दिल्ली मेट्रो रेल कॉर्पोरेशन लिमिटेड
DELHI METRO RAIL CORPORATION LTD.

REVISED ENVIRONMENTAL IMPACT ASSESSMENT FOR PHASE IV PRIORITY CORRIDORS OF DELHI METRO

June 2020

दिल्ली मेट्रो रेल कॉर्पोरेशन लिमिटेड
DELHI METRO RAIL CORPORATION LTD.
(भारत सरकार एवं दिल्ली सरकार का संयुक्त उपक्रम)
(A JOINT VENTURE OF GOVT. OF INDIA AND GOVT. OF NCT DELHI)

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ANNEXURES

ABBREVIATIONS

AFC	-	Automatic Fare Collection System
AMASR	-	Ancient Monuments and Archaeological Sites and Remains
ASI	-	Archaeological Survey of India
ATO	-	Automatic Train Operation
ATP	-	Automatic Protection System
BIS	-	Bureau of Indian Standards
CATC	-	Continuous Automatic Train Control
CGWB	-	Central Ground Water Board
CPCB	-	Central Pollution Control Board
CRRI	-	Central Road Research Institute
CTE	-	Consent To Establishment
DAMEP	-	Delhi Airport Metro Pvt. Ltd.
DMRC	-	Delhi Metro Rail Corporation
DPCC	-	Delhi Pollution Control Board
DPR	-	Detailed Project Report
DTC	-	Delhi Transport Corporation
DTL	-	Delhi Transco Limited
EIA	-	Environmental Impact Assessment
EMP	-	Environmental Management Plan
EPA	-	Environmental Protection Act
EPR	-	Extended Producer Responsibility
ETP	-	Effluent Treatment Plant
FIRR	-	Financial Internal Rate of Return
GHG	-	Green House Gas
GSDP	-	Gross State Domestic Product
IMD	-	Indian Meteorological Department
JBIC	-	Japan Bank for International Cooperation
JICA	-	Japan International Cooperation Agency
KLD	-	Kilo Liter Per Day
MCD	-	Municipal Development Corporation
MGD	-	Million Galan Per Day
MoEFCC	-	Ministry of Environmental Forest and Climate Change
MRTS	-	Mass Rapid Transit System
NCR	-	National Capital Region
NCT	-	National Capital Territory
NGO	-	Non Government Organization
NHAI	-	National Highway Authority of India
NOC	-	No Objection certificate
NSDP	-	Net State Domestic Product
OHE	-	Over Head Equipment
PAP	-	Project Affect People
PIU	-	Project Implementation Report
R & R	-	Rehabilitation and Resettlement
SPCB	-	State Pollution Control Board
SPM	-	Suspended Particulate Matter
STP	-	Sewage Treatment Plant
TBM	-	Tunnel Boring Machine
VVVF	-	Variable Voltage Variable Frequency
WHO	-	World Health Organization

CHAPTER 0 EXECUTIVE SUMMARY

0.1 INTRODUCTION

0.3.1 Objective and Scope

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

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

0.2 PROJECT DESCRIPTION

The study area for the EIA study is the area along the metro corridors. The priority corridors comprise 27.083 km underground section and 38.017 km elevated section and 45 total stations. The depots facility for these priority corridors will be utilized from existing depots.

0.3 ENVIRONMENTAL BASELINE DATA

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

0.3.1 Land Environment

Physiography: The physiography of Delhi is dominated by the river Yamuna, the Aravalli range and the plains in between and the Delhi Ridge and its four sections. The Delhi and Noida drains into the Yamuna River. The average gradient is of the order of 1 to 4 m/km. Delhi area is generally flat. The Yamuna River is Delhi's source of drinking water.

Soil: The geology of Delhi is of mix type containing various soil deposits. It consists of quartz rock and extends from south part to west bank of the Yamuna River for about 35 km. The soil textures in Delhi are alluvial and quartz type. The soils of the Delhi area are mostly light with subordinate amount of medium texture soils. The light texture soils are represented by sandy, loamy and sandy loam types; whereas medium texture soils are represented by loam silty loam.

In order to know the characteristic of soil, soil samples were collected and analyzed. Test results shows that soil is tending to become alkali except at Janakpuri West and Roop Nagar where it is neutral. Calcium and Organic Matter is low. Conductivity is normal; Nitrogen is high, at all locations. Potassium is medium at all location except at Mangolpuri west where it is low. Soil is sandy loam at all locations.

Seismicity: Delhi is located in Seismic Zone IV.

0.3.2 Water Environment

Water Resources: Delhi gets it water from the Ganga Canal, the western Yamuna canal, the Bhakra Canal and the river Yamuna. The water availability of river Yamuna at 90% dependability during different seasons in a year is as follows: Monsoon 10.0 Mm^3/day, Post monsoon 1.2 Mm^3/day, Winter 0.8 Mm^3/day, Summer 0.1 Mm^3/day Delhi receives average yearly rainfall of 611.8 mm. The utilized rainwater runoff is 193 Mm^3 per year.

Ground Water: A decline in water table of 4 m has been observed in Delhi for last few decades. The Depth to water level recorded in NCT Delhi ranges from 1.20 to 67.73 mbgl. The deeper water levels are mostly found in south and south west districts of NCT Delhi, while the shallower water levels are found in central, northern and eastern part of Delhi. The Yamuna flood plain in NCT Delhi has depth to water level in the range of 2-5 mbgl.

0.3.3 Meteorology and Air Environment

Meteorology: Delhi has an extreme climate, which is very cold in winter and hot in summer. The climatic conditions in project area are characterized by a rainy season (July-October), winter (November-March) and Summer (April-June). Delhi has a monsoon climate with an average yearly rainfall of 611.8 mm of which 81% is received during rainy season. The relative humidity at Delhi varies almost throughout the year but seldom drops below 30%.

Maximum temperature varies between 38 deg Celsius to 45 deg Celsius, minimum temperature varies from 5 deg Celsius to 14 deg Celsius.

Air Quality: Air quality monitoring was carried out at 13 locations near to the corridors. $PM_{2.5}$, PM_{10} and Ozone were found to exceed permissible limits.

0.3.4 Noise Environment

Ambient noise levels were monitored at 13 locations. Levels were found to exceed respective day and night permissible limits for residential areas.

0.3.5 Ecological Environment

The main species are Pipal, Neem, Kikar, Eucalyptus, Ashok, Ficus and Bakaan, etc. About 11,121 tress will have to be felled. The domestic animals in the project area consist of cows, bullock, sheep, goat, cat and dogs. No rare or endangered species have been reported in the project area. No wildlife has been observed within the project area or its surroundings.

0.3.6 Archaeological Sites or structures

The ASI protected archaeological structures along the corridors are as follows.

Sl. No.	Name of the monument	Corridor	Distance in m
1.	Tughlakabad Fort	Aerocity - Tughlakabad	212
2.	Ghiyasuddin Tomb		168
3.	Nai-ka-kot		179
4.	Adilabad Fort		135
5.	Tomb of Shah Alam	Mukundpur - Maujpur	108
6.	Tripolia Gate	RK Ashram – Janakpuri West	138
7.	Roshnara Bagh		130

0.4 NEGATIVE ENVIRONMENTAL IMPACTS

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

0.4.1 Impacts due to Project Location

Project Affected People (PAPs): Details have been presented in the Social Impact Assessment (SIA) report.

Change in Land Use: The project shall require the acquisition/transfer of 91.6032 ha of land. Out of the total land, 90.7573 ha is government land and 0.8459 ha is private land. Out of the total government land, 18.80 ha for permanent use and 71.9573 ha is identified for temporary use.

Loss of Forests/Trees: There are approximately 11,121 trees along the alignment. With removal of these trees, CO_2 absorption is likely to decrease by 2,42,438 kg/year and Oxygen production is likely to decrease by 5,44,929 kg/year on their maturity.

Utility/Drainage Problems: The alignment will cross drains, large number of sub- surface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, traffic signals etc.

Impact on Archaeological Monuments/sites: Impact on archaeological Monuments / sites is summarized in Section 0.3.6.

0.4.2 Impacts due to Project Design

Impacts due to project design are seen in following ways:

Station Planning: The Elevated station is generally located on the road median. All the stations are two-level stations. The concourse is planned along the whole length of the platform with staircases leading from either side of the road. Passenger facilities and operational areas are provided at the concourse level. Minimum vertical clearance is 5.5m under the concourse. The typical underground station is a two-level station with platforms at the lower level and concourse on the upper level. Structure of the underground station is essentially a concrete box about 22-m wide, 14.6-m high and240 to 260 m long. Provision has been made for staircases and escalators from street to concourse and to platforms. Lifts have been provided for elderly and disabled.

Ventilation and Lighting: The platform and concourse areas will be air-conditioned. Ancillary spaces such as Staff Room, Equipment Room, will be mechanically ventilated or air conditioned

Risk Due to Earthquake: The project area lies in Seismic Zone IV. Structures shall be suitably designed.

0.4.3 Impact due to Project Construction

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

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

Noise Pollution: When Dump Truck, Excavator and Pneumatic Tool is working simultaneously at site, person working near the equipment will be exposed to maximum noise levels Leq 93.3 dB(A) and Lmax 94.9 at 5m. Therefore additional protective measures may not be required.

Vibration: Vibration level of more than one inch/second is found to impact humans and structures.

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

Risk at labour camps: Improper disposal of municipal solid waste generated by labour camps can pollute surface water bodies and groundwater. Burning of waste can cause air pollution. Construction workers are more prone to infectious diseases due to unsafe sexual activity and lack of sanitation facilities (water supply and human waste disposal) and insect vectors. Problems could arise due to cultural differences between workers from outside and local residents.

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

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

Muck Disposal: Construction activities will generate about 3.4 Mm^3 of soil. Out of this, about 1.02 Mm^3 is likely to be reutilized in backfilling in underground stations. The balance 2.38 Mm^3 shall be disposed off in environmental friendly manner.

Pollution due to Transportation of Construction Material and Soil: During the period of construction emission due to truck movement on account of transportation of civil construction material and disposal/backfill of earth is estimated to be as follows: the total dust emission/pollution would be 7 kg/day, 1.27 kg/day of particulate matter, 28.42 kg/day of CO, 1.27 kg/day of HC, 59.03 kg/day of NOx and 3668.70 kg/day of CO_2.

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

Increased Water and Energy Demand: The demand for water and energy will increase during construction phase.

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

Impact due to Construction of Bridges on Yamuna: Impact on water flow in river will be minimised based on detailed hydrological and water flow modelling. Dropping of material during in-situ construction will be minimised.

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

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

0.4.4 Impacts due to Project Operation

The project may cause the following negative impacts during operation.

Noise Pollution: Metro noise level will be in range of 80-85 dB(A) at 10 m distance, 74-81 dB(A) at distance of 20m and 72-78 dB(A) at 30m. Metro corridor is underground in congested residential areas where noise levels will come down due to reduction of vehicles. There are certain sensitive receptors like Hospitals, schools and colleges near to elevated section where noise barrier will be required.

Vibration: Based on Delhi Metro's previous experience, the intensity of vibration varies from 65 VdB to 90 VdB. As per International guidelines, humans start perceiving vibration from 65 VdB and it becomes an annoyance from 72 VdB. If any building especially residential building falls within 25 meters on either side from central line of the tunnel precautionary measures need to be taken to mitigate the effect of ground borne vibration. In the case of sensitive building such as archaeological buildings it is safe to keep a minimum horizontal distance of 60 meters from the tunnel.

Water Supply at Stations: Estimated water demand at stations is 2047 KLD.

Solid waste at stations: As per the available data from Delhi Metro Phase I and II, about 28 cum of solid waste will be generated from underground stations and 38.25 cum from elevated/ at grade stations from Phase IV.

0.5 POSITIVE ENVIRONMENTAL IMPACTS

Employment Opportunities: In post-construction phase, about 2710 people will be employed for operation and maintenance of the system. Thus, the project would provide substantial direct employment and consequent indirect employment.

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

It is estimated that 102 persons will be saved from death due to traffic accidents due to operation of metro.

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

Reduced Fuel Consumption: It is estimated that about 3.486 million litres of diesel, 10.912 million litres of petrol and 14.846 million kg of CNG gas will be saved in year 2021. These reductions will increase to 5.683 million litres of diesel, 17.790 million litres of petrol and 24.203

million kg of CNG gas in year 2041. It is estimated that savings will be of Rs 1258.921 million in year 2021, Rs 1647.490 million in year 2031 and Rs 2052.486 million in year 2041.

Reduced air pollution: There are significant reductions of air pollutants due to proposed metro corridors. The reduction in PM, CO, HC, NOx and CO2 will be expected as 30 ton/year, 1296 ton/year, 662 ton/year, 901 ton/year and 139665 ton/year respectively in year 2041.

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

0.6 ENVIRONMENTAL MANAGEMENT PLAN

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

0.6.1 Management Plan for Location and Design

Compensatory Afforestation: About 11,121 trees are likely to be lost. Hence 1,11,210 trees need to be planted. Estimated compensatory afforestation cost is about **Rs 35,498 Lakh**. The 1,11,210 trees on maturing will absorb about 2,424 ton of CO_2 per year and will release 5,449 ton of Oxygen per year meeting oxygen demand of 18,988 persons per year.

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

Risk Due to Earthquake: Engineering design and construction shall be done so as to meet codal provisions. Station design shall be done to facilitate quicker emergency evacuation.

0.6.2. Management Plan during Construction

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Construction of bridge on river Yamuna: The mitigation measures like spillage of materials into the river, ready mix concrete for concreting, non polluting polymer in the pile foundation etc will be done.

0.6.3 Management Plan during Operation

Noise management: In addition to track-related measures**,** parabolic noise barriers are proposed on each side of the track. Noise barriers shall be placed along the curved portion of the viaduct and at stations during operation. The estimated cost of noise barriers is about **Rs 1217.76 Lakh** for all priority corridors.

Water Supply and Sanitation at Stations: Water supply for drinking, washing of stations, air

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

Rain Water Harvesting: To conserve and augment the storage of groundwater, it has been proposed to construct roof top rainwater harvesting structure of suitable capacity at the elevated stations and in the elevated alignment. The annual rainwater harvesting potential of elevated stations and elevated section is estimated as 1,65,605 cubic meter per year.

Training and Extension: The training for engineers and managers will be imparted by DMRC on regular basis to implement the environmental protection clauses of the tender document and to implement the best environmental practices during the construction phase. Apart from training, such programme should include guidelines for safety, methods of disaster prevention, action required in case of emergency, fire protection, environmental risk analysis etc. The estimated cost is Rs 25.50 Lakh.

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

0.7 ENVIRONMENTAL MONITORING PLAN

During construction and operation stages environmental monitoring will be carried out for air quality, noise levels, vibration, water quality and ecology. The estimated environmental monitoring cost during construction and operation phases is Rs 157.59 Lakh.

Establishment of Environmental Division

Environment Division shall be established to supervise and coordinate studies, environmental monitoring and implementation of environmental mitigation measures. The estimated cost of its establishment and operation is Rs 168.43 Lakh.

0.8 ESTIMATED TOTAL COST

Estimated cost of environmental management and monitoring plan is **Rs 37077.19 Lakh.**

1. INTRODUCTION

Delhi, the capital of India has a strong historical background. It was ruled by some of the most powerful emperors in Indian history. The history of the city is as old as the epic Mahabharata. The town was known as Indraprastha, where Pandavas used to live. In due course eight more cities came alive adjacent to Indraprastha: Lal Kot, Siri, Dinpanah, Quila Rai Pithora, Ferozabad, Jahanpanah, Tughlakabad and Shahjahanabad.

Delhi has been a witness to the political turmoil for over five centuries. It was ruled by the Mughals in succession to Khiljis and Tughlaqs. In 1192 the legions of the Afghan warrior Muhammad of Ghori captured the Rajput town, and the Delhi Sultanate was established (1206). The invasion of Delhi by Timur in 1398 put an end to the sultanate; the Lodis, last of the Delhi sultans, gave way to Babur, who, after the battle of Panipat in 1526, founded the Mughal Empire. The early Mughal emperors favoured Agra as their capital, and Delhi became their permanent seat only after Shah Jahan built (1638) the walls of Old Delhi.

From Hindu Kings to Muslim Sultans, the reins of the city kept shifting from one ruler to another. The soils of the city smell of blood, sacrifices and love for the nation. The old 'Havelis' and edifices from the past stand silent but their silence also speaks volumes for their owners and people who lived here centuries back. In the year 1803 AD, the city came under the British rule. In 1911, British shifted their capital from Calcutta to Delhi. It again became the centre of all the governing activities. But, the city has the reputation of over throwing the occupants of its throne. It included the British and the current political parties that have had the honour of leading free India.

After independence in 1947, New Delhi was officially declared as the Capital of India. It was made a Union Territory in 1956. Lying in the northern part of the country, Delhi is surrounded by Haryana on all sides except the east, where it borders with Uttar Pradesh. The 69th Constitutional amendment is a milestone in Delhi's history, as it got a Legislative Assembly with the enactment of the National Capital Territory Act, 1991. New Delhi houses important offices of the Federal Government, including the Parliament of India, as well as numerous national museums, monuments, and art galleries.

The National Capital Region (NCR) in India is a name for the conurbation or metropolitan area which encompasses the entire National Capital Territory of Delhi as well as urban areas ringing it in neighbouring states of Haryana, Uttar Pradesh and Rajasthan. The National Capital Territory of Delhi lies central to the National Capital Region. It includes the city of Delhi and New Delhi. This region has largest concentration of population in whole of the NCR.

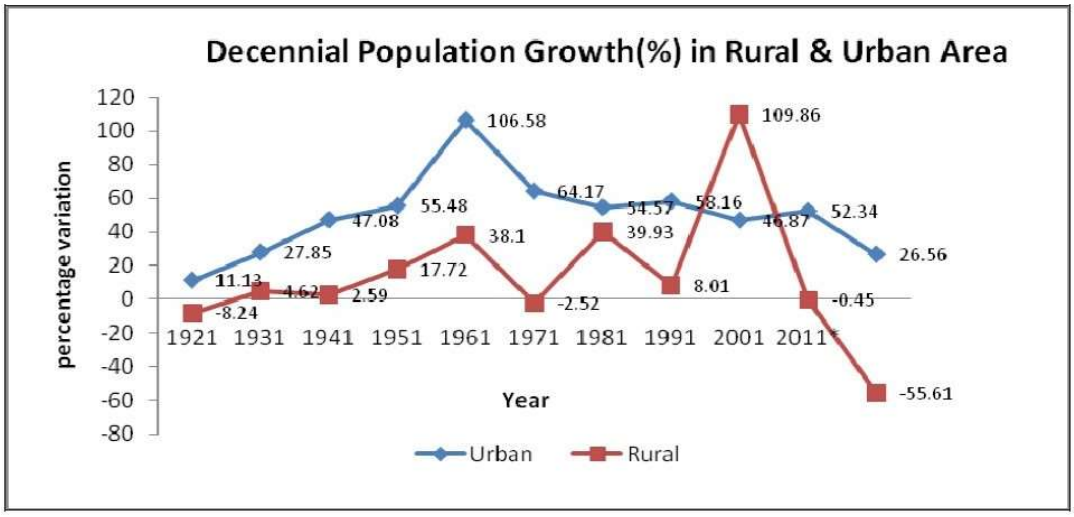
Delhi, the capital of India is the largest metropolis by area and the second-largest metropolis by population in India. It is the eighth largest metropolis in the world by population. According to 2011 census, the population of Delhi was 16.78 millions as against 13.85 millions in 2001. Area and population figures of Delhi are given in **Table 1.1.** North – East district and New Delhi district of Delhi have the highest and lowest population density of 36,155 and 4,057 person per square km respectively. According to Census 2011, the density of population in Delhi is worked out at 11,320 persons per sq. km. as against 9,340 persons in 2001. The density of population in Delhi is highest in the country.

Table 1.1: Population of Delhi

Region	Area (Sqkm)	Population		Sex Ratio (females per 1000 males)		Density of population/Sqkm	
		2001	2011	2001	2011	2001	2011
New Delhi Municipal council	42.74	3,02,363	2,57,803	825	838	7,074	6032
Delhi cantonment Board	42.97	1,24,917	1,10,351	647	731	2,907	2568
Delhi Municipal corporation Urban Rural and Census towns	1397.29	1,34,23,227	1,64,19,787	822	869	9,607	11,751
Total	**1483**	**1,38,50,507**	**1,67,87,941**	**821**	**868**	**9,340**	**11,320**

Source: Statistical handbook of Delhi 2014

Figure 1.1: Decennial Population Growth (%) Rural & Urban Of Delhii



1.1. TRANSPORT

Delhi is well connected by roads, rail and air with all parts of India. It has three airports - Indira Gandhi International Airport for the international flights, Palam Airport for domestic air services and Safdarjung Airport for training purposes. It has three important railway stations - Delhi Junction, New Delhi Railway Station and Nizamuddin Railway Station. Delhi has three inter-state bus terminals at Kashmeri Gate, Sarai Kale Khan and Anand Vihar.

Delhi has significant reliance on its transport infrastructure. The city has developed a highly efficient public transport system with the introduction of the Delhi Metro which is undergoing a rapid modernization and expansion. Vehicle population in Delhi is highest among all metropolitan cities (Mumbai, Kolkata, Delhi and Chennai). The phenomenal population growth in Delhi has been accompanied by an equally rapid increase in vehicle population. There are 83,92,283 registered vehicles in the city as of 30th June 2014, which is the highest in the world among all cities most of which do not follow any pollution emission norm (within municipal limits). Therefore serious efforts, including a number of transport infrastructure projects, are under way to encourage usage of public transport in the city. Delhi roads are India's most dangerous. **TABLE**

1.2 shows the details of private and commercial registered vehicles in Delhi as on 30th June 2014.

