thickly wooded areas. However, compensatory afforestation is suggested to minimize this impact. Increase in noise levels is significant during construction phase particularly at educational institutions. The proposed alignment passes near two notified archaeological monuments. The impact on the surrounding environment by project during the construction and operational stages were envisaged based on the observations during the baseline surveys.

The impacts on the surrounding environment during construction and operational stages are summarized in the Impact Identification Matrix given below in Table 5-15.

Table 5-15: Environmental Impact Matrix for the proposed elevated road project

Environmental Attributes Different components of project implementation	Physical Environment						Biological Environment		Social Environment			Cultural Environment
	Air Quality	Surface & Ground water quality	Noise	Soil	Hydrology & Natural Drainage	Topography	Destruction of Habitat		Public Health & Safety	Land use	Public well-being	Temples and Archaeological monuments
							Flora	Fauna				
I. Pre-construction Phase												
Land acquisition	-	-	-	-	-	-	-	-	-	+ve/p	-ve/p	-ve/p
Demolition of physical properties	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-	-	-ve/t	+ve/p	-ve p	-ve p
Cutting of Trees	-ve/p	-ve/p	-ve/p	-ve/p	-ve/p	-	-ve/p	-ve/p	-ve/p	-ve/p	-ve/p	-
Utility shifting	-ve/t	-	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-	-ve/t	-ve/p	-ve/t	-
II. Construction Phase												
Clearing, Grubbing	-ve/t	-ve/t	-ve/t	-ve/p	-ve/t	-ve/t	-ve/p	-ve/t	-ve/t	-ve/t	-ve/t	-
Borrowing & Quarrying	-ve/p	-ve p	-ve p	-ve/p	-ve/p	-ve/p	-ve/p	-ve/p	-ve/t	-ve/p	-	-
Pile Foundation	-ve/t	-ve/t	-ve/t	-ve/t	-ve/p	-ve/t	-	-	-ve/t	-	-ve/t	-
Casting and casting yards	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-	-ve/t	-ve/t	-ve/t	-
Material Transport & Storage	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-	-	-ve/t	-ve/t	-	-
Traffic Diversion	-ve/t	-	-ve/t	-ve/t	-	-	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-
Labour/Construction Camp Activities	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-
Batching Plant & Hot Mix Plant	-ve p	-ve/t	-ve/t	-ve/t	-ve/t	-ve/t	-ve/p	-	-ve/t	-ve/p	-ve/t	-
Use of Construction Equipment	+ve/t	-	+ve/t	-ve/t	-ve/t	-	-ve/t	-	-ve/t	-	-ve/t	-
Pavement works	-ve/t	-ve/p	-ve/t	-	-ve/p	-	-ve/t	-	+ve/t	-	-	-
II. Operational Phase												
Tree Plantation	+ve/p	+ve/p	+ve/p	+ve/p	+ve/p	+ve/p	+ve/p	+ve/p	+ve/p	+ve/p	+ve/p	+ve/p
Vehicular Movement	-ve/p	-	-ve/p	-	-	-	+ve/p	+ve/p	+ve/p	-	+ve/p	+ve/p

Note: t – Temporary; p- Permanent; Impacts indicated in bold letters are significant impacts.

The impacts indicated above are indicative and represent the impact without mitigation measures.

5.2.16 Matrix Representation

The potential impacts during construction and operation phases are presented in the form of a matrix in Table 1-18. The table of matrix indicates the significance of the impact of different project activities both during construction and operation phases of the project. The quantification of these impacts is done using numerical scores from 0 to 5 as per the following criteria.

Table 5-16: Score to quantify the impacts

Sl. No.	Impact Indicators	Severity criteria	Impact Score
1	-	No impact	0
2	-ve t	Slight/ Short-term Impact	1
3	-ve t	Occasional reversible Impact	2
4	-ve p	Irreversible/ Long-term Impact	3
5	-ve p	Permanent damage	4

Scores for various environmental parameters and project activities (Pre-construction and Construction phase) are presented in Table 5-17.