Table 1.2: Registered Vehicles In Delhi Up To 30th June 2014

S.No.	Vehicle Type	Number
Private 2-Wheeler *		
1.	Moped	100277
2.	Motor Cycle	2695148
3.	Motor Cycle (Imp.)	742
4.	Motor Cycle With Side Car	10
5.	Scooter	2588247
6.	Scooter With Side Car	729
Total		**53,85,153**
Private 4-Wheeler *		
1.	Invalid Carriage	410
2.	L.M.V. (CAR)	2516200
3.	L.M.V. (IMP.)	8513
4.	L.M.V. (JEEP)	67894
5.	L.M.V. (VAN)	74257
6.	Omni Bus (Private Use)	5
7.	Three Wheeler (Passenger)	2
8.	Three Wheeler Private	33
9.	Tractor (Agriculture)	40
Total		**26,67,354**
Comm. Passenger Vehicles #		
1.	Bus	19688
2.	Cab Scheme	3896
3.	Eco Friendly Sewa	628
4.	Economy Radio Taxi	4103
5.	Gramin Sewa	6153
6.	Light Pass. Vehicle	11285
7.	Light Passanger (Taxi)	3509
8.	Light Passenger(Imp)	60
9.	Local Taxi	7205
10.	Maxi Cab	134
11.	Maxi Cab-(School Cab)	10305
12.	Motor Cab-(School Cab)	1640
13.	Phatphat Sewa	38
14.	Radio Taxi	6006
15.	Three Wheeler(Passenger)	78967
16.	Tourist Taxi	29111
17.	Tourist Taxi Deluxe	820
18.	Tourist Taxi Dlx (Imp)	2130
Total		**1,85,678**
Comm. Goods Vehicles #		
1.	Ambulance	1478
2.	Ambulance(Imp.)	35
3.	Heavy Goods Veh.(Imp)	11
4.	Heavy Goods Vehicle	6338
5.	Light Goods (3 Wheeler)	60477

6.	Light Goods Veh.(Imp)	10
7.	Light Goods Vehicle	77539
8.	Medium Goods Veh.(Imp)	8
9.	Medium Goods Vehicle	6511
10.	Mobile Service Van	10
11.	Tractor	1612
12.	Utility Van	69
Total		**1,54,098**
Grand Total		**83,92,283**

** (Excl. NOC taken/Converted vehicles)*
 # (Excl. NOC taken/Converted/Replaced/Age >15 Yrs. vehicles) Source: Delhi Transport Department website

1.2. OBJECTIVE AND SCOPE OF THE STUDY

The objective of the study is to carry out EIA study and preparation of EIA report as per requirement of regulatory or funding agency. The scope of EIA includes the impacts resulting from pre-construction, construction and operation phases of Phase IV Metro priority corridors and sub-stations. DMRC plans for funding for the proposed priority corridors of Delhi Metro Phase IV from Japan International Cooperation Agency (JICA). It also proposed to establish environmental baseline and safeguard measures for protection of environment for sustainable development during project cycles. The MoEFCC, Government of India, Notification of 14th September 2006 and its amendment dated 1st December 2009 enlist projects in Schedule that require environmental clearance. However as per the said notification Metro Projects does not require environmental clearance from MoEFCC.

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

JICA Requirement

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

BOX 1.1 EIA Categorization System in JICA Systems

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

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

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

According to JICA Guidelines for confirmation of Environmental and social Considerations, the current project is classified as Category A as it is likely to have significant environmental impacts on the environment. Category A includes sensitive sectors such as “Roads, railways and bridges” which is similar to that of the metro lines or located in or near sensitive areas such as such as areas of cultural, historical or archeological value.

1.3. LEGAL, POLICY AND INSTITUTIONAL FRAME WORK

Keeping the pace with international laws, the Ministry of Environment Forest and Climate Change enacted Environmental Protection Act in 1986. Over the years, the Government of India has framed several policies and promulgated number of Acts, Rules and Notifications aimed at management and protection of the environment. During last three decades an extensive network of environmental legislation has grown and presently it has a fairly complex body of environmental legislation aimed at ensuring that the development process meets the overall objective of promoting sustainability in the long run. The available legal Acts and Legislation referred during the study are:

- The Environment (Protection) Act, 1986, amended 1991.
- The Environment (Protection) Rules, 1986.
- The Water (Prevention and Control of Pollution) Act, 1974 (Amendment 1988).
- The Water (Prevention and Control of Pollution) Cess Act 1977, (Amendment), 2003.
- The Water (Prevention and Control of Pollution) Cess Rules, 1978, 1991.
- The Air (Prevention and Control of Pollution) Act 1981, amended 1987.
- The Air (Prevention and Control of Pollution) (Union Territories) Rules, 1982, 1983
- Noise Pollution (Regulation and Control) Rules, 2000 amendment 2002, 2006.
- Solid Waste Management Rules, 2016 and The Hazardous and other wastes (Management and Handling and Trans-boundary Movement) Rules, 2016
- The Indian Forest Act, 1927.
- Forest (Conservation) Act, 1980, amended 1988.
- Forest (Conservation) Rules, 2003.
- The Wild Life (Protection) Act 1972, Amendment, 2002
- The Ancient Monuments and Archaeological sites and Remains Act,1958 amended in 2010
- Fly ash utilization notification, Sept 1999 and its subsequent amendments
- Construction and Demolition Waste Management Rules 2016
- E-Waste (Management) Rules 2016
- Plastic Waste Management Rules, 2016

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

1.3.1 Water and Water Pollution

The use of water resources and also the discharge of polluted water (sewerage) are primarily regulated by the Water (Prevention and Control of Pollution) Act, 1974 amended in 1988. The Water Cess Act, 1977 amended in 1992 and 2003, including Rules 1978 and 1991 provides for levy and collection of Cess on water consumed with a view to generate resources for prevention and control of water pollution. The Act assigns functions and powers to the Central Pollution

Control Board (CPCB) and State Pollution Control Board (SPCBs) for prevention and control of water pollution.

The Environment (Protection) Act 1986 amended in 1991 and Rules also lays down specific standards for quality of water effluents to be discharged into different type of water bodies (sewers, surface water bodies like lakes and rivers, marine discharge). Additionally, the water supplied to users for drinking shall also conform to the National Drinking Water Standard, IS-10500 (2012) **(Annexure 1.1)**. **Annexure 1.2** summarizes the general standards for discharge effluent in Inland Surface Water Bodies. To ascertain and categorize the existing water quality, the results of the analysis of water quality need to be compared with the water quality standards given in **Annexure 1.3.**

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

1.3.2 Air Quality

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

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

1.3.3 Noise Quality

With the objective of regulating ambient noise quality in the environment, the Central Government has notified the Noise Pollution (Regulation and Control) Rules, 2000 amended in 2002 and 2006 under the EPA. The noise standards for different category of areas are based on the weighted equivalent noise level (Leq). The EPR also lays down equipment noise standards for DG sets, Air conditioners and Construction Equipment, which would be in use for the project. Ambient Noise level standards have been notified by the MoEFCC vide Gazette Notification dated 26th December 1989 and also in the Schedule III of the Environmental (Protection) Rules 1986. It is based on the 'A' weighted equivalent noise level (L_{eq}). These are presented in **Annexure 1.5.**

1.3.4 Solid Waste Management

Project construction and operation generates solid waste at site. The DMRC would be

responsible for collection and handling of solid waste as per the provisions of the Solid Waste Management Rules, 2016. The Hazardous and other wastes (Management and Handling and Trans-boundary Movement) Rules, 2016 require facilities to classify wastes into categories, manage them as per the prescribed guidelines and obtain prior authorization from the SPCB for handling, treatment, storage and disposal of Hazardous Wastes.

1.3.5 The Ancient Monuments and Archaeological sites and Remains Act, 1958 amended in 2010

The Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010 has been enacted to amend the Ancient Monuments and Archaeological Sites and Remains Act, 1958 and to make provision for validation of certain actions taken by the Central Government under the said Act. The act has come into force on January 23, 2010.
The act states that the limits of prohibited area and regulated area around the monuments, archaeological sites and remains declared by the Central Government as protected have been specified in the principle Act as 100 m and 200m respectively. The limits so fixed may be further extended on the basis of gradation and classification of the monuments, archaeological sites and remains to be done by the National Monuments Authority, which is to be constituted by the Central Government by virtue of the Amendment in the principle Act. The Act defines regulated area and prohibited area as follows:

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

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

The amendment act provides that none other than an archaeological officer can carry out any construction in any prohibited area. The acts provides that no permission, including carrying out any public work or project essential to the public or other constructions, shall be granted in any prohibited area on and after the date on which the Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010 comes in to force. This provision does not include cleansing of drains and drainage works and of public latrines, urinals and similar conveniences, or, the construction and maintenance of works meant for providing supply of water for public, or the construction or maintenance, extension, management for supply and distribution of electricity to the public or provision for similar facilities for public.

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

Permissions are granted by Competent Authority as per Ancient Monuments and Archaeological Sites & Remains (Validation and Manedment) Act 2010 and Rules made therunder, for any repair, renovation, construction and reconstruction. Within 100 m of prohibited area around any centrally protected monument or site, permissions for repair and renovation are granted for

buildings/structures constructed before 1992 or constructed after 1992 with approval from Director-General of ASI. Within 100-300 m of Regulated area around any centrally protected monument or site, permissions for repair, renovation, construction and reconstruction are granted for buildings/structures.

Procedure for Application:

In Delhi any application for repair and renovation in prohibited area and repair, renovation, construction and reconstruction in regulated area can be submitted to the Competent Authority in Form I.

After an application is submitted, it is scrutinized to find whether the information and attachments have been duly provided. Thereafter site inspection is conducted by an officer authroised by Competent Authority and the proposal is forwarded to the Secretary, National Monuments Authority at 24, Tilak Marg, New Delhi. On approval from the National Monuments Authority (NMA), the Competent Authority, as the case may be, issues a permission or refusal to the owner.

1.3.6 Various Environment Permissions Required

Various permissions related to environment required for the project during Pre- construction, Construction and Operation phase of the project. The key permissions required for the project are listed in **Table 1.3**.

Table 1.3: Key Environment Clearances Required

Permission/ Clearance/Permit	ACTS/RULES	Concerned Agency	Stage
Consent to establish and consent to operated for batching plants and casting yards	The Water (Prevention and Control of Pollution) Act, 1974, amended 1988 and The Air (Prevention and Control of Pollution) Act 1981, amended 1987	Delhi Pollution Control Committee	Construction
Consent to establish and operation of STP and ETP	The Water (Prevention and Control of Pollution) Act, 1974, amended 1988	Delhi Pollution Control Committee	Operation
Generation, storage and transportation hazardous waste	Hazardous and Other Wastes (Management & Transboundary Movement) Rules, 2016	Delhi Pollution Control Committee	Construction and operation
Permission for construction within the regulated/ prohibited zone	The Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010	Department of Archaeology	Pre-Construction/ Construction

Permission for extraction of ground water during construction and operation	Environment (Protection) Act, 1986	Delhi Jal Board/NDMC	Before Construction and during operation
Permission for felling of trees	Delhi (Prevention) of tree act 1994	Department of Forest, Govt. of NCT	Before Construction
Pollution Under Control Certificate	Central Motor and Vehicle Act 1988 Vehicular Exhaust Norms, CPCB 2007	Department of Transport, Delhi	Construction
Waste management Plan	Construction & Demolition Waste Management Rules, 2016	Local Authority (Municipal Corporation)	Before construction

1.4. INSTITUTIONAL FRAMEWORK

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

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

1.4.1 Central and State Pollution Control Boards

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

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

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

1.5. APPROACH AND METHODOLOGY

The environmental study is carried out for the three priority corridors of DMRC Phase IV project. The approach is to follow the sequence of steps adopted in an EIA study. The basic concept is to ascertain the existing baseline conditions and assess the impacts as a result of construction and operation of the project. The changes likely to occur in different components of the environment viz. physical, biological / ecological, environmental and socio-economic etc. have been studied, analyzed and quantified, wherever possible. The baseline data has been documented for various parameters of physical (physiographic and soils), ecological, and environmental pollution (air, water, noise, and solid waste). The impacts are assessed for various phases of project cycle namely:

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

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

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

1.5.1 Data Collection

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

Water Resources in the project were considered in terms of precipitation and quality of water. These will facilitate to decide sources of water for uses such as drinking, construction etc.

Air and Noise quality is an important consideration during construction and operation phases. Ambient air quality and noise levels were monitored in an around project area to develop present baseline levels in the area.

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

1.5.2 Environmental Impact Assessment

The objective of the study is to assess the impacts as a result of construction of the priority corridors DMRC Phase IV metro project along with sub-stations. The changes likely to occur in different components of the environment were studied and analyzed. The core area of study is to be 200 m on either side of proposed alignment and 25 m for sensitive receptors. Based on project particulars and the existing environmental conditions, potential impacts were identified that are expected to be affected as a result of the proposed project and wherever possible, these are quantified. Both positive and negative impacts are evaluated to have an idea about resultant impacts. These impacts were assessed for various phases of project cycle namely, location, design, construction and operation. The standard methodology was adopted for impact prediction and assessment. The environmental impact of the project includes changes in land use, soil, erosion, water quality, air quality and noise levels etc. The impact on water quality in the water bodies was evaluated with the help of water quality analysis. More details on Environmental Impact Assessment are available in **Chapter 4.**

1.5.3 Environmental Management Plan

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

1.5.4 Environmental Monitoring

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

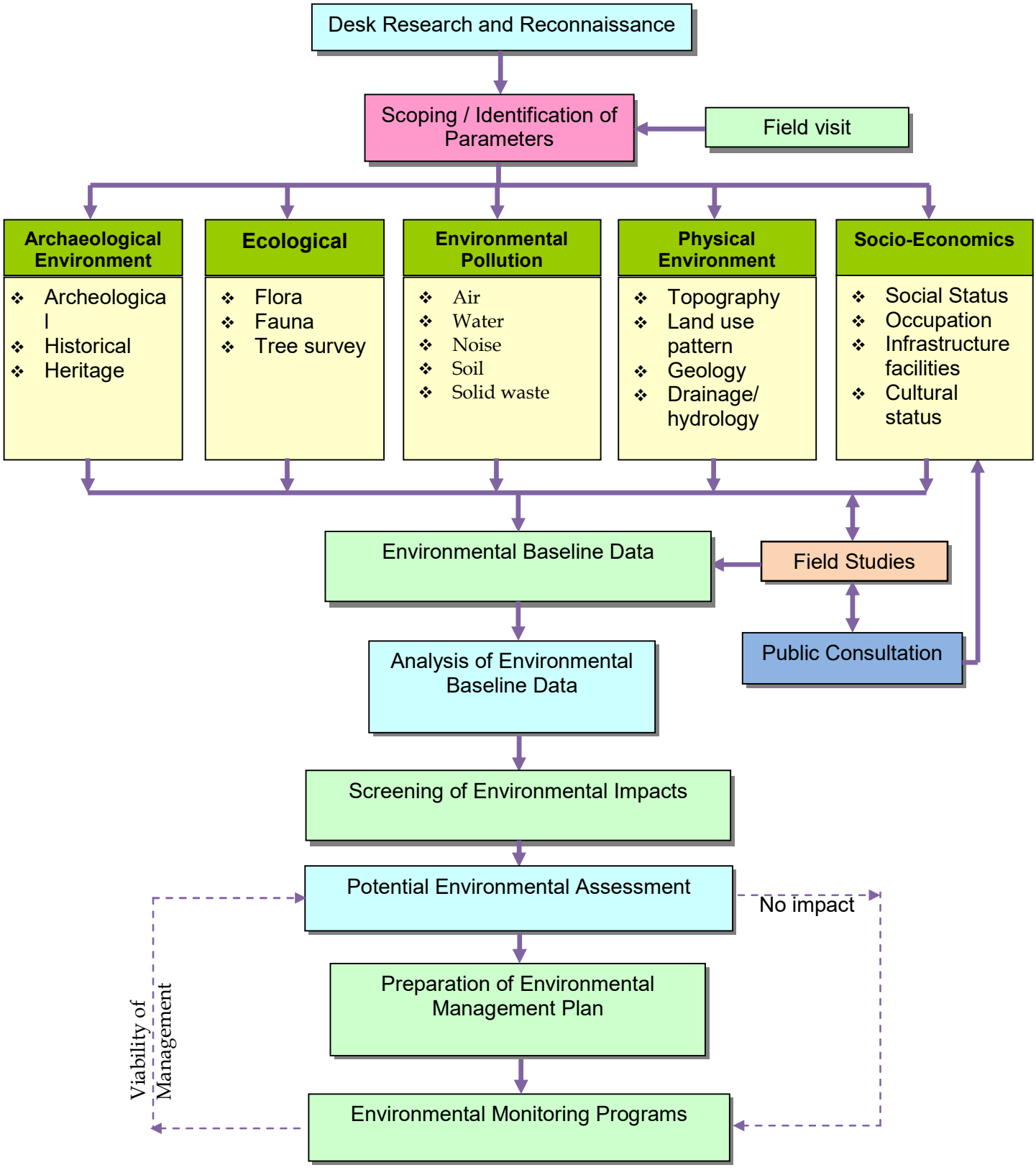
1.6. FORMAT OF THE REPORT

The main elements of the study are as follows: In **Chapter-2** a concise documentation is given on current and planned activities. **Chapter-3** summarizes environmental baseline conditions including physical, biological and socio-economic parameters and pre-project environmental constraint such as air pollution, problems related to public health and traffic congestion. Potential negative and positive impacts are presented in **Chapters-4 and 5** respectively. These include issues such as loss of land, rehabilitation and resettlement, disposal of soil, loss of trees, noise and vibration, disruption of utilities/ facilities, socio- economic and other problems due to the development of proposed Mass Rapid Transport System Phase-IV in Delhi.

Based on the anticipated negative impacts, the project may bring about an environmental management strategy, which has been outlined in **Chapter-6. Chapter-7** includes post project environmental monitoring programmes. This programme aims at signalling any potential environmental problem during construction and operation of the project and it should allow for timely implementation of corrective measures. Finally, a summary of the costs of the environmental management and monitoring programmes falling under the responsibility of the project is presented in **Chapter-8.**

The revised SIA report along with resettlement and rehabilitation plan for the priority corridors of DMRC Phase IV project has been submitted in February 2020.

Figure 1.2: Flow Chart oftThe EIA Study



2. PROJECT DESCRIPTION

2.1 EXISTING SYSTEMS

With the fast expansion of urban area in the NCT of Delhi the transportation network has also expanded with many new features. The mega cities with population of more than 10 million need to maintain their Public Transport System in view of the requirement of linkages between work place and residence, educational institutions and residence, trade and cultural centers and residence besides linkages with inter-city transportation terminals of rail, road and air.

The intra-city traffic volume in Delhi necessitated needs a full-fledged integrated multi modal mass rapid passenger system. In view of this, the then Delhi Government entrusted the task to RITES for conducting a Feasibility Study in 1990-91 for an 'Integrated Multi-Modal Mass Rapid System'. The Feasibility Report submitted by RITES, a Govt agency, recommended a three-tier transport system comprising of Rail corridors (elevated & at-grade), Metro corridors (underground) and dedicated bus way. The recommended Metro network in the 'Revised Metro Master Plan for 2021', prepared by RITES, totaled to a length of 413.83 km and was slated for completion latest by the year 2021 in four phases. Accordingly, on the basis of traffic and transport studies conducted by the authorized agencies, various corridors had been identified in Phase-I, II & III of Delhi Metro Project. All the corridors of Phase-I, Phase-II and Phase III are also fully operational.

2.1.1 Existing Metro System

Following are the corridors of Delhi Metro under Phase-I, II and Phase-III.

First Phase of Delhi Metro Project

i)	Shahdara-Rithala	-	22.00 km
ii)	Vishwa Vidyalaya-Central Secretariat	-	11.00 km
iii)	Barakhamba Road-Dwarka	-	22.80 km
iv)	Barakhamba Road-Indraprastha	-	2.80 km
v)	Extension of Line-3 into Dwarka sub-city	-	6.50 km
Sub-total (Phase-I)		**-**	**65.10 km**

Second Phase of Delhi Metro Project

i) Vishwa Vidyalaya-Jahangirpuri		-	6.36 km
ii) Central Secretariat-Qutab Minar		-	12.53 km
iii) Shahdra-Dilshad Garden		-	3.09 km
iv) Indraprastha-New Ashok Nagar		-	8.07 km
v) Yamuna Bank-Anand Vihar ISBT		-	6.17 km
vi) Kirti Nagar-Mundka (with operational Link to Line-1 at Inderlok)		-	18.46 km
vii)	Dwarka Sec.9-Sec.21	-	2.76 km
viii)	Qutub Minar-Arjan Garh (Delhi portion)	-	7.42 km
ix)	Central Secretariat-Badarpur	-	20.01 km
x)	Airport Link	-	19.20 km
xi)	Dwarka Sec.21-Airport	-	3.50 km

Sub-total (Phase-II)	**-**	**107.57 km**

In addition, the following extensions of Delhi Metro Phase-II to NCR have also been implemented and already operational:-

(a)	New Ashok Nagar-Noida City Centre	-	7.00 km
(b)	Arjan Garh-Sushant Lok	-	7.05 km
(c)	Anand Vihar ISBT-Vaishali	-	2.57 km
Sub-total		**-**	**16.62 km**

Third Phase of Delhi Metro Project (under implementation)

i)	Jahangirpuri-Badli	-	4.49 km
ii)	Central Secretariat-Kashmiri Gate	-	9.37 km
iii)	Mukundpur- Yamuna Vihar	-	55.70 km
iv)	Janakpuri-Kalindi Kunj	-	33.50 km
v)	Shiv Vihar Extension	-	2.70 km
vi)	Najafgarh Extension	-	5.50 km
Sub-total (Phase-III)		**-**	**111.25 km**

In addition, the following extensions of Delhi Metro corridors to NCR are also being implemented in phase III:-

(d)	Faridabad Extension	-	13.88 km
(e)	Mundka –Bahadurgarh	-	11.18 km
(f)	Kalindikunj to Botanical garden	-	3.96 km
(g)	Dilshad Garden to New Bus Adda Ghaziabad	-	9.60 km
(h)	Escorts Mujesar to Ballabhgarh	-	3.20 km
(i)	Noida City Centre – Noida Elec. City	-	6.68 km
Sub-total		**-**	**48.50 km**
Total Phase-I, II, III & Extensions to NCR		**-**	**349.88 km**

Even with the fully operational of Phase III, Delhi would still lag behind in terms of having adequate coverage by metro network to meet the transport requirements of its population. Hence the need to plan Phase IV has arisen. The total length for Phase-IV as approved by the Central Government is approximately 61.66 kms for three priority corridors and is planned for completion by 2025.

2.1.2 Proposed Phase IV Metro Corridors

While sanctioning Phase-III of Delhi Metro, Empowered Group of Ministers (EGoM) desired that the under mentioned corridors should be examined and brought to them for sanction:

1. Yamuna Vihar to Shiv Vihar
2. Dwarka to Najafgarh
3. Mundaka to Bahadurgarh
4. Rithala to Bawana

5. Sec-21 Dwarka to IFFCO Chowk
6. Shiv Vihar to Mukundpur (modified as Maujpur to Mukundpur)
7. Bawana to Rithala

In addition to above, DMRC was also directed to come up with proposal for Phase IV of Delhi Metro. Following corridors were proposed by DMRC to be taken up in Phase IV of Delhi Metro.

Table 2.1: Phase – IV Corridors

S. No.	Corridors	Total (km)
1.	Yamuna Bank To Loni Border	11.97
2.	Rithala To Bawana.	12.50
3.	Janak Puri West To Mukundpur	18.74
4.	Mukundpur to Dilshad Garden	17.54
5.	Kirti Nagar to Dwarka Sec-28	18.17
6.	Badarpur to Delhi Aero City	20.79
7.	Lajpat Nagar to Madangir	7.33
8.	Azadpur to R.K.Ashram	8.90
Total		**115.94**

However, in between, Delhi Govt. got prepared DPR for Trilokpuri to Shastri Park to be taken up as Monorail corridor and hence the same will not be part of Phase-IV Metro. The traffic study done by M/s. RITES brought out that under mentioned corridors are having the requisite traffic and to be considered for implementation as part of Phase IV:

1. Janakpuri (W) – Mukundpur – R.K. Ashram (28.92 km)
2. Trilokpuri to Loni Border (20 km): The part of this corridor, as mentioned above, is already decided to be taken up as Monorail corridor and hence will not be part of Phase-IV Metro but entire corridor may have Monorail.
3. Tughlakabad to Aerocity – (20.2 km)
4. Lajpat Nagar to Saket G Block (7.96 km)
5. Inderlok to Indraprastha (12.58 km)
6. Rithala –Bawana –Narela (21.73 km):
7. Maujpur to Mukundpur (12.54 km): (i.e. Maujpur-Yamuna Vihar – Mukundpur)

The total of length of above corridors comes to 103.93 Km. However, following 3 priority corridors have been identified for implementation under Phase-IV-Part A of Delhi Metro.

Table 2.2: Proposed Phase – IV Corridors

S. No.	Corridors	Total (km)
PHASE-IV – PART A METRO RAIL PRIORITY CORRIDORS		
1	Janak Puri West to R.K.Ashram	28.920
2	Mukundpur to Maujpur	12.588
3	Aero City to Tughlakabad	23.622
Total for Metro Rail Corridors		**65.100**

2.1.3 Description of Route Alignments

Aero City-Tuglakabad Corridor: This corridor originates from Aero City; adjacent to an existing station on the Airport expresses line; crosses National Highway-8; leads in southeast direction as underground section under Mahipal Pur village up to km 1.4. There after it aligns along the Abdul Gaffar Khan Marg leading towards Andheria Mor and runs along it up to Kisangarh. Here it turns left passes under Vasant Kunj and Mehrauli by the side of Bhul Bhulliya and aligns along Mehrauli – Badarpur Road. It emerges out from underground section to elevated secition between km 11.715 and km 11.866. First elevated station is Saket. Alignment continue to run along the Mehrauli – Badarpur road as elevated secition upto km 18.55. Here it further changes from elevated section to underground section and remains underground till Tughlakabad.

Janakpuri West To Ram Krishna Ashram Marg Corridor: This corridor is an extension of alindi Kunj-Janakpuri West Corridor of Phase-III of Delhi Metro. From Janakpuri West (underground station) this corridor takes left turn to fall on Dr. Hedgewar Marg (outer ring road) and becomes elevated through ramp near Anand Kunj red light on outer ring road. Then up to Ashok Vihar, the corridor is elevated corridor and passes through many prime locality like Krishna Park, Vikas Puri, Keshopur, Meera Bag, Sunder Vihar, Peeragarhi, Mangolpuri, West Enclave, Pushpanjali Enclave, Deepali, Rohini, Saraswati Vihar, Madhuban Chowk, Pitampura, Prashant Vihar, Badali Mor, Makaraba Chowk, Jahangir Puri and Bhalaswa Gaon. From Derawal Nagar onward, the alignment becomes underground and generally passes under G.T.Road. The underground alignment passes through Rajpura, Ghanta Ghar, Subji Mandi, Pulbangesh, Sadar Bazar, Motia Khan and finally terminates at Ram Krishna Ashram Marg where it has passenger interchange with existing Ram Krishna Ashram Marg Station of Line-3.

Mukundpur - Maujpur Corridor (Via Burari, Khajuri Khas): This corridor is an extension of Mukundpur- Rajouri Garden-INA- Nizamuddin- Anand Vihar - Maujpur Corridor of Phase-III of Delhi Metro. From Maujpur this corridor runs along Road no-66 and near Yamuna Vihar takes left turn to fall on Mangal Pandey Marg. Then upto Wazirabad Bridge, the corridor is elevated corridor and remains on Mangal Pandey Marg and passes through many prime locality like Yamuna Vihar, Gokulpuri, Bhajanpura, Khajurikhas etc. After crossing Wazirabad Bridge, it reaches Soorghat and then takes a right turn to fall on Dr Hedgewar Marg (outer ring road). Further, it remains on same road and passes through Jagatpur, Burari and finally at Mukundpur Red Light on Dr Hedgewar Marg (outer ring road), it turns left to terminate at Majlis Park Station of Phase-III.

2.2 Alternative Analysis

Out of six corridors three priority corridors of the proposed Delhi Metro Phase IV project have been finalized after taking into account environmental and social concerns, considerations of traffic, integration with the existing system and importantly, the overall economic and financial viability. The underlying principles for evaluation for each corridor, without affecting the overall usefulness of the corridor, are:

- Minimum private land acquisition,
- Least disturbance to properties,
- Minimum disturbance to people and
- Minimum disturbance to ecology/ biodiversity.

In the analysis of alternatives, a comparison of scenario with and without the project has also been made. Advantages and disadvantages have been spelt out. The positive impacts of the chosen corridors are further elaborated in Chapter 5. These being the over-riding criteria, financial implications of these alternatives were not worked out.

No Development Alternative

In case the phase IV of Delhi Metro is not constructed, the city will be deprived of the following benefits:

- Employment Opportunities,
- Enhancement of Economy,
- Mobility,
- Safety,
- Traffic Congestion Reduction, Reduction in Number of Buses,
- Reduced Fuel Consumption,
- Reduced Air Pollution,
- Carbon Dioxide and Green House Gases (GHG) Reduction,
- Saving in Road Infrastructure.

Since the positive impacts are more than a few negative impacts, consideration of 'no development alternative' is a non-starter and has thus not merited any further consideration.

Environment and Social Considerations

No alternative analysis was done due to limited option for railway route. However the alignment of the above corridors are so selected that they will serve the maximum population, will entail less private land acquisition, least demolition of private and government structures, least tree cutting and will avoid impact on archaeological and historical structures. To achieve the above goals, the alignment suggested is mainly on the central verge of the road. In the highly densely populated area the alignment is kept under the ground so as to lessen the social impacts that may have resulted from acquisition of property. Similarly to protect the archaeological/historical monuments, the proposed metro corridors near the monuments are underground except Shah Alam Tomb where alignment is elevated. The entire underground section will be constructed by tunnelling through State of Art Tunnel Boring Machine (TBM). The existing depots will be utilized for these priority corridors

Table 2.3: Details of Phase IV Part A (Priority) Corridors

S.No.	Corridor	Under-ground	Elevated /at Grade	Total Length (km)	Stations (Nos)		
					Under-ground	Elevated	Total
1.0	Aerocity to Tughlakabad	19.343	4.279	23.622	12	4	16
2.0	Janakpuri West to R.K. Ashram	7.740	21.180	28.920	7	14	21
3.0	Mukundpur-Maujpur	0.000	12.558	12.558	0	8	8
	Total	27.083	38.017	65.100	**19**	**26**	**45**

Figure 2.1: Index Plan for Aero City to Tughlakabad

Figure 2.2: Index Plan for R. K. Ashram to Janakpuri West

Figure 2.3: Index Plan for Mukundpur To Maujpur

2.3 RIDERSHIP ON PHASE IV

Daily ridership on the phase IV corridors of metro system in 2021 is expected to be 5.22 lakh passengers with 10 lakh boarding's. The average trip length with full system up to Phase-IV is 16.8 km in year 2021. Phase IV corridor wise total daily boarding and trips for the years 2021, 2031 and 2041 are shown in **Table 2.4.**

Table 2.4: Corridorwise Daily Ridership On Phase-IV Delhi Metro Corridors

S No.	Name	Daily Boarding (including Interchanges)			Daily Trips (Passengers)		
		2021	2031	2041	2021	2031	2041
1	Janakpuri West to RK Ashram	550719	757503	1026359	275579	528054	776060
2	Mukundpur to Maujpur	178631	270411	329894	96198	188503	249442
3	Tughlakabad / Lajpat Nagar to Aero City	279176	357867	478131	150345	249468	361529
Grand Total Daily Boarding's / Trips		**1008526**	**1385781**	**1834384**	**522122**	**966025**	**1387031**

The increment in daily trips due to implementation of phase-IV of Delhi Metro corridors is expected to be 5.22 Lakh, 9.66 Lakh and 13.8 Lakh passengers in the years 2021, 2031 and 2041 respectively as shown in the **Table 2.5** below.

Table 2.5: Incremental Daily Trips (Passengers) Due To Phase IV Part A Of Delhi Metro

Year	Daily Trips		Incremental Trips Due to Ph IV
	With Phase I,II & III	With Phase I,II,III & IV	
2021	4,055,753	4,577,875	522,122
2031	5,184,850	6,150,875	966,025
2041	6,516,690	9,903,721	1,387,031

2.4 ROLLING STOCK

Following are the salient features of rolling stock

- ❖ Running of services for 19 hours of the day (5 AM to Midnight) with a station dwell time of 30 seconds,
- ❖ Make up time of 5% with 8% coasting.

Scheduled speed has been assumed as below:-

(a) Tughlakabad to Aerocity Corridor: 35 kmph
(b) Janakpuri West to R K Ashram (Botanical Garden to R. K. Ashram Corridor): 35 kmph
(c) Mukundpur to Maujpur : 35 kmph

Table 2.6: Salient Features of Standard Gauge (3.2 M Wide Stock) Cars

S. No.	Parameter	Standard Gauge (3.2 m wide stock) Cars
1	Gauge (Nominal)	1435mm Standard Gauge
2	Traction system	
2.1	Voltage	25 KV AC
2.2	Method of current collection	Overhead Current Collection System
3	Train composition	
3.1	6 car:	DMC+TC+MC+MC+TC+DMC
4	Coach Body	Stainless Steel
5	Coach Dimensions	
5.1	Height	3.9 m
5.2	Width	3.2 m
5.3	Length over body (approx)	
	- Driving Motor Car (DMC)	21.81 m
	- Trailer Car (TC)	21.34 m
	- Motor Car (MC)	21.34 m
	Maximum length of coach over couplers/buffers:	22 to 22.6 m (depending upon Kinematic Envelop)
5.4	Locked down Panto height	4048 mm
5.5	Floor height	1100mm
6	Designed - Passenger Loading	
6.1	Design of Propulsion equipment	8 Passenger/ m^2
6.2	Design of Mechanical systems	10 Passenger/ m^2
7	Carrying capacity- @ 6 standees/sqm	
7.1	Coach carrying capacity	
	DMC	300 (seating - 50 ; standing - 250)
	TC	300 (seating - 50 ; standing - 250)
	MC	300 (seating - 50 ; standing - 250)
7.2	Train Carrying capacity	
	6 car train	1800 (seating - 300 ; standing - 1500)
8	Weight (Tonnes)	
8.1	Tare weight (maximum)	
	DMC	42.502
	TC	40.852
	MC	42.104
8.2	Passenger Weight in tons	@ 0.065 T per passenger
	DMC	19.50
	TC	19.50
	MC	19.50
8.3	Gross weight in tons	
	DMC	62.002
	TC	60.352

	MC	61.604
9	Axle load(T)(@ 8 persons per sqm of standee area)	17
		System should be designed for 17T axle load
10	Maximum Train Length (approx.)	135.6 m
11	Speed	
11.1	Maximum Design Speed	95 Kmph
11.2	Maximum Operating Speed	85 Kmph
11.3	Scheduled Speed	35 kmph
12	Wheel Profile	UIC 510-2
13	Noise Limits (ISO 3381 and 3095 - 2005)	
13.1	Stationary (Elevated and at grade)	
13.1.1	Internal (cab and saloon)	LpAFmax 65 dB(A)
13.1.2	External (at 7.5 mtr from centre line of track)	LpAFmax 68 dB(A)
13.2	Running at 85 kmph (Elevated and at grade)	
13.2.1	Internal (cab and saloon)	LpAeq,30 72 dB(A)
13.2.2	External (at 7.5 mtr from centre line	LpAFmax 85 dB(A)
	of track)	
13.3	Stationary (Underground)	
13.3.1	Internal (cab and saloon)	LpAFmax 72 dB(A)
14	Traction Motors Ventilation	Self
15	Acceleration on level tangent track	1.0 m/sec^2
16	Deceleration on level tangent track	1.1 m/sec^2 (>1.3 m/sec^2 during emergency)
17	Type of Bogie	Fabricated
18	Secondary Suspension springs	Air
19	Brakes	An electro-pneumatic (EP) service friction brake An electric regenerative service brake Provision of smooth and continuous blending of EP and regenerative braking A fail safe, pneumatic friction emergency brake A spring applied air-release parking brake The brake actuator shall operate a Tread brake Brake Electronic Control Unit (BECU) Independent for each car
20	Coupler	

	Outer end of 2-car/3-car Unit (except driving cab ends)	Automatic coupler with mechanical, electrical & pneumatic coupling (between two 'DM+T+M' units)
	Between cars of same Unit	Semi-permanent couplers (between 'M' car and 'T' car and 'DM' car and 'T' car)
	Driving Cab end of cars (DMC)	Automatic coupler with mechanical & pneumatic coupling but without electrical coupling head
21	Detrainment Door	Front
22	Type of Doors	Sliding
23	Passenger Seats	Stainless Steel
24	Cooling	
24.1	Transformer	Forced
24.2	CI & SIV	Self/Forced
24.3	TM	Self ventilated
25	Control System	Train based Monitor & Control System (TCMS/TIMS)
26	Traction Motors	3 phase VVVF controlled
27	Temperature Rise Limits	
27.1	Traction Motor	Temperature Index minus 70 deg C
27.2	CI & SIV	10 deg C temperature margin for Junction temperature
27.3	Transformer	IEC specified limit minus 20 deg C
28	HVAC	Cooling, Heating & Humidifier (As required) - Automatic controlling of interior temperature throughout the passenger area at 25°C with 65% RH all the times under varying ambient conditions up to full load.
29	PA/PIS	Required
30	Passenger Surviellance (CCTV)	Required
31	Battery	Ni-Cd
32	Headlight type	LED
33	Coasting	8% (Run time with 8% coasting shall be the 'Run Time in All out mode plus 8%')

2.5 MAINTENANCE DEPOTS

No new maintenance depots have been proposed for the Phase-IV Part A corridors. Existing depots at Sarita Vihar, Kalindi Kunj and Mukundpur will be augmented to accommodate the additional requirements of Aerocity – Tughlakabad, Janakpuri West – R K Ashram and Mukundpur – Maujpur corridors respectively.

2.6 TRACTION SYSTEM

Existing system of electric traction on all the corridors of Delhi Metro constructed in Phase – I, Phase

– II and adopted in Phase – III is at 25kV ac single phase. This is based on techno economic studies for Delhi.

(a) The same traction system for the proposed Phase-IV corridors has been considered, viz 25 kV 50 Hz ac single phase.

(b) Alternatively study is also being carried out for 2x25 kV AC single Phase traction system which has benefits in terms of the following:-

(i) RSS requirement is reduced to half.

(ii) Do away with the BT/RC system as no electromagnetic interference mitigation is required in 2x25 kV system.

(iii) Reduced transmission losses in the system.

In the open area at grade and on elevated structures flexible over head equipment (OHE), similar to the existing corridors has been considered and to be provided or if 2x25 kV system is adopted will need additional feeder wire to be taken and the design shall be finalized accordingly.

The underground sections will have rigid overhead catenary system, similar to that provided for the underground sections constructed in Phase – I, Phase – II and adopted in Phase – III of Delhi metro and in case of 2x25 kV system it will be finalized similar to Sin - Bundang line of Seoul Metro.

2.7 AUXILIARY SUPPLY

The auxiliary supply and general electrical services of the elevated and above ground portion shall generally follow the system design of 33 kV ring main adopted for corresponding sections of Phase – II with some modifications based on techno-economic study being done and same may be adopted in phase-III.

2.8 SOURCES OF POWER SUPPLY

Since Delhi metro has adopted 25kV ac single phase overhead catenary traction system or planning for 2 X 25 kV traction system, therefore the power supply at 66 kV or 220kV level only has to be taken from the Grid Sub Stations of Delhi Transco Limited (DTL) on technical consideration of short circuit level etc. Following will be the sources as tabulated in **Table 2.8**.

Table 2.7: Traction System*

Corridor		Location of source of power
Janakpuri West to R. K. Ashram Corridor (28.83 km, 25 Stations of which 7 Underground stations).	1	Feed extension from Janakpuri West station of phase-III supply.
	2	At 66 kV from proposed Sanjay Gandhi Transport Nagar 220 kV GSS.
	3	At 66 kV from Park Street 220 kV GSS.
Aerocity to Tughlakabad Corridor (20.20 km, 15 Stations of which 10 Underground Stations)	1	At 66 kV from Vasant Kunj 220 kV GSS or proposed Rangpuri 220 KV GSS.
	2	At 66 kV from Tughlakabad 220 kV GSS.
Mukundpur –Burari- Maujpur		Mukundpur and Yamuna Vihar RSS

* In case of 2 x 25 kV system being adopted no of RSS required will be by fifty percent and there may be need of Auto Transformers posts (ATP).

In Phase – IV, the corridors described above, are passing through the densely populated areas of Delhi and will be having underground stations and tunnels. The availability of power from the existing grid sub-station in these areas is scarce and, therefore, innovative methods are to be "thought – of" for providing reliable power at high voltage based on techno economic considerations.

The locations of the RSS – cum – TSS to be constructed in Phase – IV will be finalized during detailed design stage keeping in view the location of Delhi Transco Limited's supply sources (GSS) in the vicinity and the availability of land for RSS.

2.9 POWER DEMAND ASSESSMENT

(a) Traction Power:-

The traction power system is designed for the ultimate 6-car train operation at headway of 90-seconds corresponding to 40 trains per hour for corridors Janakpuri West to R.K.Ashram, Aerocity to Tughlakabad, Indraprastha to Inderlok and Lajpat Nagar to saket G Block.

(b) Auxiliary Power:-

i) Elevated Stations:-

The demand of power at each elevated station is expected to be about 200 kW in the initial years and is likely to reach 500kW later. In addition there will be some additional requirement for other property development loads at stations. The limited requirement of load due to property development within the footprints of the station can be met either from the spare capacity in the station transformers or by adding one additional transformer of 630 kVA capacity in the station ASS for which provision for space will be made during design stage. This may be feasible depending upon the diversity of station loads and property development loads.

For larger property development loads (above capacity of transformers of 630 kVA), the power transformer at RSS and the corresponding cable network may need an up gradation for which the expenditure is to be charged to property development.

ii) Underground Stations:-

The demand of power at each underground station is assessed at connected load of 2.8 MW with a load factor of 0.8 of 3.5 MVA for 6 car.

The additional peak demands of power for the corridor for the year 2021, 2031 and 2041 have been indicated in **Table 2.9**. Peak power demand for the designed headway of 90 seconds with 6-car train operation has also been indicated in this table.

Table 2.8: Power Demand Assessment (in MVA)

Year	Corridor	Traction	Auxiliary	Traction	Auxiliary	Total
2021	Janakpuri West to R. K. Ashram	12.32	23.59	24.43	54.7	79.13
	Aerocity to Tughlakabad	7.11	28.91			
	Mukundpur-Burari-Maujpur	5.00	2.20			

Year	Corridor	Traction	Auxiliary	Traction	Auxiliary	Total
2031	Janakpuri West to R. K. Ashram	14.57	28.29	30.86	64.21	95.07
	Aerocity to Tughlakabad	8.89	32.92			
	Mukundpur-Burari-Maujpur	7.40	3.00			
2041	Janakpuri West to R. K. Ashram	19.57	35.21	40.54	76.46	117
	Aerocity to Tughlakabad	11.67	37.55			
	Mukundpur-Burari-Maujpur	9.30	3.70			
Design	Janakpuri West to R. K. Ashram	59.13	35.21	119.44	76.46	195.9
	Aerocity to Tughlakabad	41.71	37.55			
	Mukundpur-Burari-Maujpur	18.60	3.70			

2.10 POWER DEMAND

Power demand has been worked out for the proposed corridors accordingly and is given in the table below:-

Table 2.9: Power Demand

S. No	Corridor	Power Demand in MVA			
		2021	2031	2041	Designed Headway of (6-car train at 90 sec)
1.	Janakpuri West to R. K. Ashram	35.92	42.86	54.87	94.33
2.	Aerocity to Tughlakabad	36.02	41.81	49.22	79.26
5.	Mukundpur to Maujpur	7.2	10.4	13.0	22.30

2.11 CONSTRUCTION METHODOLOGY

Elevated corridor

It is proposed to provide single box-shaped girders as super structure for the viaduct as adopted in various sections in phase-I, II & III. As the alignment passes through sufficiently wide roads, no difficulty is envisaged during construction. However, at some locations, these will be a need of providing special spans to be finalized at the stage of detailed design. Typical Drawings are presented in **Annexure-2.1**.

Elevated Stations

Elevated stations will normally of two types (concourse under the platform and concourse on both sides of alignment provided in towers and inter connection between two through a FOB) as adopted in Phase I, II & III. The construction methodology shall remain the same as adopted for respective type of stations in phase- I, II & III. Typical Drawings are presented in **Annexure -2.1**.

Underground Section

Construction of the underground section shall be done by "cut and cover" as well as by "bored" tunneling method (TBM). Cut and cover methodology for various sections of proposed corridor will be the same as already done in phase- I, II & III. Typical Drawing is presented in **Annexure -2.1**.

Underground Station

All the underground stations have been proposed to be constructed by cut and cover with top- down method. The diaphragm walls for such station constructions would be 80 to 100 cm thick and will function as a permanent side wall of the station. By resorting to top-down method the surface could be restored quickly and further excavations and construction of the station will not hamper the surface activity. Cut and Cover mainly consists of following steps:

1. Diversion of utilities
2. Construction of support walls
3. Excavation between the support walls along with the installation of struts between the two walls to keep them in position.
4. Construction of tunnel/structure and removal of temporary struts.
5. Back filling and restoration of the surface

2.12 CONSTRUCTION STRATEGY

Civil works

It is proposed that whole corridor can be subdivided into smaller stretches. Each stretch can be 5 to 6 km long. These can be termed as Contract Packages. Each Contract Package will include even Metro stations falling in that particular stretch.

Sources of procurement of construction material will be decided by the Contractor, but it will be from existing licensed suppliers. Typical materials and their source are provided in **Table 2.11**.

Table 2.10: Construction Materials

S.No.	Material	Source (with Approximate distance)
1	Coarse aggregate	Kotputli, Rajasthan (180 km)
2	Fine aggregate	Bazpur (250 Km), Patankot, (480 km,)
3	Cement	Shambupura (600km), Neemach (650Km) etc
4	Steel	Raipur (1200 km), Patratu,Jharkhand (Approx 1188 km)
5	Bricks	Dadri (80 km), Mahilpalpur, Delhi
6	Granite	Karnataka (>1000km), Madurai. Tamilnadu (Approx 2584.8 Km), Jaipur, Rajasthan (300km)

Large numbers of pre-cast segments are required for construction of elevated/underground structures for which a large open area is required for setting up of casting yards. As far as possible, this area will be close to the site, easily accessible and away from habitation. The Contractor will construct temporary batching plant near the construction sites. The location of the temporary construction

facilities will be decided with the Contractor, but it will be located in open land to avoid any displacement. The site for Casting yard and Batching plant has not been finalized and site will be provided by land owning agency subjected to availability of land before the start of project. Fresh concrete will be supplied from new concrete batching plants constructed specifically for this Project.