Table 5-17: Cumulative Impact Score for the proposed elevated corridor project

Environmental Attributes Different activities of project implementation	Physical Environment						Biological Environment		Social Environment			Cultural Environment
	Air Quality	Surface & Ground water quality	Noise	Soil	Hydrology & Natural Drainage	Topography	Destruction of Habitat		Public Health & Safety	Land use	Public well-being	Temples and Archaeological monuments
							Flora	Fauna				
I. Pre-construction Phase												
Land acquisition	0	0	0	0	0	0	0	0	0	4	4	3
Demolition of physical properties	2	1	2	1	1	1	0	0	1	4	3	4
Cutting of Trees	4	4	3	4	4	0	4	4	4	4	4	0
Utility shifting	1	0	1	1	1	1	1	0	1	3	1	0
II. Construction Phase												
Clearing, Grubbing	1	1	1	3	2	2	4	2	1	1	1	0
Borrowing & Quarrying	3	3	3	3	4	4	4	3	1	4	0	0
Pile Foundation	2	1	2	2	3	1	0	0	1	0	1	0
Casting and casting yards	2	1	2	1	1	1	1	0	1	1	1	0
Material Transport & Storage	2	2	2	2	2	2	0	0	1	1	0	0
Traffic Diversion	2	0	2	1	0	0	1	1	1	2	1	0
Labour/Construction Camp Activities	2	2	2	2	1	2	2	1	2	2	1	0
Batching Plant & Hot Mix Plant	3	2	2	2	1	2	3	0	2	3	2	0
Use of Construction Equipment	2	0	2	1	1	0	1	0	1	0	1	0
Pavement works	2	3	2	0	4	0	1	0	1	0	0	0
Total Cumulative Score	28	20	26	23	25	16	22	11	18	29	20	7

5.2.17 Determining the sensitiveness of Project Corridor

For analysis of sensitiveness of the project corridor, twelve categories of commonly and frequently occurring environmental attributes present in impact zone, such as inhabitants resided within 50 m from the corridor; trees being cut and pruned within the corridor of impact and buffer zone respectively; impact of noise on noise sensitive receptors like schools, education institutions & hospitals; sensitive religious and community establishments; commercial establishments along the corridor; water bodies adjacent to project corridor; narrow and congested locations which are prone to increased air and noise pollution; impact on the common utilities like electrical lines, water pipelines, optical fibres, manholes; impact from project associated construction establishments such as borrow areas, quarries, batching plants, hot mix plants, construction camps, crushers, etc., are considered.

The total negative impact of various project activities (15 major activities) on an environmental parameter is represented as a cumulative impact score and the cumulative scores of various environmental parameters (12 Nos.) are given as total cumulative score. Any particular parameter having an individual score greater than 10 or more implies serious effects due to the project and calls for suitable mitigation measures. Implementation of mitigation measures in the form of Environmental Management plan will bring down the impact score of the project and reduces the sensitiveness of the project.

6. ADDITIONAL STUDIES

6.1 Rain water Harvesting Potential and Proposal:

In absence of effective management of surface runoff water, elevated corridor may create havoc in the form of flash floods, if the lead drains are not maintained properly during monsoon. Hence, provisions are made to harvest the surface runoff and guide it to ground water recharge pits after suitable treatment.

Rainwater harvesting potential of pavement surface of elevated corridor is calculated and given in Table 6-1. Total of 5,63,000 m³ of harvested water is expected from the elevated structure. The rainwater from pavement surface will be collected through rain drain pipes and made to pass through stabilization tank fitted with specialised oil skimmers for removal of silt, grit and floating oil residues. The treated water will be led into series of percolation pits located in the median of at-grade roads for groundwater recharge.

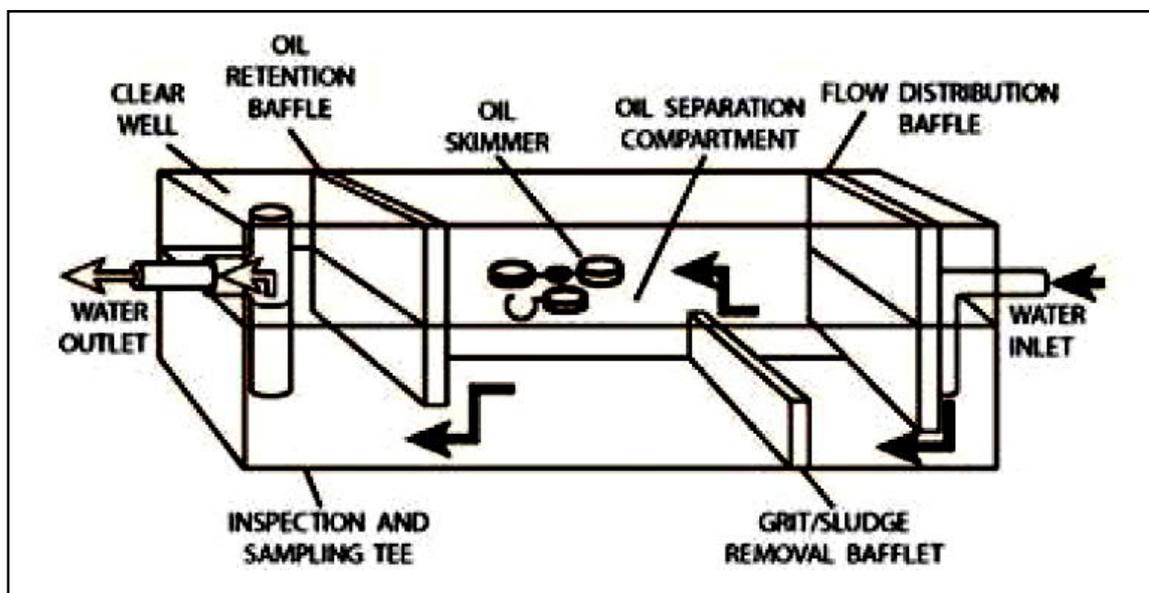
Rainwater from pavement surfaces - $2181105 \times 0.86 \times 0.3 = 5,62,725 \text{ m}^3 / \text{Year}^*$

Table 6-1: Rainwater harvesting potential of the proposed elevated corridors

Sl. No.	Corridor Name	Corridor Length (Km)	Carriageway area (Sq.m.)	Rainwater harvesting potential (m ³ /Yr)
1	Phase I	24.47	523046	134946
2	Phase II	41.20	880650	227208
3	Phase III	10.08	215460	55589
4	Phase IV	9.25	197719	51011
5	Phase V	17.04	364230	93971
		102.04	2181105	562725

(* Length of corridor x Width of corridor x Annual rainfall in m (assumed annual rainfall of 0.86 m per year) x Coefficient of runoff)

Figure 6-1: Typical Oil Separation Pits



Rain water harvesting pits will be accommodated in the middle of median structure. The plan of the oil separation pits and rain water recharge pits all along the at-grade median is shown in Figure 6.2. There will be approximately 2500 rain water harvesting pits accommodated between piers. Figure 2-17 shows the pictures of rain harvesting pits along the metro alignment implemented by BMRCL in Bangalore.