Power Supply & Electric Traction Works

Detailed Designs of 'Power Supply & Electric Traction' works will mostly be done in-house. For detailed designs of a few specialized items DDCs will be engaged. These works will be got executed through 'construct' contracts. Cables and other materials required in bulk will be procured by DMRC itself and supplied to the 'construction' contractors. This strategy of mostly doing the detailed design work in-house, getting the works executed through construction contracts, procuring cable and other bulk materials and supplying the same to the construction contractors will enable DMRC to reduce the cost of these works. Entire Power Supply & Electric Traction works can be carried out through a single contract for each corridor respectively.

Track Work

Detailed design of ballastless / ballasted track will be done in-house by DMRC. Track work shall be got executed through 'construct' contract. Material like rails, sleepers, track fittings, turnouts, etc. will be procured by DMRC and supplied to the construction contractors. It is proposed to have one track work contract for approximately 15 kms long alignment.

Signalling & Telecommunication works

These will be split into separate Signalling contracts & Telecommunication contracts. Signalling works will be got executed through 'Design, Construct, installation, testing, & commissioning' basis. It is proposed to have one Signalling contract for entire stretch for each corridor respectively.

Telecommunication works will be got done through 'construct' contract with detailed designs being done in-house. DDCs may also be engaged for specialized items where necessary. Most of the materials required for telecommunication works like cable etc. will be procured by DMRC and supplied to the construction contractors. Entire Telecommunication works can be carried out through a single contract for each corridor respectively.

Automatic Fare Collection (AFC) System

Installation of AFC system will be got done by DMRC through 'construct' contracts. Hardware and software required for the AFC system will, however, be procured by DMRC and supplied to the contractors. Entire AFC works can be carried out through a single contract for each corridor respectively.

Tunnel Ventilation and Air-conditioning System

Design work of this system will be done in-house but execution will be done through 'construct' contracts. SES analysis, however, may be got done through a DDC. Bulk of materials required for ventilation and Air-conditioning system will be procured by DMRC and supplied to the construction contractors. Entire Tunnel ventilation and Air-conditioning works can be carried out through a single contract for each corridor respectively.

Rolling Stock

Rolling Stock required for the project will be procured on design, manufacture, supply, testing and

commissioning basis.

2.13 CONSTRUCTION PERIOD

As per the acquired experience, total work can be completed in 60 months period from date of start. The work has been started by December 2019, and various sections can be opened in phases by March 2025. Project completion date is subject to land required for the project is made available to DMRC within 6 months period from date of sanction of project.

2.14 CONSTRUCTION MACHINERY

Metro construction is machine intensive. Various types of construction equipments are going to be used for construction of elevated and underground sections. The different machineries that are going to be used are presented in Table 2.12.

Table 2.11: Construction Machinery

S.No.	Construction Machinery
1.	Tunnel Boring Machine
2.	Auger Drill
3.	Backhoe
4.	Bar Bender
5.	Blasting
6.	Jack Power Unit
7.	Chain Saw
8.	Clam Shovel (dropping)
9.	Concrete Batch Plant
10.	Concrete Mixer Truck
11.	Concrete Pump Truck
12.	Concrete Saw
13.	Crane, Dozer
14.	Drill Rig Truck
15.	Drum Mixer
16.	Dump Truck
17.	Excavator
18.	Flat Bed Truck
19.	Front End Loader
20.	Generator
21.	Grader
22.	Hydra Break Ram
23.	Jackhammer
24.	Pavement Scarafier
25.	Paver, Pickup Truck
26.	Pneumatic Tools

S.No.	Construction Machinery
27.	Rivit Buster/chipping gun
28.	Rock Drill
29.	Roller
30.	Sand Blasting
31.	Shears (on backhoe)
32.	Slurry Plant
33.	Slurry Trenching Machine
34.	Tractor
35.	Vacuum Excavator (Vac-truck)
36.	Ventilation Fan
37.	Vibrating Hopper
38.	Vibratory Concrete Mixer
39.	Vibratory Pile Driver
40.	Warning Horn

2.15 MAINTENANCE ACTIVITIES DURING OPERATION

During operation phase, train maintenance activities will be carried out in the main depot cum workshops where the overhaul and corrective maintenance facilities for whole fleet are planned. The maintenance workshops will be managed by a team of managers who will plan, coordinate and manage various activities in depot to ensure that the trains are well maintained and cleaned for daily passenger service. The main activities that will be taking place in maintenance depot will be train washing, filter cleaning, HVAC filter cleaning, bogie cleaning, internal train cleaning, roof wash, heavy train cleaning, evaporator cleaning and condenser cleaning.

2.16 COST ESTIMATES

Project Cost estimates for the DMRC's Phase-IV Part A metro network has been prepared covering civil, electrical, signalling and telecommunication works, rolling stock, environmental protection, rehabilitation, considering 25 kV AC traction at January 2019 price level, both for Capital and Operation & Maintenance costs.

In order to arrive at realistic cost of various items, costs have been assessed on the basis of accepted/completion rates in various contracts, awarded for similar works by DMRC in Phase-II, Phase-III. A suitable escalation factor has been applied to bring these costs to January 2019 price level. Taxes & Duties such as Customs Duty, Excise Duty, Sales Tax, Works Tax, VAT, etc, wherever applicable, have been worked out on the basis of prevailing rates and included in the cost estimates separately.

The overall Capital Cost for the DMRC's Phase-IV metro of priority corridors at January 2019 price level works out to **Rs. 22,493 Crores** including applicable Taxes & Duties and also including the cost of rolling stock for the additional induced traffic on Botanical Garden-Janakpuri West Corridor due to Phase IV Part A, as tabulated hereunder

Table 2.12: Corridor-Wise Details of Capital Cost

S.No.	Corridor	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
1.	Aerocity - Tughlakabad	7293	938	8231
2.	RK Ashram – Jnakpuri West	8394	955	9349
3.	Mukundpur-Maujpur	1943	247	2190
4	Additional Rolling Stock including augmentation of depot	2339	384	2723
Total		**19969**	**2524**	**22493**

3. ENVIRONMENTAL BASELINE DATA

3.1 ENVIRONMENTAL SCOPING

The information presented in this chapter stems from various sources. The objective of Environmental Impact Assessment (EIA) is to ascertain the baseline environmental conditions and then assess the impacts as a result of the proposed project during various phases of the project cycle. Identification of environmental parameters, data collection and impact predictions form the core of Environmental Impact Assessment process. Data on land environment has been collected and compiled from various reports and field surveys. The data on water quality, ground water hydrology, vegetation and fauna, air and noise quality was collected during field studies. Efforts have been made to compile the available data from literature, books, maps, websites and reports. The methodology adopted for data collection is highlighted wherever necessary. Environmental Attributes and Frequency of Baseline Survey is presented in **Table 3.1**. A scoping matrix has been formulated to identify the attributes likely to be affected due to the proposed project and summarized in **Table 3.2**.

Table 3.1: Environmental Attributes and Frequency of Monitoring

S. No	Attribute	Parameter	Frequency	Source
Land Environment				
1	Soil	Soil Characteristics	Once	Field Study/Literature review
2	Geology	Geological Status	---	Literature review
3	Seismology	Seismic Hazard	---	Literature review
Water Environment				
4	Water Quality	Physical, Chemical and Biological parameters	Data	Field Study/Literature review (DPCB)
Air, Noise And Meteorology				
5	Ambient Air Quality	$PM_{2.5}$, PM_{10}, NOx, SO_2, CO, O_3, NH_3, Pb and HC	24 hourly	Field Studies/literature review
6	Meteorology	Temperature, Relative humidity, Rainfall, wind direction and speed	Data	India Meteorological Department/literature review
7	Noise	Noise levels in dB (A)	24 hourly	Field monitoring/ Literature review
Scio-Economic				
8	Socio-economic aspects	Socio-economic characteristic	Once	Field Studies, Literature review.
Ecology				
9	Trees	Number/species	Once	Filed Studies

Table 3.2: Scoping Matrix

No.	Impacts	Rating	Brief Description	Assumed mitigation measures	Survey for assessing impacts in this study
Social Environment					
1	Involuntary resettlement	A	Involuntary resettlement is required for construction of Phase IV corridors.	- To provide proper compensation and rehabilitation. - To obtain consensus with the inhabitants.	- Social condition of the area will be studied through interview of PAP/PAF's **(Social baseline survey)**
2	Local economy such as employment and livelihood, etc.	A	Local economy and livelihood in the land acquisition area will be affected since the people need to be relocated.	(same as No.1)	(same as No.1)
3	Land use and utilization of local resources	A	Private and government properties will be acquired for alignment and stations.	(same as No.1)	(same as No.1) - Properties will be identified during topographical survey and route alignment.
4	Social institutions such as social infrastructure and local decision-making institutions	D			
5	Existing social infrastructures and services	B	Infrastructures such as water lines, sewer, storm water drains, telephone lines, gas pipelines, overhead electrical lines	- The utility services will be maintained in working order during different stages of construction by temporary / permanent diversions or by supporting in position - The utilities will be restored to normal positions after construction	Departments whose utilities bare being impacted will be identified.
		B	Traffic at the existing road may be affected during the construction work.	- Diversion/ suggest alternative routes for smooth flow of traffic	Existing condition of the road and road traffic will be observed through traffic survey.
6	The poor, indigenous and ethnic people	D			
7	Misdistribution of benefit and damage	D			
8	Cultural heritage	C	Few small religious structures may be affected	(same as No.1)	- Cultural heritages will be identified during survey

No.	Impacts	Rating	Brief Description	Assumed mitigation measures	Survey for assessing impacts in this study
9	Local conflict of interests	D			
10	Water Usage or Water Rights and Rights of Common	D	No impact is anticipated as water requirement will be met from separate tube wells for the project	–	- .
11	Sanitation	B	Sanitation condition may deteriorate due to inflow of large number of construction workers.	Proper sanitation facilities will be provided (e.g. portable toilets) and ensure the proper management of waste.	Current sanitation condition at the project site will be ascertained.
12	Hazards (Risk) Infectious diseases such as HIV/AIDS	B	The risk of infectious diseases may increase due to inflow of large number of construction workers.	To consider health care programs.	nformation about diseases will be collected through the interview survey. **(Social baseline survey)**
Natural Environment					
13	Topography and Geographical features	D	No Impact on topography and geographical features is anticipated	–	–
14	Soil Erosion	B	Run off from unprotected excavated areas, and underground tunnel faces can result in excessive soil erosion	Careful planning, timing of cut and fill operations and revegetation	Soil condition will be assessed by taking soil sample and geotechnical study
15	Groundwater	B	Impact on ground water is expected as requirement of water for construction and operation of depot will met though tube well.	Rainwater harvesting will be done	Baseline data of ground water table and availability
16	Hydrological Situation	D	No impact on hydrological situation is anticipated.		
17	Coastal Zone (Mangroves, Coral reefs, Tidal flats, etc.)	D	The project area is not in the coastal zone.		
18	Flora, Fauna and Biodiversity	B D	Trees will be cut which are falling along the alignment. No rare and endangered species are found.	Compensatory afforestation will be carried out.	ee survey will be carried out during the study

No.	Impacts	Rating	Brief Description	Assumed mitigation measures	Survey for assessing impacts in this study
		D	No impact on fauna is anticipated as the project is in urban area where there is no wildlife		
19	Meteorology	D	No impact on meteorology in anticipated		
20	Landscape	D	There is no valuable landscape to be protected at the project site.		
21	Global Warming	D	No activity which will cause the global warming is anticipated.		
Pollution					
22	Air Pollution	B	Emission from construction equipments and vehicles will increase air pollutants.	To use proper construction vehicles with good condition to minimize emission.	Air quality monitoring in project area
23	Water Pollution	C	Construction of bridge on Yamuna may create water pollution	To select proper construction method. -	/ater quality of the river will be surveyed by water sampling.
24	Soil Contamination	D	Oil spills, paints, solvents may cause soil contamination	To provide for oil trays and drip pans and provision of separate storage	- Soil testing
25	Waste	B	Construction surplus soil will be generated.	- To select proper site to dispose the soil.	- Quantity of surplus soil will be identified.
26	Noise and Vibration	B	Construction noise will be generated. Noise and vibration from metro operation may impact surrounding area.	To restrict construction at night. To install noise barriers if necessary	Noise quality monitoring in project area
27	Ground Subsidence	C	There will be possibility of subsidence.	the detailed survey of condition of buildings/houses along proposed alignment will be conducted. During construction monitoring of condition of buildings/houses will be conducted. In case of occurrence of crack at wall of buildings/houses, damaged wall will be	

No.	Impacts	Rating	Brief Description	Assumed mitigation measures	Survey for assessing impacts in this study
				repaired immediately	
28	Offensive Odor	D	No odour is anticipated		
29	Bottom sediment	D	No Sedimentation is expected		
30	Accidents	B	There are risks of accidents during construction. During operation accidents will be reduced	To secure the safely-control.	

Rating: A: Significant negative impact is expected. B: Some negative impact is expected.
C: Extent of impact is unknown D: No impact is expected

3.2 LAND ENVIRONMENT

The Project area is situated in Delhi, the Capital of India. The average elevation of Delhi plains is 200 m above the sea level (a-MSL). The ridge however has a higher elevation going upto 300 m above mean sea level and is about 15 to 60 m above the surrounding plains. Delhi is located between $28^{O}24'15"$ and $25^{O}53'00"$ North latitude and $76^{O}50'24"$ and $77^{O}20'30"$ East Longitude. Parameters involved in land environment are, physiography, geology, soil and seismicity. These are discussed in the following paragraphs.

3.2.1 Physiography

The physiography of Delhi is dominated by the river Yamuna, the Aravalli range and the plains in between formed by alluvium deposits of recent formation. The Delhi Ridge and its four sections, the northern, the central, the south central and the southern constitute the farthest extension of the Aravalli range, its spurs meeting the Yamuna at two points in the north and the east. The Noida or Shahdara area drains from east to west into the Yamuna River. Similarly Delhi and New Delhi areas also drain in Yamuna River through various drains such as Najafgarh drain. The average gradient is gentle of the order of 1 to 4 m/km. Delhi area is generally flat except for a gentle rise to form a central ridge from North – East to South – South – West. The Yamuna River is Delhi's source of drinking water.

3.2.2 Geology and Soils

The geology of Delhi is of mix type containing various soil deposits. It consists of quartz rock and extends from south part to west bank of the Yamuna River for about 35 km. The soil textures in Delhi are alluvial and quartz type. The Yamuna river flood carried different types of soils and hence at some places the soil is a mixture of various constituents. General stratigraphic sequences of the rock formation in Delhi are unconsolidated; inter bedded, sand lenses, silt, gravel, clay, kankar and quartz. The Yamuna is the only river flows through the city and it enters into Delhi at north-west side and leave at south-east end. The soils of the Delhi area are mostly light with subordinate amount of medium texture soils. The light texture soils are represented by sandy, loamy and sandy loam types; whereas medium texture soils are represented by loam silty loam.

In order to know the characteristic of soil of the project area, 13 soil samples were collected along the corridors. The samples were collected in the month of June 2020 and analyzed by

NABL accredited laboratory. The location details are given in the **Table 3.3** and the results of soil samples are presented in **Table 3.4**. Test results shows that soil is little bit alkaline except at Khanpur. The soil is found sandy at all locations.

Figure 3.1: The Map Showing Geological Units of Delhi

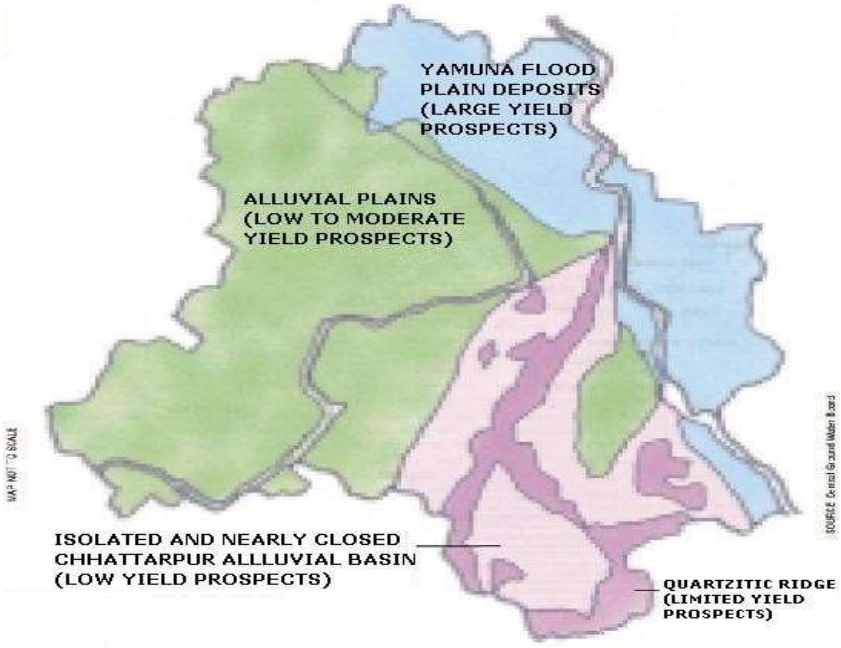


Table 3.3: Soil and Water Sampling Locations

Sampling Location Number	Location Name
R K Ashram - Janakpuri West	
1	Krishanpark
2	Peeragarhi
3	Prashantvihar
4	Nabi Karim
5	Pulbhangash
6	Derawal Nagar
Mukundpur - Maujpur	
7	Yamuna Viahr Casting Yard
8	Jagatpur
Aerocity -Tughalakabad	
9	Tughalakabad
10	Khanpur
11	Aerocity
12	Saket
13	Mundka Casting Yard

Figure 3.2: Soil Sample Location Map

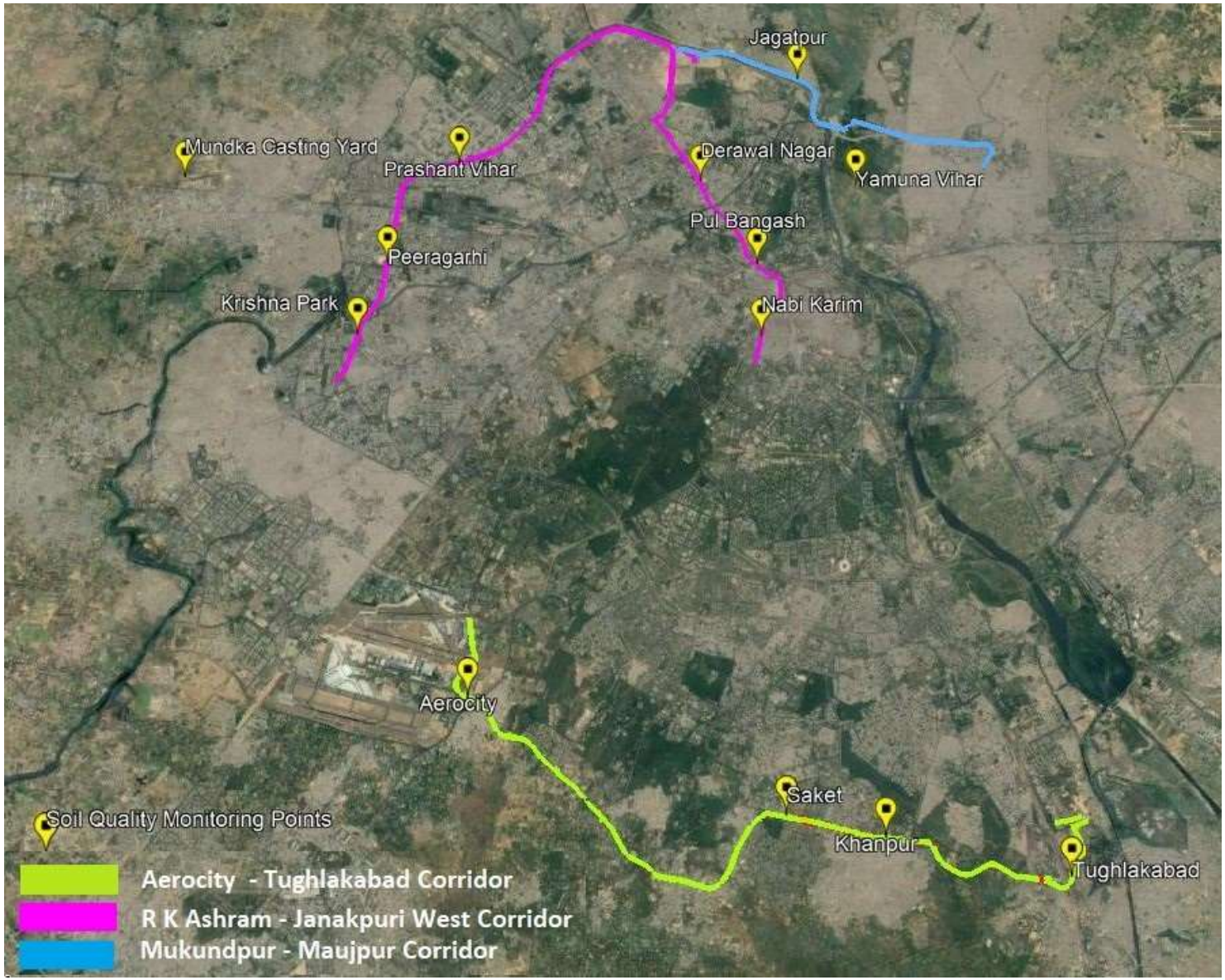


Table 3.4: Soil Test Results

Sl. No.	PARAMETERS	R K Ashram - Janakpuri West						Mukundpur - Maujpur		Aerocity - Tughalakabad				Casting yard Location
		1	2	3	4	5	6	7	8	9	10	11	12	13
1	PH	7.71	7.69	7.67	6.87	7.19	8.29	7.84	7.58	7.37	6.94	7.28	8.15	7.42
2	Conductivity,µs/cm	557	735	783	689	543	621	715	793	829	498	859	961	948
3	Calcium as Ca,mg/kg	798	825	894	934	879	963	1084	957	931	864	985	784	1024
4	Sodium as Na,mg/kg	163	212	239	181	167	235	261	278	197	185	205	239	306
5	Potassium as K,mg/kg	57	61	84	73	91	69	73	56	82	61	89	77	83
6	Magnesium as Mg,Mg/kg	267	245	239	287	263	274	291	261	303	247	279	312	237
7	Organic Matter,% by mass	0.67	0.89	1.07	0.92	0.93	1.07	0.59	0.94	0.88	0.76	1.02	0.66	1.08
8	Nitrogen as N,mg/kg	37.3	37.9	41.2	36.9	36.1	38.6	40.1	37.1	37.5	39.4	36.2	38.9	39.6
9	Phosphorous Content,mg/kg	7.1	7.7	7.3	8.1	8.4	7.6	8.2	7.4	7.2	8.5	8.9	7.8	7.1
10	Texture													
	Sand,%by mass	78	72	79	80	73	77	81	79	74	77	76	75	71
	Clay,by mass	12	17	13	15	15	13	5	10	17	12	15	19	17
	Slit,by mass	10	11	8	5	12	10	14	11	8	11	9	6	12

Note: 1 to 13 is location numbers, Ref: Table 3.2

3.2.3 Seismicity

The country has been classified into different zones indicating the intensity of damage or frequency of earthquake occurrences. These zoning maps indicate broadly the seismic coefficient that could generally be adopted for design of buildings in different parts of the country. These maps are based on subjective estimates of intensity from available information on earthquake occurrence, geology and tectonics of the country. Delhi is located in zone IV of seismic zoning map of India (**Figure 3.3**). The zone has fairly high seismicity with general occurrence of earthquakes of 5-6 magnitude, a few of magnitude 6-7 and occasionally of 7-8 magnitude. Delhi thus lies among the high-risk areas. Seismicity around Delhi appears to be associated with a major geological structure known as the Delhi-Haridwar Ridge. This ridge constitutes an important tectonic block between 28^{O}-30^{O} N and 76^{O}-79^{O} E with a NE-SW trend. It coincides with the extension of the Aravalli Mountain belt beneath the alluvial plains of the Ganga basin to the northeast of Delhi towards the Himalayan Mountain. The first recorded major earthquake in this region occurred on 15th July 1720 of intensity 9.0. Subsequent other earthquake events occurred in 1803, 1819, 19005, 1934, 1937, 1945, 1949, 1958, 1960, 1966, 1975, 1980, 1994, of intensity between 7.0 to 9.0.

3.3 WATER ENVIRONMENT

Water environment consists of water resources and its quality. Its study is important from the point of view to assess the sufficiency of water resources for the needs of the project in its various stages of the project cycle and also to assess the impact of the project on water environment. In the present project, ground water is proposed to be used during construction after taking approval from competent authority i.e. Central Ground Water Board. Anticipated impacts of the proposed project on water environment have also been addressed.

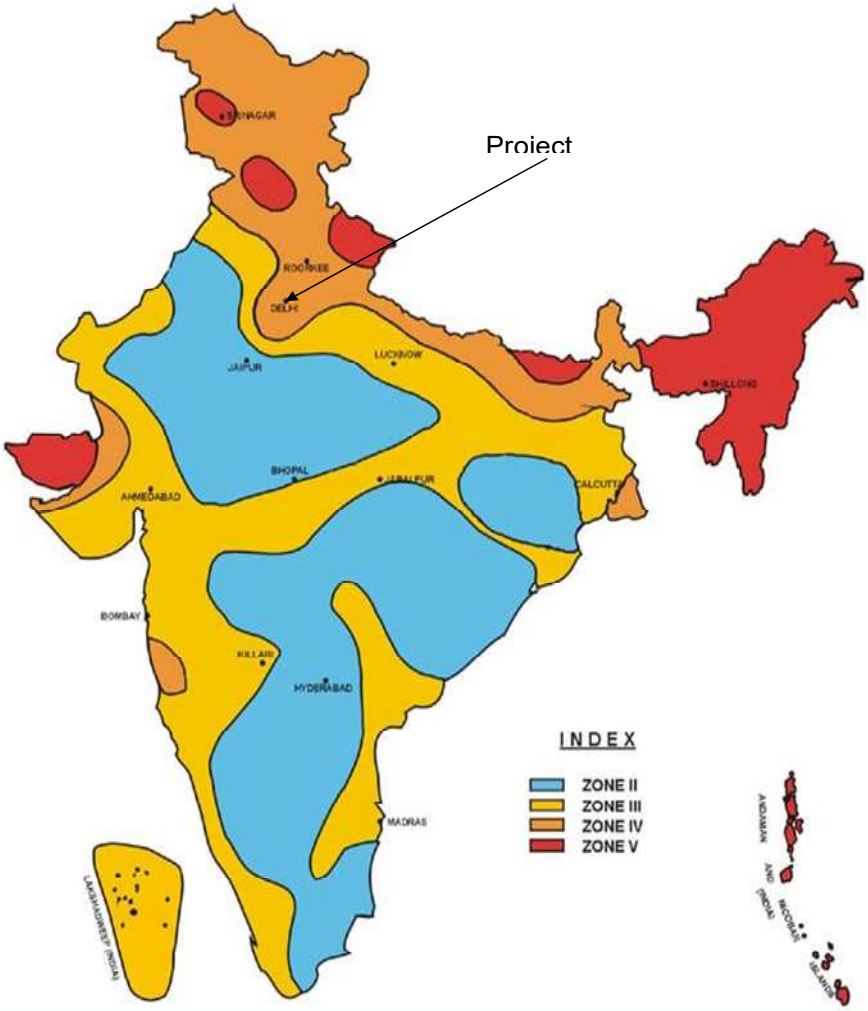
3.3.1 Water Resources

The water availability and its quality play a significant role in the project. Water supply to Delhi is from Yamuna River which flows through the project area. The Yamuna River originates from the Yamnotri glacier in the lower Himalayas at an elevation of about 6,387 metre above mean sea level. The river sluggishly meanders from Tajewala via Delhi to its confluence with the Ganga at Allahabad after flowing a distance of about 1,200 kms. Delhi's share of river Yamuna, as per inter-state agreements, is 4.6%. The water availability of river Yamuna at 90% dependability during different seasons in a year
is as follows:

- Monsoon : 10.0 Mm^3/day
- Post monsoon : 1.2 Mm^3/day
- Winter : 0.8 Mm^3/day
- Summer : 0.1 Mm^3/day

Delhi gets it water from the Ganga Canal, the western Yamuna canal, the Bhakra Canal and the river Yamuna. The ground water table in Delhi has been depleting in various area across the city. It is said that water table is falling about 3m/year. Ground water levels have depleted by 2-6 m in Alipur and Kanhwla Blocks, 10m in Najafgarh block and about 20m in Mehrauli Block. The flow of river varies from season to season as reported above. During summer the flow is less, since most of the treated sewage, untreated flow from drains are directly discharged into the river at at-least 17 locations which make the river unsuitable for supporting any aquatic life specially the fish species. Plans by the Government, to clean up the river, under the Yamuna Action Plan, are underway.

Figure 3.3: Seismic Zoning Map Of India



Rainwater: Delhi has a monsoon climate with an average yearly rainfall of 611.8 mm. The utilized rainwater runoff is 193 Mm^3 per year.

3.3.2 Ground Water

The ground water availability in the territory is controlled by the hydro geological situation characterized by occurrence of alluvial formation and quartzite hard rocks. The NCT Delhi can be divided into following distinct hydro geological units: Newer Alluvium - Yamuna flood plain deposits, Older Alluvium - Eastern and western sides of the ridge, Older Alluvium - Isolated and nearly closed Chattarpur alluvial basin and Quartzitic Formation - NNE-SSW trending Quartzitic Ridge. The formation wise details of ground water characteristics in NCT Delhi are given in **Table 3.5**.

Table 3.5: Ground Water Characteristics in Different Geological Formation

S. No.	Nature of Formation	Depth of the well (mbgl)	Discharge (m^3/hr)	Drawdown (m)	Transmissivity (m^3/day)
1.	Newer Alluvium	40-60	50-180	6.0-8.0	600-2000
2.	Older Alluvium	30-60	20-60	6.0-24	130-403
3.	Quartzite	50-150	02-10	6.0-30	05-135

Source: Groundwater Management in NCT Delhi, by Shashank Shekhar, Raja Ram Purohit & Y. B. Kaushik

The complex situations of ground water occurrence in different formations, presence of saline ground water at varying depth in the aquifers and growing urbanization influences availability of ground water in different parts of NCT of Delhi. Central Ground Water Board estimated the annual replenishable ground water resources in NCT Delhi as 29,710 hectare meter (ha-m) and the net ground water availability of NCT Delhi as 28,156 ha-m. The annual ground draft for NCT Delhi (as on 2004) is 47,945 ha-m of which 20,002 ha-m is for irrigation use, 21,506 ha-m is for domestic use, 2,137 ha-m by farmhouses and around 4,300 ha-m for industrial uses. A decline in water table of 4 m has been observed in Delhi for last few decades. District wise details of fall in ground water levels are given in **Table 3.6.** The main reasons for decline in ground water levels in NCT of Delhi include increasing ground water withdrawal for various purposes especially in areas where piped water supply is inadequate and rapid pace of urbanization resulting in reduced natural recharge to aquifers. The Depth to water level recorded in NCT Delhi ranges from 1.20 to 67.73 mbgl. The deeper water levels are mostly found in south and south west districts of NCT Delhi, while the shallower water levels are found in central, northern and eastern part of Delhi. The Yamuna flood plain in NCT Delhi has depth to water level in the range of 2-5 mbgl. Depth to ground water level is shown in **Figure 3.4.**

Table 3.6: Groundwater Fall In Delhi

District	Total No. of observation wells monitored	No. of wells showing fall in ground water levels	Minimum fall (m)	Maximum fall (m)
Central	2	1	1.91	1.91
East	21	14	0.13	3.34
New Delhi	23	22	0.05	5.83
North	11	9	0.01	1.10
North East	7	5	0.07	0.91
North West	40	27	0.04	3.97
South	39	34	0.04	7.92
South West	46	39	0.05	9.25
West	12	9	0.16	2.36

Source: http://pib.nic.in/newsite/erelease.aspx?relid=68305

3.3.3 Water Quality

Water quality is the physical, chemical and biological characteristics of water. It is most frequently used with reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to drinking water, safety of human contact and for health of ecosystems. An understanding of the various factors influencing water quality is thus very important as human health is largely dependent on the quality of water available for our use. The ground water samples have been collected at 13 locations along the corridors. The samples were collected in the month of June 2020, location details are given in **Table 3.3** and water quality have been analyzed in NABL accredited laboratory. The laboratory analysis results are given in **Table 3.7**. The water parameters are compared with the prescribed limits of various parameters as per IS 10500:2012. TDS is below permissible limit at all locations except at the Mundka casting yard. The fluorides is found high at all locations. Coliform found in all water samples except at four locations. Most of the parameters at all locations are within permissiblelimits.

Table 3.7: Water Quality at Project Site

PARAMETERS	R K Ashram - Janakpuri West						Mukundpur - Maujpur		Aerocity -Tughalakabad				Casting yard Location	LIMITS (IS 10500-2012)
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Colour, Hazen	Colour less	Colour less	Colou rless	Colour less	Colour less	Colour less	Colour less	Colour less	Colour less	Colour less	Colour less	Colour less	Colourless	5 (15) Max
Turbidity, NTU	1.8	2.3	2.7	0.89	1.7	2.3	0.62	1.4	4.2	2.8	1.5	0.67	2.6	1 (5) Max
PH	7.86	7.74	7.59	7.89	7.82	7.74	7.71	7.69	7.52	7.53	7.68	7.81	7.85	6.5-8.5 Max
Total Hardness as Caco3, Mg/l	354	326	282	348	414	396	292	306	267	304	404	382	598	200 (600) Max
Chloride as Cl, Mg/l	196	268	279	187	294	264	157	132	239	309	294	174	729	250 (1000) Max
Total Iron as Fe, Mg/l	0.08	0.07	0.11	0.15	0.21	0.27	0.06	0.23	0.24	0.23	0.19	0.17	0.14	0.3 Max
Total Dissolved Solids, Mg/l	1352	1478	128 5	1634	1795	1538	967	1482	1067	1173	1751	1638	4128	500 (2000) Max
RFC, Mg/l	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.2(1) Max
Total Suspended Solids,Mg/l	12	19	21	BDL	18	21	BDL	11	24	14	10	BDL	16	--
Sulphates as So4, Mg/l	136	124	89	96	209	214	154	115	132	128	164	173	362	200 (400) Max
Nitrates as No3, Mg/l	21	23	29	41	53	38	42	19	27	32	39	56	61	45 Max
Fluorides as F, Mg/l	3.28	2.74	3.26	2.87	2.45	2.74	3.14	3.12	3.19	2.17	1.89	3.68	2.94	1.0 (1.5) Max
Lead as Pb, Mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01 Max
Copper as Cu,Mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05 (1.5) Max
Manganese as Mn,Mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.1 (0.3) Max
Phenolic Compound as C6H5OH,Mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.001 (0.002) Max
Mercury as Hg,Mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.001 Max
Cadmium as Cd,Mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01 Max

Selenium as Se, Mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01 Max
Arsenic as As,Mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05 Max
Cyanide as Cn,Mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05 Max
Zinc as Zn, Mg/l	0.65	0.19	0.23	BDL	0.28	1.42	1.23	0.69	BDL	1.33	0.39	1.27	1.44	5 (15) Max
Nickel as Ni, Mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.02Max
Calcium as Ca,Mg/l	81	78	67	85	105	91	71	83	69	79	91	89	126	75(200)Max
Magnesium as Mg,Mg/l	**37**	**32**	**28**	**33**	**37**	**41**	**28**	**24**	**23**	**26**	**43**	**39**	**69**	30 (100)Max
Dissolved Oxyzen, Mg/l	7.2	6.9	8.1	6.3	7.4	8	7.6	6.3	6.7	6.9	8.2	7.9	7.1	--
Chromium as Cr+6 ,Mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05 Max
Total Alkalinity as Caco3,Mg/l	217	207	185	231	287	239	203	244	212	231	248	219	393	200 (600) Max
Aluminum as Al,Mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.03(2) Max
Boron as B, Mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.5(1) Max
COD,mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
Oil & Grease,Mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	--
Ammonia as N,mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.5 Max
PAH	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.0001 Max
Pesticides	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	No relaxation
Bacteriological Analysis														
a) Coliform,MPN/100Ml	856	Nil	Nil	697	1125	487	589	1548	663	Nil	389	Nil	1609	10 Max
b) E-Coli/Ml	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative

Note: 1 to 13 are the location number, Ref: Table 3.2

Figure 3.4: Depth to Water Level Map, NCT Delhi (Pre-Monsoon, May 2009)

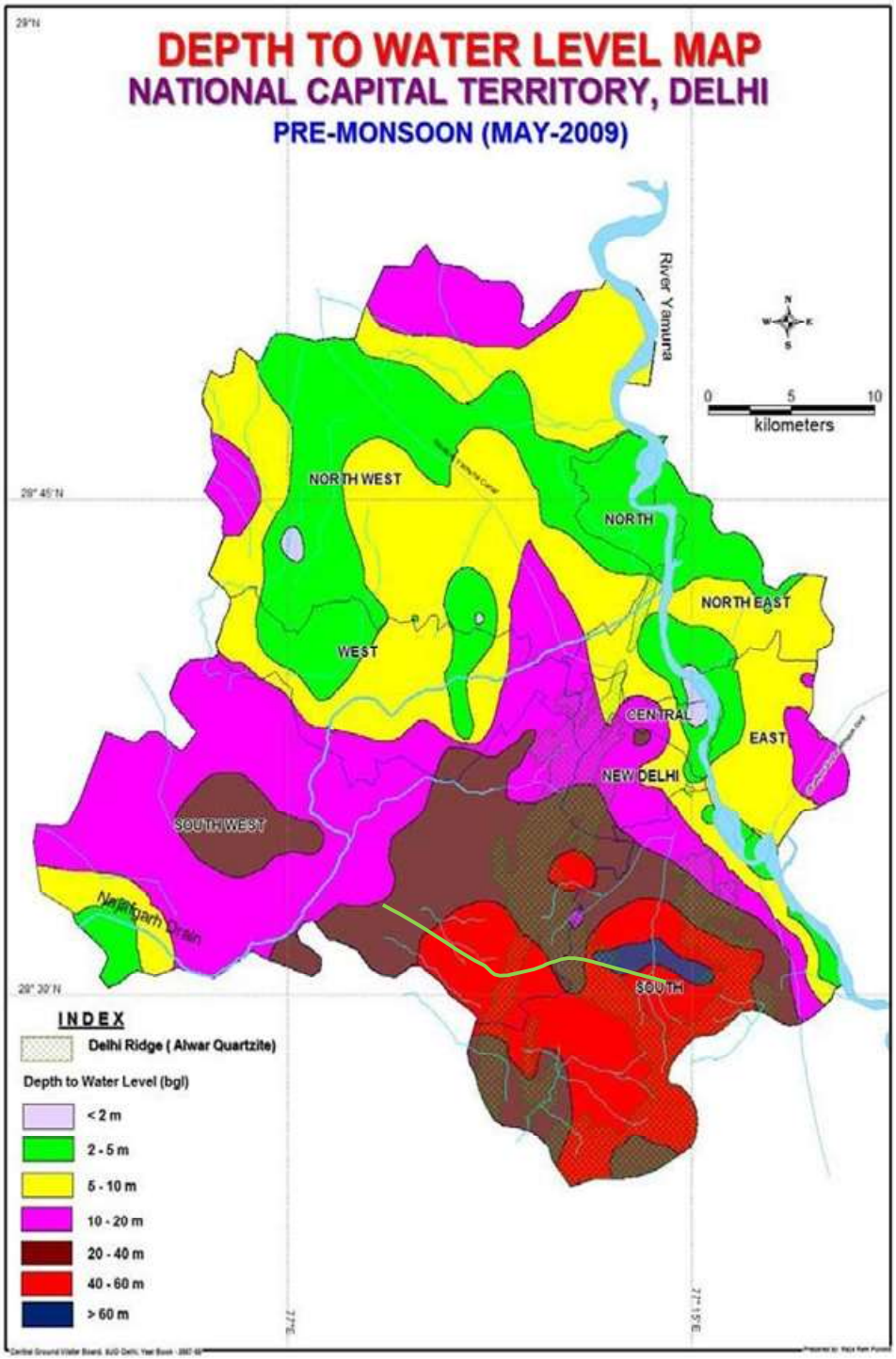
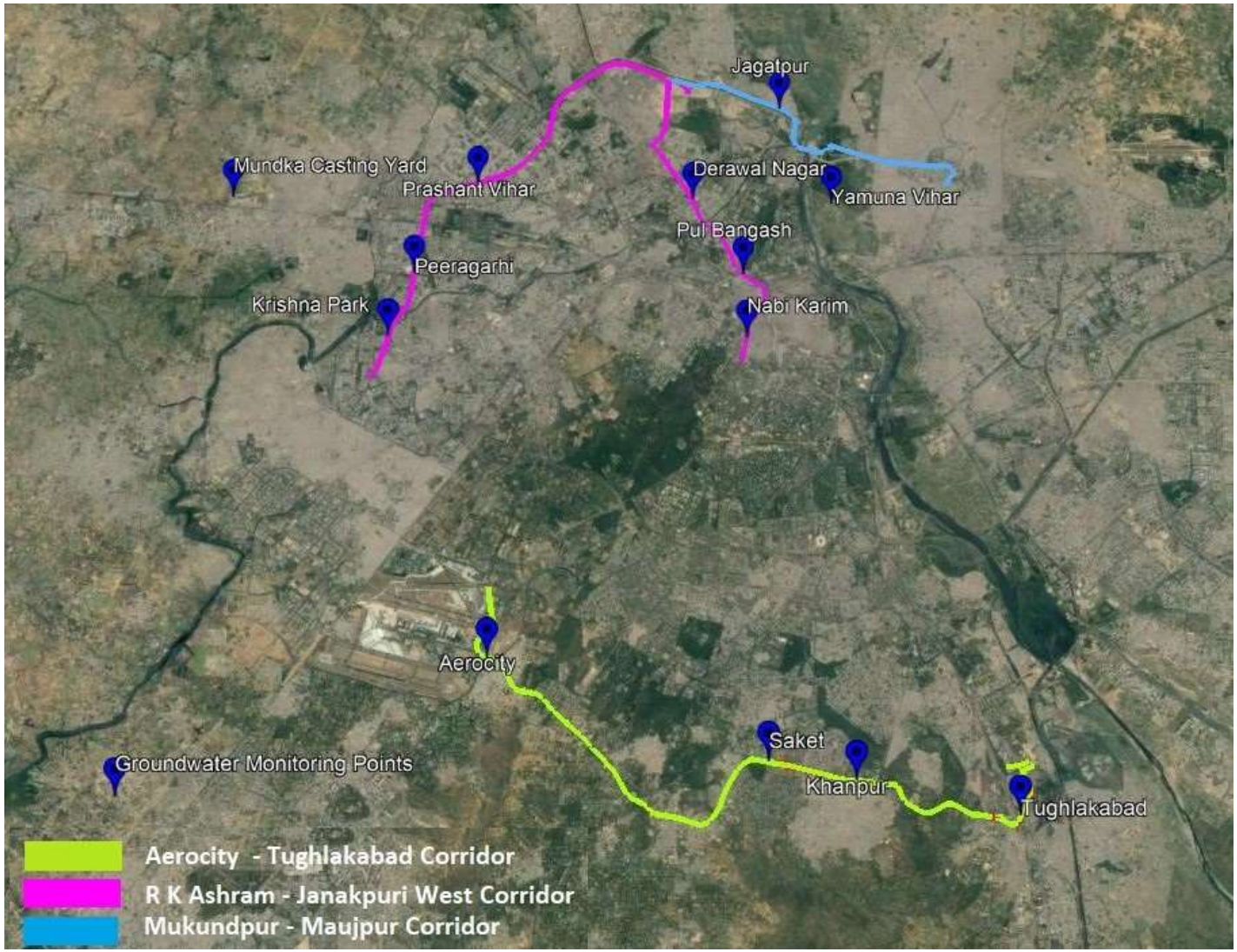


Figure 3.5: Water Sample Location Map



3.4 METEOROLOGY AND AIR ENVIRONMENT

Meteorology is an important parameter in an environmental impact assessment exercise. All air pollutants emitted by point and non-point sources are transported, dispersed or concentrated by meteorological and topographical conditions. The main parameters are: temperature, humidity, rainfall, winds and cloud cover. The meteorology and air environment of the area are discussed in subsequent sections.

3.4.1 Meteorology

Delhi has an extreme climate, which is very cold in winter and hot in summer. The climatic conditions in project area are characterized by a rainy season (July-October), winter (November-March) and Summer (April-June). Delhi has a monsoon climate with an average yearly rainfall of 611.8 mm of which 81% is received during rainy season. The relative humidity at Delhi varies almost throughout the year but seldom drops below 30%. Records of monthly rainfall, relative humidity of Delhi obtained from Indian Meteorological Department, for year 2012 are given in **Table 3.8 to Table 3.10**. Records of mean maximum and mean minimum temperatures for year 2012 are given in **Table 3.11** and **Table 3.12** respectively. Windrose diagrams for year 2012 are given in **Figure 3.6.** As seen from windrose diagrams for year 2012, predominant wind direction is westerlies.