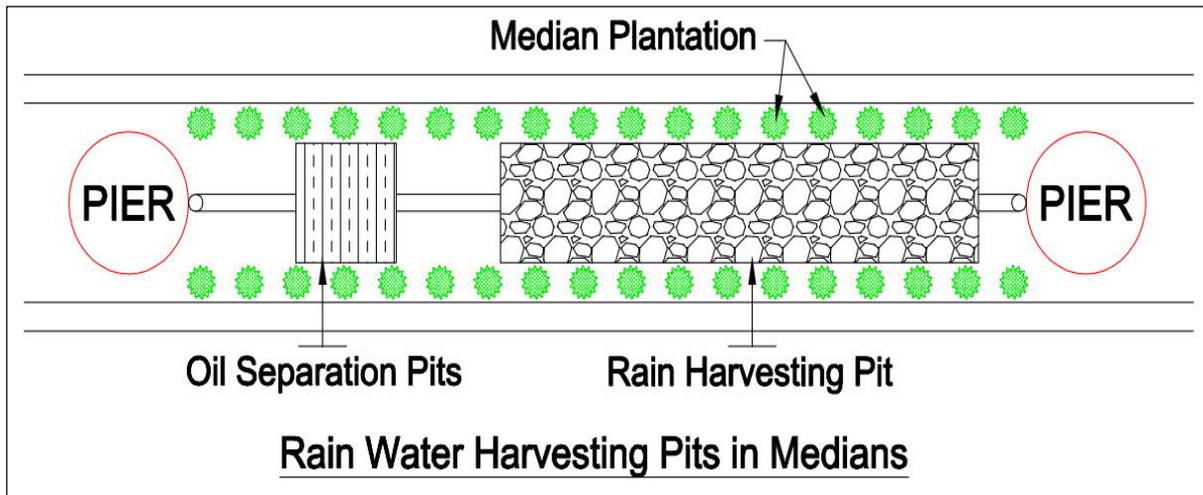


Figure 6-2: Rain Water Harvesting pits in medians



Figure 6-3: Rain Harvesting pits implemented by BMRCL along metro alignment

6.2 Tree Transplantation

No trees shall be cut unnecessarily until the construction starts. Transplanting or felling shall be considered only if it is impossible and impractical to preserve. Transplantation of trees shall be properly planned and implemented to ensure that sufficient space and trees future growth. Priority shall be given to transplant the trees to appropriate locations near to the project site so as to increase the trees' survival rate after transplanting and minimize the loss of greenery in the project area. In absence of space nearby, transplantation shall be done to a suitable location, in the proximity of project site. Tree transplantation is done in following stages.

Identification of trees for transplantation: Identification of large trees for transplantation requires great care and depends on conditions like

- General health, form and structure of the tree
- Size of root ball / quality of root system
- Size of trees
- Species and conservation status of the tree
- Availability and suitability (environmental and cultural factors) of a receptor site
- Time for preparation
- Maintenance requirements
- Access to the existing and receptor locations and transportation
- Site considerations - functional and engineering constraints
- Cost effectiveness

Most common trees suitable for transplantation are Ficus trees (Peepal, Banyan etc.) neem trees, etc.

Soil Sampling, Testing & Site Selection: The soil condition where the tree has to be transplanted is thoroughly checked & necessary treatments are done to the soil after digging a pit. The pit size has to be in accordance with the root ball of the tree. There are specific environmental requirement for each tree. The light, moisture, soil pH, wind exposure & soil drainage should be considered. Transplanted tree requires space for root and crown development therefore adequate distance between other plants is necessary.

Documenting trees being transplanted: Details of the trees being transplanted have to be noted such as girth of tree, space between the adjacent trees and any other relevant, practical information. This information will help during the transplantation and monitoring of tree for its survival and also serve as data bank for similar future works.

Tying up different Departments: Forest Department, BBMP, BESCO, PWD, Police & Traffic Police whose help is required for successful implementation of

transplantation in large scale. It is also important to involve NGOs and connect to the enthusiastic and supportive local public as this activity requires lot of on-site support.

Procurement of required permissions: It is important to check out the protocol for permissions from concerned departments to translocate from one place to other.

Involvement of tree transplantation experts: The experts who have experience in transplantation shall be consulted for identification of trees for transplantation, precaution required during transplantation, post transplantation care, etc.

Provision for Funds: It is important to estimate and strategize funds required for transplantation. The cost of transplanting depends on number of trees identified for transplantation, size of the tree, machinery cost, location of the tree, distance to transplanting location and other constraints.

Safety precautions: Tree transplantation should be conducted in a controlled and safe manner. Sites shall be checked for potential hazards prior to start of transplantation. Workers who are involved in transplanting trees should be given adequate instructions, safety gears and supervision to ensure that transplantation works are completed in a safe manner.