Table 3.8: Monthly Rainfall (mm), 2012

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0	0	0	0	0	0	0	15.6	0	0	0	0
2	0.6	0	0	0	0	0	0	8.9	0	0	0	0
3	0	0	0	0	0	0.2	0	0.1	2.5	0	0	0
4	0	0	0	0	0	0	0	0	0.6	0	0	0
5	0	0	0	0	0	0	0	0	2.8	0	0	0
6	0.7	0	0	0	0	12	0	0.8	0	0	0	0
7	7.9	0	0	0	0	0.8	40.1	0.1	0	0	0	0
8	0	1.6	0	0	0	0	0.3	5	2.6	0	0	0
9	0	0	0	0	0	0	0	10.7	0	0	0	0
10	0	0	0	0.4	0	0	5.3	0.2	0	0	0	0
11	0	0	0	5.6	0	0	6.4	0	0	0	0	0
12	0	0	0	0.4	0	0	0.2	17.8	0	0	0	0
13	0	0	6.2	0	1.4	0	4.1	0	9.3	0	0	2
14	0	0	0	0	0	0	15.6	15.1	0	0	0	0
15	0	0	0	6.6	0	0	0.1	3	10.8	0	0	0.1
16	4.2	0	0	0	0	0	1	0	24	0	0	0
17	0.5	0	0	0.7	1.7	0	0	0	0	0	0	0.2
18	0	0	0	0	0	2.1	0	0	2.2	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	2.3	0	0	0	0
21	0	0	0	0	0.1	0	0	54.5	0	0	0	0
22	0	0	0	0	0	0	0	28.4	0	0	0	0
23	0	0	0	1.4	0	0	0	25.4	0	0	0	0
24	0	0	0	0	0	0	0.1	9.6	0	8.1	0	0
25	0	0	0	0.4	0	0	0	13.7	0	0	0	0
26	0	0	0	0	0	0	0	24.6	0	0	0	0

27	0	0	0	2.8	0	0	0.1	26	0	0	0	0
28	0	0	0	0	0	0.4	12	43.1	0	0	0	0
29	0	0	0	0	0	0	0	59.5	0	0	0	0
30	0		0	0	0	0	0	14.4	0	0	1.1	0
31	0		0		0		9.5	0		0		0

Table 3.9: Relative Humidity at 8:30 Hrs (%), 2012

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	88	79	88	60	40	31	33	95	81	67	92	83
2	95	69	78	49	49	41	66	78	84	66	88	76
3	97	75	67	50	35	45	59	63	86	75	75	82
4	97	90	75	53	45	42	64	79	83	62	78	82
5	97	88	63	54	36	39	64	84	78	65	86	69
6	98	93	85	44	49	45	69	74	76	62	77	66
7	95	78	71	58	51	46	97	83	81	64	85	60
8	86	65	68	49	43	45	74	83	93	61	85	52
9	94	60	76	54	42	44	77	83	82	63	79	85
10	94	64	67	59	34	31	74	89	77	72	86	88
11	85	69	78	68	45	42	92	80	84	75	90	89
12	88	76	69	61	52	44	83	82	81	62	92	92
13	76	70	75	54	49	42	77	79	85	84	96	95
14	69	89	78	61	38	29	75	89	85	64	77	87
15	90	42	61	81	43	40	72	85	89	56	86	80
16	82	68	67	55	34	43	65	80	80	68	84	93
17	97	67	71	67	45	41	65	82	39	71	90	84
18	100	81	81	61	40	74	55	77	81	75	72	75
19	97	50	72	54	39	58	50	72	89	71	86	66
20	100	65	75	49	38	36	55	79	86	83	72	64
21	89	88	46	50	34	41	76	100	83	82	70	73
22	76	91	39	43	43	44	69	86	81	81	67	84
23	86	78	43	46	33	41	70	97	77	75	76	97
24	77	68	47	45	24	42	75	93	66	81	86	100
25	73	55	62	53	21	42	77	92	63	77	90	97
26	72	54	62	56	28	42	85	92	62	84	70	89
27	87	56	63	64	34	44	73	94	78	75	58	87
28	88	66	62	46	26	47	81	90	76	80	66	91
29	81	80	55	44	23	37	80	98	76	77	88	90
30	76		49	50	20	37	81	97	75	92	95	97
31	88		58		24		95	97		90		94

Table 3.10: Relative Humidity at 17:30 (%), 2012

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	86	34	35	32	25	22	22	83	64	49	68	54
2	82	28	30	32	20	32	37	64	75	43	74	57
3	58	34	33	36	18	44	65	55	63	44	68	50
4	71	51	45	23	26	26	56	68	72	30	70	53
5	78	39	38	15	21	56	46	62	60	25	66	49
6	85	43	42	36	32	32	53	61	60	28	78	37

7	85	67	34	34	21	35	75	75	68	36	49	47
8	76	28	56	21	22	30	60	94	69	32	48	56
9	50	37	27	19	18	23	64	79	65	33	54	54
10	48	28	32	68	28	23	59	68	61	40	47	58
11	50	36	21	54	41	22	64	86	70	41	64	83
12	50	39	36	31	53	26	88	62	77	42	60	68
13	49	51	43	43	27	20	71	95	71	38	62	59
14	52	42	34	60	27	15	60	76	81	38	59	65
15	59	36	30	35	16	19	51	68	75	42	67	66
16	82	35	36	24	13	23	44	65	71	44	60	72
17	79	45	30	33	23	20	40	59	77	96	61	50
18	67	27	40	36	17	57	40	53	79	40	59	39
19	64	35	44	28	16	27	33	72	65	46	52	39
20	73	38	38	30	22	19	66	94	65	51	38	48
21	52	41	26	28	14	21	57	88	53	45	55	49
22	62	38	29	31	18	27	54	92	45	44	52	55
23	51	44	27	22	11	27	68	77	47	82	54	82
24	50	39	24	30	10	28	52	95	44	53	57	69
25	54	28	20	26	19	34	63	92	54	42	48	77
26	59	38	29	41	25	27	67	89	45	51	50	76
27	58	29	28	29	15	38	87	83	51	52	51	76
28	55	40	32	17	15	23	62	97	41	57	50	65
29	38	34	21	21	12	28	76	81	49	56	59	61
30	31		23	36	15	21	75	84	41	58	74	66
31	35		33		19		86	63		48		76

Table 3.11: Maximum Temperature (^{O}C), 2012

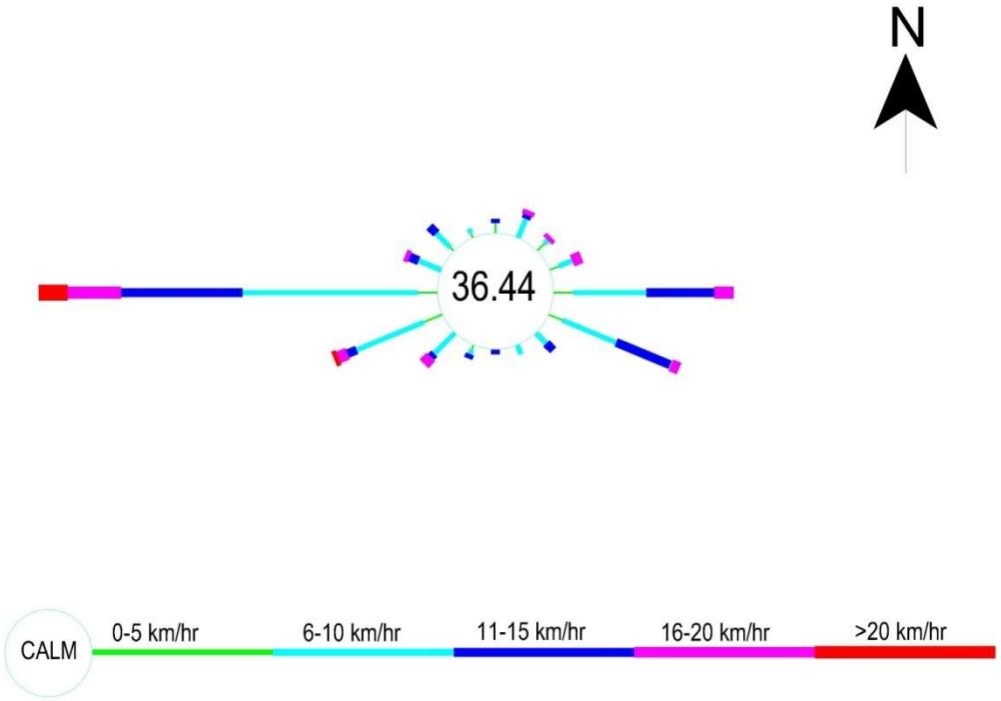
DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	23.3	21.6	26.7	36.5	36.9	45.4	42.4	27.9	34.5	35.1	28.7	21.6
2	19.5	22.1	29.4	37.6	36	44.4	43.5	29.4	35.3	34.6	28.8	23.1
3	19.7	22.8	29.5	38.3	37.7	44.2	41.8	36.9	34.9	34.6	27.2	24.5
4	20.6	23.6	29.2	38.7	37.6	42.4	40.7	36.6	34.4	35.4	27.8	23.8
5	21.8	24	32.7	37.6	38.7	41.9	41.2	34.3	32.6	36.3	26.5	24
6	19.3	23.8	33	37.4	39.6	40.8	41.1	35.5	34.9	36.1	28.9	24.7
7	16.9	22	29.1	37	39.6	38.7	38.4	34.6	33.8	35.9	26.9	26.1
8	17.7	20.5	29	37.5	39.8	38.2	30.3	32.9	32.6	34.1	29.3	25.9
9	18	19.3	27.7	36.6	40.6	39.3	33.9	34.6	33.6	33.6	28.1	26.8
10	17.6	19	25	38.5	40.8	40.6	33.9	31.7	35.5	33.7	30.3	28.1
11	17.9	20.6	26.2	37.8	42.6	41.8	36.2	34.1	36.9	33.7	30.9	27.7
12	18.5	21.8	27.6	30.3	39.2	41.4	33.9	35.1	35.1	33.1	30.7	18.7
13	18.7	26.1	30.2	35.5	40.3	42.3	32.8	35.2	34	34.7	30.3	23.8
14	19.8	24.8	27.2	29.7	37.6	43.2	36.2	33.2	35.8	35.3	26.6	25.6
15	22.6	23.6	25.8	29.6	34.8	42.7	33	32.6	32.6	35.5	27.5	22.8
16	25.6	21.7	27.8	31.3	39.8	43.5	37	33.7	34	34.7	26.8	24.7
17	20.3	21.2	31	35.6	42.2	43.2	37.8	33.1	32.4	31.8	26.8	23.5
18	14	22.3	34.6	34.1	38.2	43.6	38.4	35.6	31.5	32.2	26.7	22.8
19	15.5	23.7	35.6	33.6	41	37.2	40.3	35.7	31.3	32	28.4	24.9

20	17.7	24.6	37	36.7	40.8	41.5	40.5	34.5	33.1	32.6	27.7	22.7
21	14.6	25.5	34.5	37.5	41.4	43.3	36.7	33.3	32.9	31	27.1	21.6
22	18.4	29.3	26.3	34.8	42.3	43	36.6	29.4	33.5	30.9	26.4	22.8
23	18	30.1	27.4	35.6	42.2	43	37.5	32.6	35.5	31.3	25.6	21.7
24	22.7	28	30.7	36	42.2	42.4	37.2	31.1	35.1	31.8	26.6	18.7
25	21.6	26.6	32.8	37.6	43.1	42.1	38.6	30.7	34.4	27.8	27	19.1
26	21.1	23.4	33.4	35.6	44	42.3	35	29	34.4	27.7	25.8	16.2
27	21.1	23.8	36.2	34.6	42.7	40.6	33.2	32.9	34.6	29.5	24.9	18.3
28	21	25	34.5	34.7	41.6	40.2	35.3	34.5	33.9	29.7	25.5	16.6
29	21.7	26.4	33.6	36.8	42.2	41.6	35.4	31.9	34.7	29.6	26	10.6
30	20.9		32.8	37.1	43.5	42	31.8	31.2	34.8	28.8	28.4	21.4
31	22.2		34.6		45		32	30.8		29.3		17

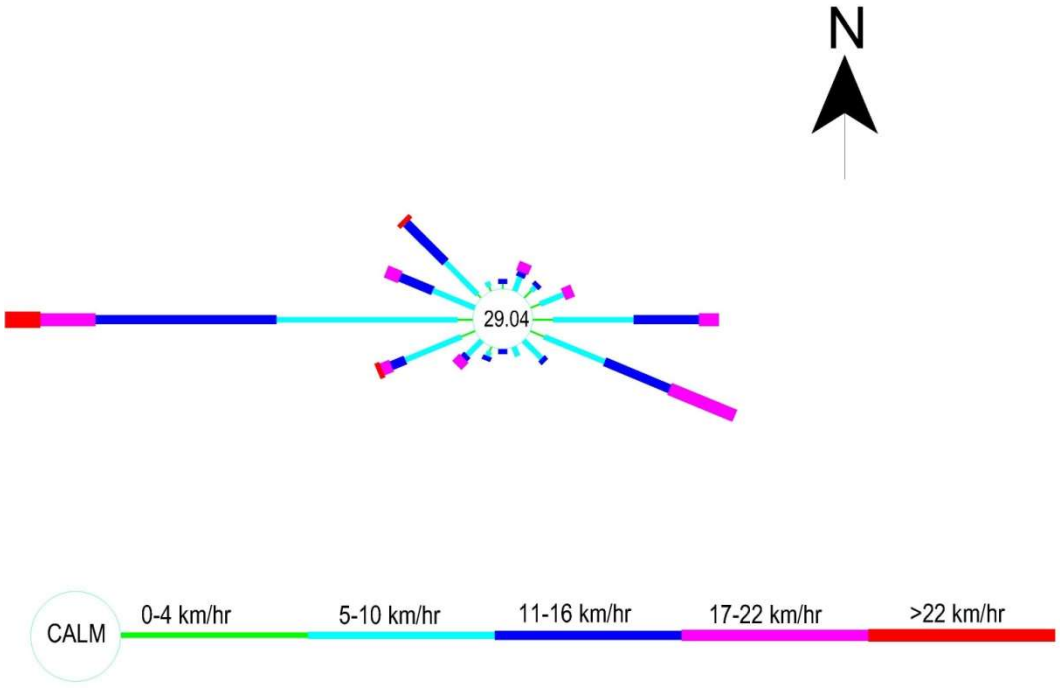
Table 3.12: Minimum Temperature (^{O}C)

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	11.3	6.7	10.6	21	21	34.3	31.4	26.6	26.8	21.3	15.3	10.1
2	11.6	8.4	12.2	22.3	20.5	33.2	32.3	26.3	28	22.5	15.9	7.8
3	7	9.8	12.4	24	21.4	29.7	32.6	28.8	25.6	24.4	15.3	6.8
4	8	10.1	14.5	21.9	21.6	29	29.2	27.5	26	20.9	15.6	6.5
5	11.2	11.7	17.5	22.2	24.4	29.5	29.5	27.5	26.4	20.8	15.2	9
6	12.4	10.6	18.6	22.4	25.4	26	29.1	28.6	26.5	19.7	13.8	7.5
7	12.5	7.6	13.1	22	24.6	26.9	23.2	27.1	26	20.4	14	10.2
8	11.9	8.5	12.7	22.1	27.2	27	26.4	27.2	24.8	19.6	14.3	9.3
9	8.4	4	11.8	23.1	28.4	29.1	28	26.1	26.2	19.7	12.8	9
10	4.5	6.4	9.7	22.3	27.4	29.5	28.4	26.6	27.4	19.5	13.9	9.4
11	4.6	6.6	9.6	21.1	26.6	30	27.2	27.8	27.8	19.7	14	11.5
12	5.3	9.2	11	19.6	25.2	28.6	28.2	25.4	27.3	19.3	14.1	7
13	5.5	11.2	14.8	23.3	22	30.4	27.4	26.8	27.2	19.7	13.4	12.5
14	6.7	11.7	13.1	21.3	26.4	31.8	25.7	25.9	27.3	19.5	13	14
15	9.5	11.3	14	19	26.4	31.5	28	26.7	24.8	20	12.8	12.8
16	10.5	7.1	14.2	18.3	25.6	32.4	27.5	25.5	24.8	19.3	12	14.1
17	9.3	6.6	15.3	19.7	27.3	32.7	29.5	26.5	26.5	19.3	10.9	11.2
18	5.6	8.7	17.3	22.6	27.5	28.2	29.2	28	24.8	19.2	10.8	10.5
19	4.8	9.6	19.4	21.7	29	28.4	32.2	29.8	24.8	17.5	12.3	11.3
20	4.5	11.4	19.4	24.8	25.4	29.7	32.2	27.4	24.6	17.8	10.8	9.5
21	5.4	11.1	13.5	23.6	27.7	33.6	28.6	24.8	23.9	18.2	9.6	7.6
22	6.6	13.5	15.1	23.4	27.2	32.4	28.5	25.2	22.6	16.7	9.6	6.2
23	5.6	13.5	14.9	19.7	26.3	31.4	29.8	25.3	22.7	17.4	8.6	5.9
24	7.5	11.6	17.7	21.5	27.3	33.3	29.3	25.5	23.2	16.4	9.5	7.7
25	9	10.5	17.3	21.4	27.8	31.2	27.9	25.5	23.4	14.9	10.3	7
26	9.3	9.7	18.2	22.6	32.5	33.3	27.7	25	23.6	13.9	10.5	7.8
27	7.6	10.3	19.2	19.8	34.2	31	28.7	26	23.3	14.2	9.4	9.2
28	5.1	12.5	17.8	21.3	26.2	30.4	27.8	25.3	22.8	13.9	8.5	6.3
29	5.3	11.9	19.2	20.7	26.8	31.6	27.9	23.6	22.4	14.6	9.3	9.8
30	7.3		17.6	20.9	28.2	31.5	28	24.2	22.4	15.6	10.9	7.7
31	4.4		18.6		31.2		25.4	24.6		17.2		5.3

Figure 3.6: Windrose Diagram



8:30 Hrs



17:30 Hrs

3.4.2 Air Quality

Delhi in terms of air pollution is ranked among the most polluted cities in the world. The ambient air quality monitoring is carried out regularly by Central Pollution Control Board and Delhi Pollution Control Committee. The annual average levels of suspended particulate matter increased to 450 µg/m^3 during 1996 and the annual average levels of CO also increased to 5587 µg/m^3 during that period as against the National Ambient Air Quality Standard of 200 µg/m^3 for SMP and 2000 µg/m^3 for CO for the residential areas notified by the Ministry of Environment, Govt. of India during that period. In fact, 1996 is considered the peak year in terms of air pollution load. The transport, industrial and the domestic sectors were the major contributors towards the rising ambient air pollution levels, in addition to the presence of natural dust due to meteorological conditions.[8] In order to establish the baseline concentrations of air pollutants, air quality monitoring was carried out near to the corridors by setting up ambient air quality monitoring stations. The air monitoring has been carried out at 12 strategic locations along the corridors. The locations chosen near to habited area or near to sensitive receptors. Air Monitoring was carried out for the following parameters $PM_{2.5}$, PM_{10}, NOx, SO_2, CO, O_3, NH_3, Pb and Ozone. The ambient air monitoring were carried out at 13 locations in the month of June 2020 and analyzed in NABL accredited laboratory. The monitoring locations details are given in **Table 3.13** and results of the air quality monitoring are presented in **Table 3.14.** All the parameters except No2, So2 and CO are more than the permissible limits specified by CPCB.

Table 3.13: Ambient Air and Noise Monitoring Locations

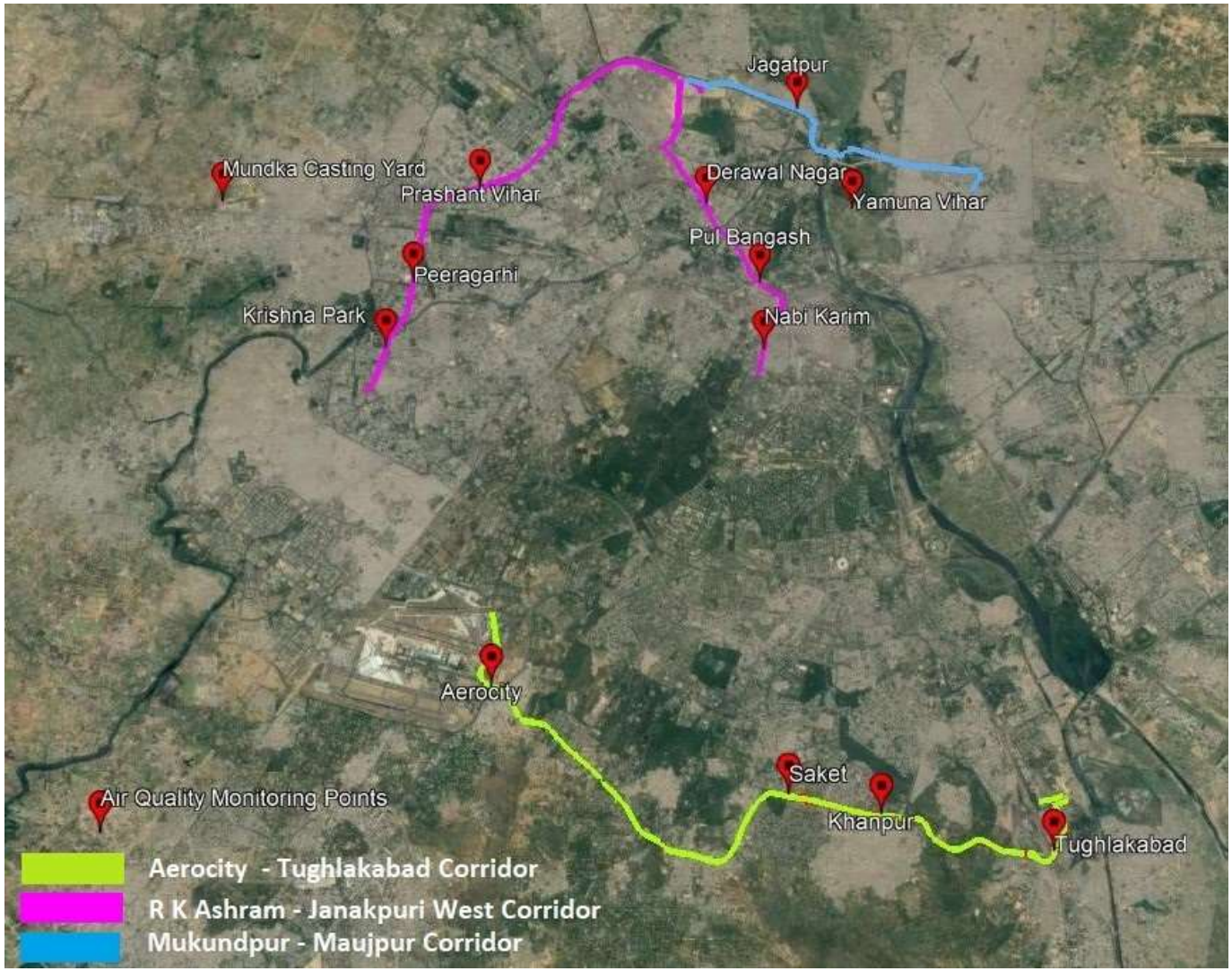
Sampling Location Number	Location Name	Corridor
1	Krishna park	R K Ashram – Janakpuri West
2	Peeragarhi	
3	Prashant vihar	
4	Nabi Karim	
5	Derawal nagar	
6	Pulbhangesh	
7	Yamuna vihar casting yard	Mukundpur – Maujpur
8	Jagatpur	
9	Aerocity	Aerocity – Tughlakabad
10	Saket	
11	Khanpur	
12	Tughalakabad	
13	Mundka	Casting yard

8 Towards Cleaner Air, A case Study of Delhi, Published by Department of Environment, Government of NCT of Delhi

Table 3.14: Ambient Air Quality along the Corridors

Name Of Location	Corridor	PM10 (24Hr)	PM2.5 (24Hr)	So2 (24Hr)	No2 (24Hr)	CO (8HR)	pb (24Hr)	Ozone (8hr)	Ammonia (24Hour)
Krishna park	R K Ashram – Janakpuri West	256	189	43.6	61.3	1.31	BDL	126	17.3
Peeragarhi		278	169	41.5	68.2	1.39	BDL	144	20.9
Prashant vihar		284	179	38.6	66.3	1.27	BDL	137	19.3
Nabi Karim		305	234	45.2	54.3	1.66	BDL	146	23.1
Derawal nagar		198	109	36.1	60.8	1.37	BDL	132	17.2
Pulbhangesh		317	219	52.8	67.1	1.79	BDL	136	22.7
Yamuna vihar casting yard	Mukundpur – Maujpur	242	126	34.6	59.7	1.32	BDL	127	21.3
Jagatpur		306	211	50.8	73.2	1.56	BDL	151	26.9
Aerocity	Aerocity – Tughlakabad	267	157	37.2	57.1	1.46	BDL	129	12.6
Saket		273	149	29.1	49.8	1.28	BDL	134	19.5
Khanpur		295	184	46.4	63.4	1.69	BDL	119	18.2
Tughalakabad		318	207	51.3	76.1	1.84	BDL	127	21.6
Mundka	Casting yard	269	134	39.2	52.8	1.34	BDL	141	23.4

Figure 3.7: Ambient Air Quality and Noise Monitoring Location Map



Note: Air and Noise monitored at same locations

3.5 NOISE ENVIRONMENT

Noise is responsible for adverse impact on physical and mental health of the people. The other impacts are:

- Physiological effects,
- Hearing impairment,
- Communication interference, and
- Sleep disruption

The assessment of impacts of noise sources on surrounding community depends on:

- Characteristics of noise sources (instantaneous, intermittent or continuous in nature).
- Time of day at which noise occurs, for example high noise levels at night in residential areas are not acceptable because of sleep disturbance.
- Location of noise source, with respect to noise sensitive land use, which determines the loudness and period of exposure.

A noise level survey was conducted along the alignments with an objective to establish the baseline noise levels and assess the impacts of total noise expected due to the proposed metro. Noise level monitoring has been carried out at 13 locations along the corridors in the month of February 2020. The monitoring location map is shown in Figure 3.6. The noise levels so obtained are summarized in **Table 3.15**. It could be concluded that the day time and night time noise levels recorded at various places are higher than prescribed permissible levels of 55-dBA (day) and 45-dBA (night) respectively for residential areas.

Table 3.15: Noise Levels

S. No.	Location	Results in dBA								
		Leq	L10	L50	L90	Lmax	Lmin	Lday	Lnight	Ldn
1.	Krishna Park	60.6	67.1	59.2	54.8	81.6	52.1	62.1	53.5	62.7
2.	Aerocity	61.4	70.4	60.4	56.1	77.2	53.2	63.4	55.2	64.2
3.	Saket	58.6	54.5	53.1	55.4	81.2	50.1	60.2	53.5	61.7
4.	Khanpur	59.2	65.8	61.5	59.9	78.4	52.5	63.4	51.9	62.9
5.	Tughalakabad	63.7	70.9	63.4	60.8	79.4	57.5	66.3	61.2	68.8
6.	Mundka Casting Yard		56.9	52.3	45.6	91.7	36.2	61.26	53.47	
7.	Peeragarhi	59.8	56.3	59.4	61.4	77.4	54.6	62.4	51.3	56.9
8.	Prashant Vihar	61.4	64.2	62.3	59.7	74.6	57.3	64.3	52.8	58.6
9.	Jagatpur	NA	69.6	57.1	42.3	95.8	35.9	64.25	53.21	NA
10.	Yamuna Vihar Casting Yard	NA	66.5	55.6	42.6	93.6	36.9	62.49	51.92	NA
11.	Derawal Nagar	61.3	63.8	60.4	57.6	76.9	55.6	64.9	52.6	58.8
12.	Pulbangesh	NA	68.4	48.5	38.2	87.1	36	59.4	51.96	NA
13.	Nabi Karim	NA	68.9	52	44.6	92.1	34.7	62.18	51.76	NA

3.6 ECOLOGY

An ecological study of the project area is essential to understand the impact due to project development activities on flora and fauna of the area. The project site is located in city area and it is free of any wildlife fauna. On site construction activities about 11,121 trees will be felled. The predominant tree species are Pipal, Neem, Kikar, Eucalyptus, Ashok, Ficus and Bakaan, etc. An inventory of trees likely to be lost has been prepared and summarized in **Table 3.16**.

Table 3.16: Inventory of Trees

Sl. No.	Corridor	Trees Affected
1.	R K Ashram to Derawal Nagar	3,829
2.	Aerocity–Tughlakabad	5,302
3.	Maujpur–Mukundpur	1,990
		11,121

3.6.1 Forests/Flora

Forests/trees play an important role in maintaining the eco-system balance. The project layout was superimposed on land-use maps to assess the number of trees in the project area. Delhi state seems overwhelmingly green. However, the green cover is not uniformly distributed, as some areas have considerably more green patches than the others. The districts of New Delhi and South Delhi are much greener compared to other districts. As per the India State of Forest Report (SFR)-2009, the total Forest and Tree Cover of NCT of Delhi is 299.58 sq. km. (20.20%) as against 283sq. km. (19.09%) reported in SFR-2005. This is made up of 123 sq. kms. of tree cover and 176.58 sq. kms. of forest cover making a total of 299.58 sq. kms. Thus there is an increase of Green Cover of Delhi from 19.09% to 20.20% which works out to 1.11% of the geographic area. The district wise forest cover of Delhi is given is **Table 3.17**.

Table 3.17: District Wise Forest Cover Of Delhi

District	Geographical Area	Forest Area in Sq km	Percentage of Forest Cover
Central Delhi	25	5.05	20.20
East Delhi	64	6.05	4.67
New Delhi	35	16.31	46.60
North Delhi	59	4.81	8.15
North East Delhi	60	3.59	5.89
North West Delhi	440	16.41	3.73
South Delhi	250	78.64	31.46
South West Delhi	421	42.45	10.08
West Delhi	129	6.33	4.91
Total	**1489.00**	**176.58**	**11.91**

Source: http://delhi.gov.in/wps/wcm/connect/doit_forest/Forest/Home/Forests+of+Delhi/

3.6.2 Fauna

Over 80 years ago Delhi was the haunt of a large variety of animals. Foxes and hare were present. Blackbuck was common in the plains while the Chinkara was found on the Ridge and in the hilly range North-east of Delhi. Wolves roamed such inhabited places as the Cantonments and were occasionally shot by the British Soldiers. Leopards too were not uncommon, especially in Tughlakabad. Bluebull or Nilgai was easily sighted. Peafowl, duck, snipe were plentiful, so were the black and gray partridge. There were deer, wild boar, blue bull, panther and a wide variety of bird life on huge trees. Hare were plentiful and so were hyenas, jackals and porcupines. Mahasir, Rohu and Betchwa were among the varieties of fish that were plentiful. Unpolluted river was infested with crocodiles.

But such wildlife in Delhi has vanished because of indiscriminate shooting after partition in 1947 and the ever-increasing human activities. The domestic animals in the project area consist of cows, bullock, sheep, goat, cat and dogs. No wildlife sanctuary/park is located within the 7km radius of project area. No rare or endangered species have been reported in the project area. No wildlife has been observed within the project area or its surroundings.

4. NEGATIVE ENVIRONMENTAL IMPACTS

4.1 GENERAL

The primary function of an environmental impact assessment study is to predict and quantify the magnitude of impacts, evaluate and assess the importance of the identified changes and formulate plans to monitor and mitigate the actual changes. Environmental impacts could be positive or negative, direct or indirect, local, regional or global, reversible or irreversible.

With rapid strides in economic development, particularly in urban development, the need for rationalizing and upgrading the transport system is imperative. In the process of development, there has been intensive use of natural resources. Very often the process of development has adversely affected the environment leading to ecological imbalances. The importance of conserving and enhancing the environmental assets has assumed urgency. Apart from land-use, conservation of water, flora and fauna, transportation planning is an important aspect of economic development.

The main aim of the project is to decongest the road traffic. The project is designed keeping in view population growth, future traffic demands and environmental protection aspects. Moreover any connection from/to Phase- I, Phase- II and Phase III Metro-Stations will help in direct interchange. This will not only reduce vehicles on road and vehicular pollution but also the pedestrians. The reduction of air pollution in Delhi is reported in Chapter 5.

The process began by identifying the development and operational activities resulting from the proposed project as contained in **Chapter-2**. **Chapter-3** was dedicated for providing information on the baseline environmental conditions for various parameters. This chapter discusses the potential impacts on environment. As far as possible, attempts have been made to quantitatively predict the impacts due to proposed project. For non-quantitative impacts, qualitative assessment has been made.

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

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

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

4.2 ENVIRONMENTAL IMPACTS

This section identifies and appraises the negative impacts on various aspects of the environment likely to result from the proposed development. It is pertinent to mention that the negative environmental impacts listed below are based on the assumption that no negative impact mitigation measure or benefit enhancements are adopted.

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

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

4.2.1 Impacts due to Project Location

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

- Project Affected People (PAPs)
- Change of Land use;
- Loss of trees/forest;
- Utility/Drainage Problems

A. Project Affected People (PAPs)

About 54 families consisting 250 persons will be affected due to the proposed metro project. Majority of families will be affected in Aero City to Tuglakabad corridor. Rehabilitation and Resettlement (R&R) of displaced families is an important issue addressed in Revised SIA Report. The main point to be addressed is the extent to which the “land for land” policy can be maintained for those who have their own land/house and suitable compensation to those who fall in the category of unauthorized occupants.

B. Change of Land Use

Under the present study, project layout maps were superimposed on land use maps to find out the change in land use. The project shall require the acquisition/transfer of 91.6032 ha of land. Out of the total land, 90.7573 ha is government land and 0.8459 ha is private land. Out of the total government land, 18.80 ha is for permanent use and 71.9573 ha is identified for temporary use. The land identified for temporary use shall be returned to the owning agencies, after the completion of the project construction. Out of the total private land, 0.3207 ha is for permanent use and 0.5252 ha is identified for temporary use. It is observed that out of the total land requirement, about 99.08 per cent of total land would be acquired from government agencies and only 0.92 per cent of the land requirements shall be fulfilled by the private landowners. The details of land requirement and acquisition are presented in **Table 4.1**.

Table 4.1: Land Requirement and Acquisition

Corridor	Land Requirement (Ha)					
	Government		Private		Total	
	P	T	P	T	P	T
Aerocity - Tughlakabad	7.17	38.66	0.2407	0.4825	7.4107	39.1425
Janakpuri West – R K Ashram	11.01	26.12	0.08	0	11.09	26.12
Mukundpur - Maujpur	0.62	7.1773	0.0	0.0427	0.62	7.22
Total	**18.8**	**71.9573**	**0.3207**	**0.5252**	**19.1207**	**72.4825**

C. Loss of Forests/Trees

The proposed corridors are in urban/city area and will not pass through any forests. However Depot for Aerocity-Tuglakabd corridor is located in Rangpuri Pahari area which falls in southern ridge. There are approximately 11,121 trees along the 3 priority corridors. These trees are likely to be cut during construction. Trees are major assets in purifications of urban air, which by utilizing CO_2 from atmosphere, release oxygen into the air. However, with removal of these trees, the process for CO_2 conversion will get effected and the losses are reported below:

i) Total number of Trees : 11,121
ii) Decrease in CO2 absorption due to loss of trees : 2,42,438 kg/year
iii) Decrease in Oxygen production due to tree loss : 5,44,929 kg/year

The above loss of oxygen production is equivalent to loss of oxygen requirement of about 1,899 people round the year. Trees help carbon sequestration acting a carbon sink. By removing the carbon and storing it as cellulose, trees release oxygen back into the air.

D. Utility/Drainage Problems

The proposed Metro corridors are planned to run through the urban area above the ground i.e. elevated in less densely populated and underground in populated and sensitive areas. The alignment will cross drains, large number of sub-surface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, traffic signals etc. These utilities/ services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position. Since these affect construction and project implementation time schedule/costs for which necessary planning/ action needs to be initiated in advance.

4.2.2 Impacts due to Project Design

Considered impacts, due to project designs are:

- Stations Planning,
- Ventilation and lighting,
- Railway station refuse, and
- Seismological factors.

A. Stations Planning

The stations of Phase IV have been planned on the basis of the norms and criteria already adopted in existing corridors. The Elevated station is generally located on the road median. Total length of the station is 140m. All the stations are two-level stations. The concourse is planned along the whole length of the platform with staircases leading from either side of the road. The maximum width of the station at concourse is ~21m. Passenger facilities like ticketing, information, etc as well as operational areas are provided at the concourse level. In elevated stations, 4.5m wide side platforms have been proposed. These platform widths also have been checked for holding capacity of the platform for worst-case scenario. Since the station is in the middle of the road, minimum vertical clearance of 5.5-m has been provided under the concourse. Platforms are at a level of about 14.5-m from the road.

The typical underground station is a two-level station with platforms at the lower level and concourse on the upper level. Structure of the underground station is essentially a concrete box about 22-m wide, 14.6-m high and 240 to 260 m long with an intermediate slab. Sides of the box are made of 1.2 m thick RCC. A uniform platform width of 13m wide is proposed for the underground stations.

Provision has been made for escalators in the paid area i.e. from concourse to platforms. On each platform, one escalator has been proposed. In addition, two staircases with a combined width of 6 m are provided on each platform connecting to the concourse. These stairs and escalator together provide an escape capacity adequate to evacuate maximum accumulated passengers in emergency from platforms to concourse in 5.5 minutes. Lifts have been provided one each on either platform, to provide access for elderly and disabled. Since the rise to road from the concourse is about 8m, it is proposed to provide escalators and lifts in addition to stairs for vertical movement of passengers from street to concourse on either side of the road.

Fire fighting provisions in Underground Metro Stations are in Accordance with the NFPA 130 Guidelines and for Elevated metro stations in accordance with the National Building Code of India 1983 (part IV, Fire protection) amendment no. 3 under Fire protection Annexure II.

B. Ventilation and Lighting

The platform and concourse areas will be air-conditioned using supply 'Air Handling Units' located in Environmental Control System (ECS) plant rooms throughout the station. Each Platform and Concourse will be served by at least two air handling units (AHU's) with the distribution systems combined along to ensure coverage of all

areas in the event of single equipment failure. Based on the initial estimation about 4 units of 30 m3/s each would be needed for the full system capacity.

Ancillary spaces such as Staff Room, Equipment Room, will be mechanically ventilated or air conditioned in accordance with the desired air change rates and temperatures/humidity. All ancillary areas that require 24-hour air conditioning will be provided with Fan Coil Units (FCUs) main Chilled Water plant for running during the revenue hours and with Air Cooled Chillers or standby AC units or VRV system for running during the non-revenue hours. Return air will be circulated through washable air filters

The platforms, concourse, staircase and escalator areas both for underground and elevated

stations will have adequate and uniform fluorescent lighting to provide pleasant and cheerful environment. It is proposed to adopt the norms prevailing in Delhi Metro Phase I, II and for illumination as reported in **Table 4.3**.

Table 4.2: Illumination at Different Locations

LOCATION/PREMISES	ILLUMINATION (LUX)
Entrance to stations from the road	250
Booking/Concourse	200
Platforms	150
Passenger staircase and escalator areas	250
Toilets	100
Offices	200
Tunnels	100
Sub-ways	250
Emergency lighting of stations, platforms, passages, escalators & public utilities.	50

C. Railway Station Refuse

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

- Garbage,
- Rubbish, and
- Floor Sweepings.

As per the available data from Delhi Metro Phase I and II, about 28 cum of solid waste will be generated from underground stations and 38.25 cum from elevated/at-grade stations from all 3 priority corridors of Phase IV metro stations. Thus a total of 66.25 cum of solid waste per day is estimated to be generated from all metro stations. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of the DMRC project authorities. The storage containers for this purpose need to be designed. However it is suggested that the capacity of these containers should not exceed 50 litres and these should be equipped with side handles to facilitate handling. To avoid odour and the accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals.

D. Risk Due to Earthquake

The project area lies in Zone IV of Bureau of Indian Standards (BIS) Seismic Zoning Map. Earthquakes of 3 to 9 magnitude on Richter scale have occurred in the past in the zone. Provision of Bureau of Indian Standards codes like IS: 1893:1984, IS: 1893 (Part 1) 2002, IS : 1893 (Part 4) 2005, IS : 4326:1993 etc. shall be incorporated suitably while designing the structures It is understood that such measures have already been taken in construction of earlier phases.

4.2.3 Impact due to Project Construction

Although environmental hazards related to construction works are mostly of temporary nature, it does not mean that these should not be considered. Appropriate measures should be included in the work plan and budgeted for. The most likely negative impacts related to the construction works are: -

- Soil erosion, pollution and health risk at construction site,
- Traffic diversion and risk of existing building,
- Excavated soil disposal problems,
- Dust Generation
- Increased water demand
- Impact due to Supply of Construction Material
- Impact due to Construction near Archaeological Structures
- Noise Pollution
- Impact due to Vibration

A. Soil Erosion, Pollution and Health Risk at Construction Site

Run off from unprotected excavated areas, can result in excessive soil erosion, especially when the erodability of soil is high. Mitigation measures include careful planning, timing of cut and fill operations and re-vegetation. In general, construction works are stopped during monsoon season.

Problems could arise from dumping of construction spoils (Concrete, bricks) waste materials (from contractor camps) etc. causing surface and ground water pollution. However, it is proposed to have mix concrete directly from batching plant for use at site. Batching plants will be located away from the site and from human settlement. The other construction material such as steel, bricks, etc. will be housed in a fenced stored yard. The balance material from these yards will be removed for use/disposal.

Health risks include disease hazards due to lack of sanitation facilities (water supply and human waste disposal) and insect vector disease hazards of local workers and disease hazards to the local population. Mitigation measures should include proper water supply, sanitation, drainage, health care and human waste disposal facilities. In addition to these, efforts need to be made to avoid water spills, adopt disease control measures and employment of local labour. Problems could arise due to difference in customs of workers from outside and local residents. These risks could be reduced by providing adequate facilities in worker's camps, raising awareness amongst workers and by employment of preferably local labour.

B. Traffic Diversions and Risk to Existing Buildings

During construction period, complete/partial traffic diversions on road will be required, as most of the construction activities are on the road but most of the roads are double lane. Hence, wherever possible, 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 roads, a clear passage of 8 m shall be maintained for smooth operation of traffic, emergency and local movements. Advance traffic updates/information on communication systems will be an advantage to users of affected roads. The elevated rail corridor does not pose any serious risk to existing buildings.

C. Problems of Excavated Soil Disposal and Construction & Demolition Waste

The metro route is both elevated and underground. The construction activity involves cut and cover, tunnel (bored and rock), foundation, fill and embankment. Owing to paucity of space in busy cites and for safety reasons, elaborate measures need to be adopted for collection, storage, transfer and disposal of soil. All these activities will generate about 3.4 Mm^3 of soil. Out of this, about 1.02 Mm^3 is likely to be reutilized in backfilling. The balance 2.38 Mm^3 shall be disposed off in environmental friendly manner. Disposal of excess soil should be permitted in low lying areas owned by DDA. The excess soil disposal site will be those identified by DDA and communicated to DMRC. During the project construction activities about 1,10,415 MT of the construction and demolition waste will be generated. About 10% to 20% of which will be utilized for backfilling and rest will be recycled.

D. Pollution Due to Disposal of Earth

Transportation of earth and establishment of the material will involve use of heavy machinery like compactors, rollers, water tankers, and dumpers. This activity is machinery intensive resulting in dust generation. However, this activity will be only short-term. Protective measures shall be undertaken during construction phase. It is estimated that, about 3.4 Mm^3 of earth will be transported in trucks for backfilling and final disposal. It is assumed that the earth will be hauled over a period of 1825 days. The truck movement required to transport the soil/earth will be about 187 truck trips per day for the entire length of construction period. On an average a truck is anticipated to move about 30 km per trip. Hence total distance travelled would be 5610 km per day. The total dust emission/pollution would be 7 kg/day, 1.27 kg/day of particulate matter, 28.42 kg/day of CO, 1.27 kg/day of HC, 59.03 kg/day of NOx and 3668.70 kg/day of CO_2.

E. Increased Water Demand

The water demand will increase during construction phase. Sufficient water for construction purpose is to be made available by digging tube well within the vicinity of the project site during the construction phase. Hence proper care shall be taken while deciding the location of these activities or drawing water from public facilities. Water requirement for construction of Metro will be met through the tube-wells bored specially for the purpose of metro construction after taking approval from competent authority i.e. Central Ground Water Board. Hence, there will be no negative impact on the residents living in the vicinity of tube wells whose water demand is, in any case, met by municipal water.

F. Impact due to Construction of Bridges on Yamuna River

Ground water contamination can take place only if chemical substances get leached by precipitation of water and percolate to the ground water table. This is not the case with the present project, as the activity does not use any harmful ingredients, which could leach down to water table. Therefore, no impact on ground water quality is anticipated from the project during the construction phase. Proposed project will not alter the existing water quality of River Yamuna. One major bridge of 560m long is planned on the alignment on river Yamuna for Mukundpur-Maujpur section. The bridge will be designed at a later stage. However, the studies have been

conducted by the Central Water and Power Research Station (CWPRS), Pune in April 2019 to ensure complete safety. In their studies CWPRS concluded that the alignment of proposed MRTS Bridge across river Yamuna between Wazirabad barrage and Signature Bridge is found to be hydraulically satisfactory in respect of river morphology. The construction of proposed MRTS Bridge will not cause any major change in the river regime in the reach under consideration.

The bridge may be with well foundation, substructure with mass concrete and superstructure with PSC girder. Because of such construction, no major impact on flow of water, surface and ground water quality is anticipated. Foundation of piers shall be on wells. Activities of well foundation and sinking shall be taken at intervals, so that the obstruction to the flow of water is limited. Care shall be taken that construction activities are not carried out during the monsoon period. Contamination of surface water bodies may result due to spilling of construction materials, however, the quantity of such spills will be negligible.

G. Impact due to Supply of Construction Material

Metro construction is a material intensive activity. Different quantity of construction material will be required for construction of metro corridor. A summary of approximate construction material required for the corridors is given in **Table 4.4**.

Quarry operations are independently regulated activities and outside the purview of the project proponent. It is nonetheless, appropriate to give consideration to the environmental implications in selection of quarry sources since poorly run operations create dust problems, contribute noise pollution, ignore safety of their employees, or cause the loss of natural resources.

About 10-15% of the construction material such as waste material from contractor camps is left behind by the contractor as construction waste/spoils. Dumping of construction waste/spoil in a haphazard manner may cause surface and ground water pollution near the construction sites.