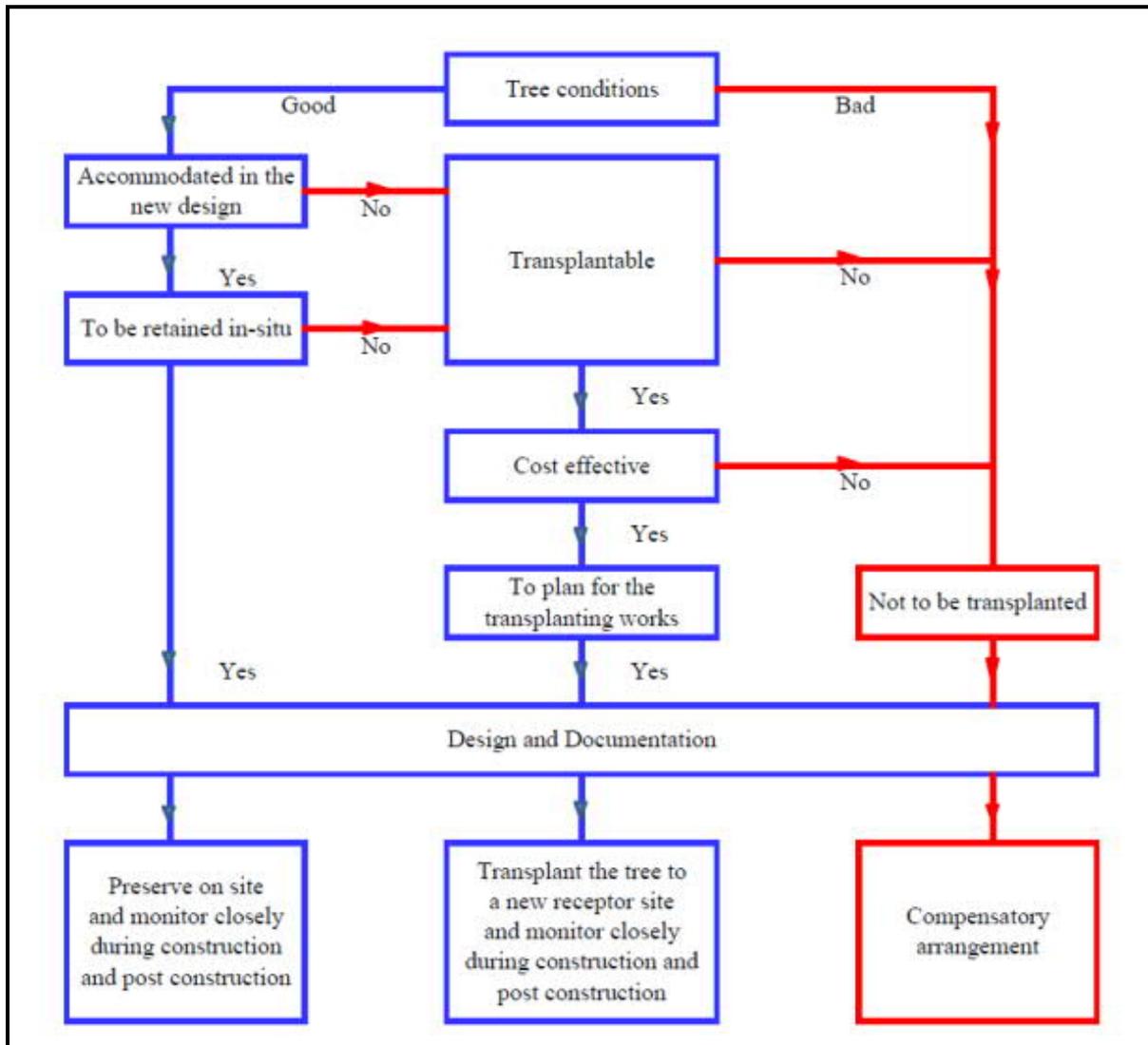


Figure 6-4: The basic work flow of tree transplantation

As per TOR, possibility of transplanting at least 20 % of the trees being affected has been considered for transplantation. The table below has the details of number of trees to be considered for transplantation.

Table 6-2: Corridor wise trees to be considered for transplantation

Trees to be Cut / Trimmed	Phase I	Phase II	Phase III	Phase IV	Total
Trees originally proposed to be cut (within Col)	940	710	983	376	3009
Trees to be transplanted	212	120	241	28	601
Remaining trees to be cut after transplantation	728	590	742	348	2408

Following are the potential spaces for consideration of transplanting the trees in the nearest possible locations from the original tree locations.

Project Reach	Potential location for transplantation	Remarks if any
Baptist Hospital to Mekhri Circle	Institute of Animal Health & Veterinary Biologicals University of Agricultural Sciences (UAS)	
Mekhri Circle to Cantonment	Palace Grounds Para Regiment Training Center	
Cantonment Loop	On the periphery of Ouddus Saheb Eidgah & Madina Masjid grounds	
Cantonment Station to Tiffany Circle	Cubbon Park Chinnaswamy Stadium Mahathma Gandhi Park St Joseph School Grounds	
CBD Area Wilson Garden Stretch	Lalbagh Botanical Garden Fort Highschool grounds	
Minerva circle to Nice Road Junction	Eidgah Masjid Maidan Chamrajpet Land behind Mysore Road Eidgah Masjid Jadeedh Eidgah Maidan, Mysore Road	
Bhattarhalli to Ulsoor Lake	ITI Campus, NGEF Layout Satellite Bus Station behind Baiyappanahalli Metro Station. Murphy Town Play ground Ulsoor Lake Pathway	
CC 2	Police Housing Corporation, General Thimmayya Road (behind ASC Centre and College)	
Ulsoor Lake to Cantonment Loop	K V MEG School pavilion Coles Park	
Varthur Lake to Domlur Flyover	Government School Grounds Siddapura Primary Health Centre PHC Grounds Kundalahalli Public Ground, Old Airport Road HAL grounds, Old Airport Road Vishweshwara College Grounds, Old Airport Road Domlur High School Play Ground	1+250 km on LHS 1+900 km on LHS 3+850 km on LHS 8+850 km on RHS 11+950 km on LHS
Domlur Flyover to Richmond Circle	Gun Troops Officers Colony Gowthamapura	14+200 RHS
CC1 St John Circle to Agara Junction	Agara Park Police Public School Grounds 3 rd & 4 th Battalion Parade Ground, KSRP, Bengaluru St.Johns Medical College Play Ground	0+300 to 0+600 km LHS 2+200 km LHS 2+500 km LHS 3+800 km LHS
NDRI to Silk Borad	NDRI premises	
Mekhri Circle to Yeshwanthpur	Kendriya Vidyalaya Play Grounds IISC Gymnasium	

6.3 Compensatory Plantation Strategy:

It will be considered for the planting of ten trees as compensation for each tree that is cut for construction of elevated corridor. The preference will be given to plant tree saplings along the proposed project alignment to compensate the trees being impacted. In addition, the plantation of trees will also be taken up in the upcoming new layouts in the suburbs of Bangalore city, parks and forests under Bangalore Urban Division shown in table 6-3 below.

Selection of trees species:

The selection of the plants for greenery development is to be made as per the following criteria;

- Plants should be fast growing & have dense canopy cover
- Indigenous species
- Preferably dry deciduous with large leaf area index
- Species resistant to air pollutants and
- Should help to maintain the ecological and hydrological balance in the region

The plant species that are selected based on the climatic condition, soil characteristics and conditions of the area. The row closest to the main carriage way will be of shade plants comprising of ornamental and flowering species. Mainly native deciduous species, which retain their foliage longest, with high crown forms, resistant to fungus and insects with rapid growth rate are selected for avenues.

Some of the preferred species for compensatory plantation are Albizzia amara, Albizzia lebbek, Anogiessus latifolia, Acacia species, Shorea talura and Santalum album

Table 6-3: Forests land available with extent (Bengaluru Urban Division)

Sl. No.	Name of the forest	Forest area in Ha.
1	Jarakabande Reserved Forest	199.92
2	Marasandra Reserved Forest	380.00
3	Kumbaranahalli Reserved Forest	34.07
4	Govindapura Reserved Forest	19.42
5	Arkavathi Reserved Forest	42.89
6	Madappanahalli Plantation	62.29
7	Jarakabande Sandal Reserved Forest	129.81
8	Sulikere Reserved Forest	210.01
9	Turahalli Gudda Protected Forest	238.97
10	Basavanathara Reserved Forest	566.80
11	Doresanipalya Reserved Forest	54.88
12	Jyothipura Reserved Forest	228.00
13	Mandoor Reserved Forest	129.60
14	B.M.Kaval Reserved Forest	562.87
15	Kadugodi Reserved Forest	38.10
	Total	2897.63

6.4 Vertical Gardens:

Vertical gardens are being used in the cities like Bangalore for physical and psychological relaxation in addition to managing ecological system. In summers, vertical gardens increase humidity and lowers temperature. These capture dust and polluted air by the foliage of the plants. The obvious benefit is the immediate improvement in environmental quality. Vertical gardens on concrete piers supporting elevated roads will have positive impact on greening and cleaning of the cities, offering micro-climate changes (humidity, temperature, aesthetics and sequestration of CO₂). In addition, the dense plant foliage protects the concrete structure against the heat and pollutants.

As suggested in the TOR vertical gardens will be proposed on the pillars of elevated corridor, similar to vertical gardens by BMRCL near Rangoli Art Centre next to MG Road Metro Station using hydroponics technology (technology used in growing plants using a mineral nutrient solution). The vertical garden concept not only increases the aesthetic value of the proposed project corridor but also helps to reduce air pollution generated by at-grade operating traffic.



Figure 6-5: The vertical garden tried by BMRDCL at MG road metro Station
The details of number of pillars in each phase/package along with the details of area available for growing vertical garden in given in the following table.

Table 6-4: Details of area considered for vertical gardens

Project Phases	Contract Packages	No of Pillars	Area considered for vertical garden (sqm)
Phase I	Package 1	370	8,718
	Package 2	269	6,338
	Package 3	136	3,204
	Connecting Corridor 1	124	2,922

Project Phases	Contract Packages	No of Pillars	Area considered for vertical garden (sqm)
Phase II	Package 1	138	3,252
	Package 2	134	3,157
	Connecting Corridor 2	122	2,875
	Connecting Corridor 3	107	2,521
	Package 3	113	2,663
Phase III	Package 1	390	9,189
Phase IV	Package 1	264	6,220
Phase V	Package 1	220	5,184
	Package 2	364	8,577
Total		2751	64,820

The 102 km elevated corridor has total of 2751 pillars with an area of 64,820 sqm which not only increases the greenery along the corridor but also helps absorbing air pollutants and dust thus reducing the impacts of obnoxious gases significantly.

6.5 Median Plantation:

Elevated corridor is supported by pillars which are 2.0 to 2.5 m thick. These pillars are located invariably at the center of the at-grade roads thus creating median of 2.0 to 2.5 m width. Two rows of median plantation is proposed to be taken up in these medians all along the proposed elevated corridor alignment. Provision has also been made for rain water harvesting in the median which is located at the centre of median.

Figure 6-6: The Median Plantation by BMRDCL



Selection of plants species is an important task and for selection, it is necessary to consider the following factors.

- i. Agro-climatic suitability, height and canopy architecture, growth rate and habit, aesthetic effect (foliage, conspicuous and attractive flower colour) and pollution tolerance.
- ii. Dust absorbing capacity:

Ornamental plant species having aesthetic value and tolerance to air pollutants are recommended for planting in the medians along the at grade roads. In addition, they should also have less water requirements, slow growth rates, should be able withstand severe climatic conditions. Drought resistant shrubs are generally tolerant to pollution

Plants/shrubs suitable for planting in medians are Saraca asoca (Sita Ashoka Tree) Pavetta indica (Paapate gida), Ixora coccinea, Acalypha wilkesiana, Nyctanthes arbor tristis (Parijatha), Gardenia gummifera, Bougainvillea spectabilis, Caesalpinia pulcherrima, Callistemon lanceolatus, Callistemon polandii, Cassia surattensis, Duranta plumeri, Euphorbia milii, Hamelia patens, Hibiscus rosa, Ixora coccinea, Jatropha panduraefolia, Lantana camara, Lantana depressa, Nerium oleander, Vinca rosea, Nerium oleander, etc.

6.6 Quantification of solar energy harvesting potential:

Most of the studies demonstrate that the available surface, railings and vertical facade area for Solar Photo Voltaic (SPV) installation is very limited on the elevated corridor road. The possible areas for solar power generation and the feasibility were explored. It is only feasible to use SPV floor tiles as a replacement to the pavements and cycling tracks. It is necessary to evaluate electrical, thermal and mechanical performance in addition to its properties like solar energy conversion efficiency, anti-slip, heat resistance, durability and compressive strength of SPV installations as a replacement to the pavements, particularly for the road pavements.

Disadvantages:

The Solar panels lying under a road has number of disadvantages.

- Solar panels on the road surface will not be at the optimum tilt angle thus produces less power.
- The road surface is more prone to shading. The shade over just 5 percent of the surface of the panel can reduce the power generation by 50 percent.
- The solar panels are also likely to be covered by dirt and dust thus requiring regular maintenance.

- The panels would need to be covered with thicker glass than the conventional panels to withstand the weight of traffic which will further limit the light they absorb.
- These solar panels will heat up more than a rooftop solar panel too. For every 1 degree Celsius increase, over optimum temperature, there will be a loss of 0.5 per cent of energy efficiency.
- Scratch resistance and toughened glass should be used for durability and required compressive strength of SPV which attracts huge costs.
- Surface of the solar panels are smooth which may not be suitable for movement of vehicles and cause slippery during monsoon.
- The road's capacity factor – which measures the efficiency of the technology by dividing its average power output by its potential maximum power output is just 4 per cent.

Case Studies:

France: One of the first solar roads to be installed is in Tourouvre-au-Perche in France. This has a maximum power output of 420 kW, from 2,800 m² and at the cost of € 5m (£4.5m) for installation. This implies the cost of €11,905 per installed kW. While the road is supposed to generate 800 kilowatt hours per day (kWh/day), some recently released data indicates a yield closer to 409 kWh/day, or 150,000 kWh/yr. In contrast, the Cestas solar plant near Bordeaux, which features rows of solar panels, carefully angled towards the sun, has the maximum power output of 300,000 kW at a capacity factor of 14 per cent and cost of € 360 m or €1,200 per installed kW, one tenth the cost of solar roadway, it generates three times more power.





In the US, a company called Solar Roadways has developed a smart highway with solar panels, including sensors and LED lights to display traffic warnings about any upcoming hazards, such as a deer. It also has heating pads to melt snow in winter. Several of its SR3 panels have been installed in a small section of pavement in Sandpoint in Idaho. This is 13.9 m² in area, with an installed capacity of 1.529 KW. The installation cost is given as \$48,734 (about £37,482), which implies a cost per installed kW of €27,500, more than 20 times higher than the Cestas power plant.

Solar Roadway's own estimates are that the LED lights would consume 106 MWh per lane mile, with the panels generating 415 MWh – so more than 25 per cent of the useful power is consumed by the LEDs. This would reduce performance even further. The heating plates are also quoted as drawing 2.28 MW per lane mile, so running them for just six days would cancel out any net gain from the solar panels. And this is before we look at the data from the Sandpoint installation, which generated 52.397 kWh in six months, or 104.8 kWh over a year. From this we can estimate a capacity factor of just 0.782 per cent, which is 20 times less efficient than the Cestas power plant.

Perhaps, all these studies suggest that using solar panels in road pavements for harvesting solar energy potential is not a great idea. However, provision has been made to use solar panels for street lighting on the elevated corridor and traffic signal posts, toll gantry.

6.7 Carbon Foot print Study

Emission inventory for all possible sources of direct and indirect carbon emissions is developed for full life cycle of the project which includes construction of individual road corridors. Total carbon footprint of the road project will comprise of road carbon footprint from three different stages including construction, operation and maintenance phases.

The carbon footprint of the construction phase is calculated from primary data collected from road construction contractors. The emissions from the project activities include both direct and indirect emissions. Some of the direct source of carbon dioxide emissions during the construction phase includes on-site use of diesel, furnace oil and light diesel oil in construction machinery, vehicles and power generators. The transport of construction materials to site also contributes to direct-CO₂ emissions. Any vegetation removed from construction site to accommodate elevated corridor also contributes to direct CO₂ emissions. The indirect emissions during construction are attributed to the embodied carbon in construction materials, fuels used on-site, amount of electricity purchased from grid. The amount of different types of construction material used per km during construction also contributes to the CO₂ emissions due to the embodied carbon. Total quantity of diesel used for transporting construction materials and/or fuel to the construction site also contributes to CO₂ emissions.

During the operation phase of the project, transport fuels used in vehicles during road operations contribute to direct and indirect CO₂ emissions on account of fuel combustion in vehicle engines and embodied carbon in fuels respectively. In our approach, wherever possible India specific emission factors are being used to estimate the CO₂ emissions from vehicle movement.

Significant maintenance work starts after few years of road operations. Maintenance work contributes to CO₂ emissions (direct or indirect) on account of on-site use of fuels and construction material and transport of materials and/or fuels to the maintenance site.

Following the completion of emission Inventorization, activity factors based on based on IPCC, 2006 methodology, fuel type with its associated emission factors (EF) is used for calculating the emission intensities under various relevant categories such as transport, material and machines. The road length and different road types were