Table 4.3: Construction Material Requirement

Material	Unit	Total Qty
Underground station		
Cement	MT	351571
Fly Ash	MT	127379
Sand	MT	772086
Aggregate 20mm	MT	751533
Aggregate 10mm	MT	559488
Reinforcement	MT	202833
Stone Work	sqm	294500
MS Structure	kg	744000
Stainless Steel	kg	1067950

Paint	Ltr	186000
Tiles Work	sqm	52700
Tunnel		
Cement	MT	75736
Fly Ash	MT	12252
Sand	MT	135974
Aggregate 20mm	MT	98890
Aggregate 10mm	MT	120878
Silica	MT	21587
Reinforcement	MT	21587
Elevated Station		
Concrete	cum	377544
Steel	MT	51238
Viaduct		
Concrete	cum	1124529
Steel	MT	159358
HT stand	MT	8096

Source: DPR, March 2019

H. Loss of Historical and Cultural Monuments

No historical/cultural monuments will be lost as a result of the proposed development. However some of the historical and cultural monuments are passing through regulated zone are described below. The details are given in **Table 4.4**, out of 7 ASI monuments the permission from ASI has been obtained for 5 and for 2 monuments (at Sr. No 6 & 7) is under process.

Aerocity- Tuglakabad Corridor:

(a) Tughlakabad Fort

Alignment from km 15.550 to km 17.520 passes through Tughlakabad area along Mehrauli Badarpur Road. Alignment in this area also is underground and construction is proposed by TBM.

(b) Ghiyasuddin Tomb

Ghiyas ud-Din Tughluq was the founder of Tughluq dynasty of the Delhi Sultanate in India. The tomb was constructed in 1325 and is built of red sandstone and white marble, materials commonly used in Islamic structures at that time.

(c) Nai-ka-kot

There's yet another fortress in the distance, tinier and even more ruined, also said to have been built by Muhammad bin Tughlaq. Not much more than a wall remains there, but its name is intriguing: Nai ka Kot (Barber's fort). Historians haven't been able to find out much about this place.

(d) Adilabad Fort

The fort of Adilabad was built in ad 1327–28, soon after the death of Ghiasuddin Tughlaq, by his son Muhammad bin Tughlaq, allegedly as a symbol of his own might and power. Adilabad, a fort of modest size, built on the hills to the south of Tughlaqabad was provided with protective massive ramparts on its boundary around the city of Jahanpanah. The fort was much smaller than its predecessor fort, Tughlaqabad fort, but of similar design.

Janakpuri West to Ram Krishna Ashram Marg Corridor:

(a) Tripolia Gate

The Tripolia Gates an archaeological monument are two historical gateways of similar form located at GT Karnal Road, Delhi. These are triple passage gateways situated 250 meters apart in the area between Rana Pratap Bagh and Gur Mandi in North Delhi. These structures were made by Nazir Mahaldar Khan, superintendent of women's quarter in the palace of Mughal emperor Muhammed Shah during the period 1728-29 as entrances towards a market from both ends. Out of these two gates, northern gate is restored and the southern gate is still under restoration.

(b) Roshnara Bagh

Roshanara Garden is a Mughal era garden built by Roshanara Begum, the second daughter of the Mughal emperor Shah Jahan. It is situated in Shakti Nagar near Kamla Nagar Clock Tower and North Campus of University of Delhi. Today the garden holds a white marble pavilion built in memory of the princess Roshanara, who died in 1671 and was buried there.

Mukundpur – Maujpur Corridor: This corridor is passing near Shah Alams Tomb at Wazirabad, which was built by Ferozshah Tughlaq during his reign.

Table 4.4: Details of Archaeological Structures

S.No.	Monument	Type of Corridor Near Monument	Distance from Alignment (m)	ASI Protected
Aerocity- Tuglakabad				
1.	Tughlakabad Fort	Underground	212	Yes
2.	Ghiyasuddin Tomb	Underground	168	Yes
3.	Nai-ka-kot	Underground	179	Yes
4	Adilabad Fort	Underground	135	
Janakpuri West To Ram Krishna Ashram Marg				
5.	Tripolia Gate	Underground	138	Yes
6.	Roshnara Bagh	Underground	130	Yes
Mukundpur - Maujpur				
7.	Tomb of Shah Alam	Elevated	108	Yes

The proposed metro corridors near these monuments are underground except Shah Alam Tomb where alignment is elevated. The tunnel will be constructed by State of Art Technology i.e. Tunnel Boring Machine (TBM) which gives negligible vibration and does not affect the surrounding structures. Station will be constructed by Cut and Cover method which is widely accepted and the safest technique being adopted by metro in India and abroad.

I. Noise Pollution

Construction noise in the community may not pose a health risk or damage to peoples hearing, but it can adversely affect people's quality of life. To some degree, construction noise can be a contributing factor to the degradation of someone's health in that it can cause people to be irritated and stressed and can interrupt their ability to sleep - all of which may lead to higher blood pressure, anxiety, and feelings of animosity toward the people or agencies responsible for producing the noise. Construction noise may disturb people at home, in office buildings or retail businesses, in public institutional buildings, at locations of religious services depending upon their vicinity to construction site. Construction noise is unwelcome during nighttime in residential areas during sleep; it can be equally unwelcome during the daytime in commercial areas if it interferes with peoples' ability to conduct business. The major sources of noise pollution during construction are movement of vehicles for transportation of construction material to the construction site and the noise generating activity at the construction site itself. The Metro construction is equipment intensive. A noise prediction is carried out for Lmax and Leq for different combinations of construction equipments working simultaneously at a site with the help of construction noise model. Various input required in the model are 1) type of landuse , ii) baseline noise levels, iii) distance to receptor and iv) type of noise generating equipment. The Result of the noise prediction is presented in **Table 4.6** and shown graphically in **Figure 4.1** through **Figure 4.3.**

Table 4.5: Noise Level Prediction during Construction

)istance (m)	Concrete Batch Plant + Concrete Mixer Truck		Auger Drill Rig +Dump Truck + Generator + Slurry Plant		Dump Truck + Excavator + Pneumatic Tools	
	Lmax	Leq	Lmax	Leq	Lmax	Leq
5	92.7	87.5	94	92.5	94.9	93.3
10	86.7	81.5	88	86.5	85.8	85.3
15	83.1	77.9	84.5	83	82.3	81.8
20	80.6	75.4	82	80.5	79.8	79.3
25	78.7	73.5	80.1	78.6	77.9	77.4
30	77.1	71.9	78.5	77	76.3	75.8
35	75.8	70.6	77.1	75.6	75	74.5
40	74.6	69.4	76	74.5	73.8	73.3
45	73.6	68.4	75	73.4	72.8	72.3
50	72.7	67.5	74	72.5	71.9	71.4
55	71.9	66.7	73.2	71.7	71	70.5
60	71.1	65.9	72.5	71	70.3	69.8
65	70.4	65.2	71.8	70.3	69.6	69.1
70	69.8	64.6	71.1	69.6	68.9	68.4
75	69.2	64	70.5	69	68.3	67.8

80	68.6	63.4	70	68.5	67.8	67.3
85	68.1	62.9	69.4	67.9	67.3	66.8
90	67.6	62.4	68.9	67.4	66.8	66.3
95	67.1	61.9	68.5	67	66.3	65.8
100	66.7	61.5	68	66.5	65.8	65.3

Figure 4.1: Noise Levels db(A)Due To Concrete Batch Plant + Concrete Mixer Truck

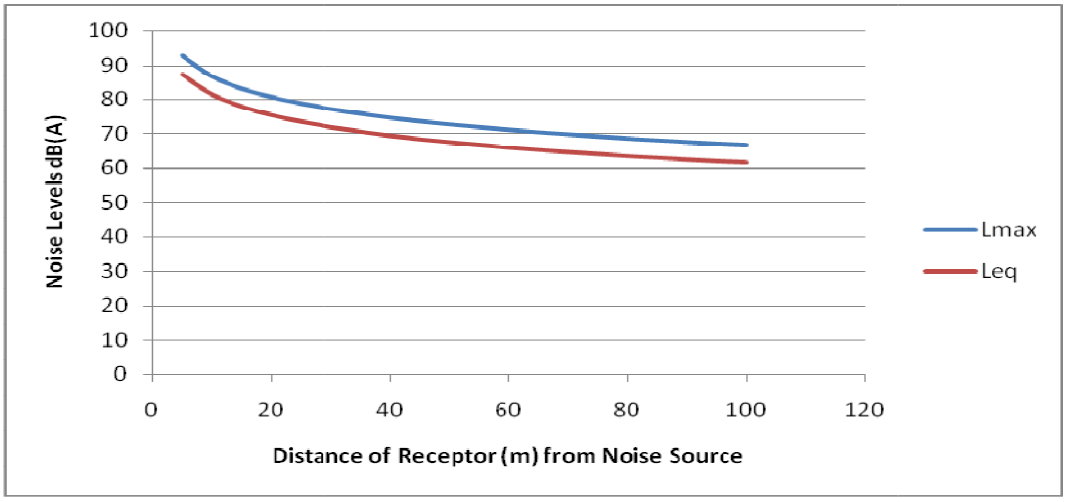


Figure 4.2: Noise Levels Db(A)Due To Auger Drill Rig + Dump Truck + Generator + Slurry Plant

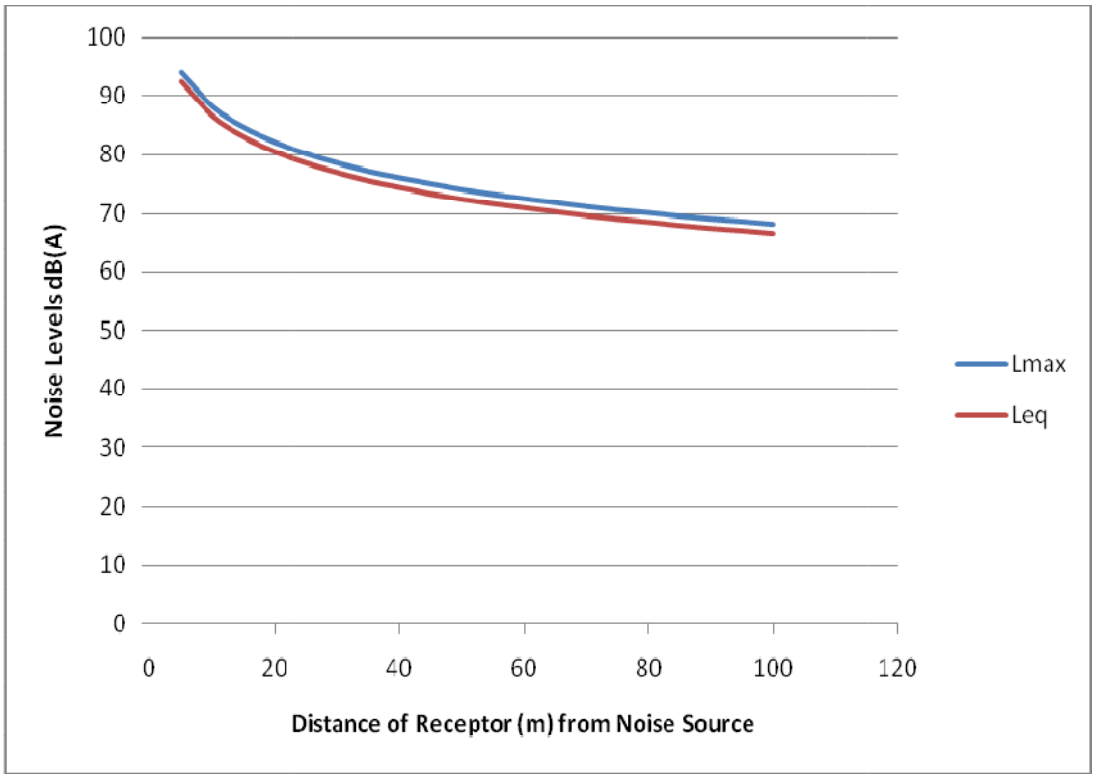
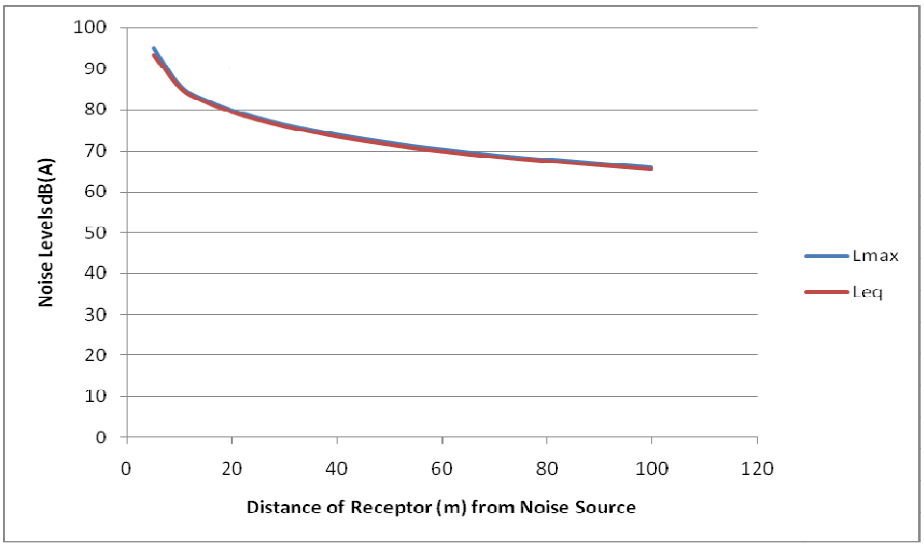


Figure 4.3: Noise Levels Db(A)Due To Dump Truck + Excavator + Pneumatic Tools



It is observed from the above table when Dump Truck, Excavator and Pneumatic Tool is working simultaneously at site, person working near the equipment will be exposed to maximum noise levels (leq 93.3 dB(A) and Lmax 94.9) at 5m. As per Hence as per OSHA guidelines (Table 4.6) if employees is subjected to sound exceeding 95 decible for more than 4 hours a day feasible administrative or engineering controls shall be utilized. If such controls fail to reduce sound levels within the 95dB(A) personal protective equipment shall be provided and used to reduce sound levels.

Table 4.6: Permissible Noise Exposures

Duration per day, hours	Sound level dB(A slow) response
8	90
6	92
4	95
3	97
2	100
1 ½	102
1	105
½	110
¼ or less	115

J. Impact Due to Subsidence

In a cut and cover method a trench is excavated with necessary ground support. The construction will be in situ concrete, precast concrete and corrugated steel. Use of permanent Diaphragm wall helps to maintain retention of the surrounding soil and ground water. The D-wall method is useful where ground water is high. The D-walls for underground station construction would be 80 to 100 cm thick and will function as a permanent side wall of the station. It is rigid type of support system and therefore ensures the maximum safety against settlement to the adjacent structures.

State of the art technology like Earth Pressure Balance Tunnel Boring Machine (TBM) will be

adopted during construction to minimize probability of subsidence. Earth Pressure Balance Machine (EPBM) is the correct technical solution when the project is located in an urban environment and ground surface subsidence cannot be tolerated. The so called Earth Pressure Balance Shields (EPB) turns the excavated material into a soil paste that is used as pliable, plastic support medium. This makes it possible to balance the pressure conditions at the tunnel face, avoids uncontrolled inflow of soil into the machine and creates the conditions for rapid tunneling with minimum settlement. The spoil is admitted into the tunnel boring machine (TBM) via a screw conveyor (cochlea) arrangement which allows the pressure at the face of the TBM to remain balanced without the use of slurry. A rotating cutting wheel equipped with tools is pressed onto the tunnel face and excavates the material. The soil enters the excavation chamber through openings, where it mixes with the soil paste already there. Mixing arms on the cutting wheel and bulkhead mix the paste until it has the required texture. The bulkhead transfers the pressure of the thrust cylinders to the pliable soil paste. When the pressure of the soil paste in the excavation chamber equals the pressure of the surrounding soil and groundwater, the necessary balance has been achieved.

Any areas with risks of land subsidence will be carefully avoided based on soil investigation tests. No notable ground subsidence has occurred in the past. The detailed survey of condition of buildings/houses along proposed alignment will be conducted. During construction monitoring of condition of buildings/houses will be conducted. In case of occurrence of crack at wall of buildings/houses, damaged wall will be repaired immediately.

The other support walls which can be used depending on the site conditions are as follows:

Sheet Piles: 'Z'/ 'U' sheet piles can be used as temporary support wall. This can be advantageous where it is possible to re-use the sheet pile again and again and therefore, economy can be achieved. However the main concern remains, driving of sheet piles causes vibrations/noise to the adjacent buildings. This may sometimes lead to damage to the building and most of the time causes inconvenience to the occupants of the building. Situation becomes more critical if sensitive buildings are adjacent to the alignment like hospitals, schools, laboratories, etc. Silent pile driving equipments however are now available and can be used where such problems are anticipated.

Retaining Casing Piles: This is suitable for situation where the cut and cover is to be done in partly soil and partly rock. The top soil retaining structure can be done with the help of Casing pile which is then grouted with cement slurry. This is considered suitable in case of shallow level, non-uniform, uneven nature of rock head surface which render the construction of sheet piles/diaphragm wall impracticable. These are suitable up to 7-meter depth. The common diameter used for such casing pile is 2.00-2.50 m dia.

Soldier Piles and Lagging: Steel piles (H Section or I section) are driven into the ground at suitable interval (normally 1-1.5 m) centre-to-centre depending on the section and depth of excavation. The gap between two piles is covered with suitable lagging of timber planks/shot-creting /steel sheets/GI sheets during the process of excavation.

Secant Piles: are cast-in-situ bored piles constructed contiguously to each other so that it forms a rigid continuous wall. This is considered an alternative to diaphragm wall where due to soil conditions it is not advisable to construct diaphragm wall from the consideration of settlement during the trenching operation. 800 to 1000 mm dia piles are commonly used. Two alternate soft piles are driven and cast in such a way that the new pile partly cuts into earlier constructed piles. This new pile is constructed with suitable reinforcement. With this, alternate soft and hard pile is

constructed. This has got all the advantages of diaphragm wall. However, this wall cannot be used as part of permanent structure and permanent structure has to be constructed in- side of this temporary wall.

H. Impact on Groundwater Flow

Due to underground tunnel construction there might be impact on groundwater flwo. However as a precautionary measure, detailed hydrological investigation will be undertaken prior to the construction of tunnel to locate the ground water aquifer falling in the alignment of metro tunnel and to safeguard the ground water flow wherever feasible. Extraction of ground water is necessary to build underground stations. This water should be used for simultaneous recharge. De-watering is going to impact ground water. A comprehensive impact study will be taken before starting de-watering. As a precautionary measure DMRC will take conservation norms.

The hydro geological study should cover

- Appraisal of hydro geological situation in and around the proposed underground Metro corridors. through field investigations, analysis of primary and secondary data.
- Decipher aquifer disposition to estimate ground water resources availability and its quality at various depth in different aquifers.
- Assess the ground water availability and its development prospects vis-à- vis water demand of the proposed project.
- Suggest suitable site for ground water monitoring wells.
- The behavior of the ground water regime with the expected stresses like withdrawal of ground water due to coming up of new infrastructurethrough ground water modeling.

I. Vibration Impact

Vibration is an Oscillatory motion. It can be described in terms of displacement, velocity or acceleration. Since motion is oscillatory, there is not net movement of the vibration element and the average of any of the motion descriptors is zero. During the vibration the oscillatory wave propagate from the source through the ground to adjacent buildings. The rumbling sound caused by the vibration of room surface is called ground-borne noise. Typical frequency range for environmental ground vibrations is 1 – 200 Hz.

Peak particle Velocity (PPV) is the maximum Instantaneous positive or negative peak of the vibration signal and Root mean square (rms) amplitude is the square root of the average of the squared amplitude of the signal. The average is typically over a one second period.

Vibration velocity level in decibel is calculated as under Lv=20xlog10(v/vref)

Where

Lv" is the velocity level in decibels, "v" is the rms velocity amplitude, and
"vref" is the reference velocity amplitude which is $1x10^{-6}$ inch/sec ($2.54*10^{-8}$ m/s) in the USA and $1x10^{-8}$ m/sec or $5x10^{-8}$ m/sec in the rest of the world

Various types of construction equipment have been measured under wide variety of construction activities with an average source levels reported in terms of velocity levels as shown in Table 4.8. The data provide a reasonable estimate for a wide range of soil conditions.

Table 4.7: Vibration Source Levels for Construction Equipments

Equipment		PPV at 25 ft (inch/sec)	Approx Lv* at 25 ft (Vdb)
Pile Driver (Impact)	Upper Range	1.518	112
	typical	0.644	104
Pile Driver (sonic)	Upper Range	0.734	105
	typical	0.17	93
Clam shovel drop (slurry wall)		0.202	94
Hydromill (slurry wall)	in soil	0.008	66
	in rock	0.017	73
Large Buldozer		0.089	87
Caisson drilling		0.089	87
Loaded Trucks		0.076	86
Jackhammer		0.035	79
Small Bulldozer		0.003	58

*RMS velocity in decibels (VdB) re 1 μinch/second

Estimated vibration level (L_V) a distance D for consideration of annoyance or interference with vibration sensitive activities can be calculated by following equation: Lv(D) = Lv (25 ft) - 20log(D/25). Results are given in Table 4.9.

Table 4.8: Vibration Levels at Different Distances (Construction)

Equipment		Distance				
		10m	20m	30m	40m	50m
Pile Driver (Impact)	Upper Range	109.23	103.26	99.68	97.18	95.25
	typical	101.78	95.81	92.24	89.74	87.80
Pile Driver (sonic)	Upper Range	102.91	96.95	93.37	90.87	88.93
	typical	90.21	84.24	80.67	78.17	76.23
Clam shovel drop (slurry wall)		91.71	85.74	82.16	79.67	77.73
Hydromill (slurry wall)	in soil	63.66	57.69	54.12	51.62	49.68
	in rock	70.21	64.24	60.67	58.17	56.23
Large Buldozer		84.59	78.62	75.05	72.55	70.61
Caisson drilling		84.59	78.62	75.05	72.55	70.61
Loaded Trucks		83.22	77.25	73.67	71.18	69.24
Jackhammer		76.48	70.51	66.94	64.44	62.50
Small Bulldozer		55.14	49.18	45.60	43.10	41.16

The threshold of human response to vibration is around 65 VdB and the background vibration velocity level in residential areas is usually 50VdB or lower. For a person in their residence, the lower threshold for annoyance is 72 VdB (FTA 2006). As per the guidelines of Research and Development Organisation (RDSO), 2015, GBV impact level shall be 72 VdB for residences and buildings where people normally sleep. The vibration affects human health by causing fatigue,

increased pulse & respiration rates, dizziness & loss of balance, anger and irritation.

The US department of Transportation has studied the effects of construction vibration and they are presented in Table 4.10.

Table 4.9: EFFECTS OF CONSTRUCTION VIBRATION

Peak Particle velocity (in/sec)	Effect on Humans	Effect on buildings
<0.005	Imperceptible	No effect on buildings
0.005 to 0.015	Barely perceptible	No effect on buildings
0.02 to 0.05	Level at which continuous vibration beings to annoy in buildings	No effect on buildings
0.1 to 0.5	Vibration considered unacceptable for people exposed to continuous or long-term vibration	Minimal potential for damage to weak or sensitive structures
0.5 to 1.0	Vibrations considered bothersome by most people, however tolerable if short term in length	Threshold at which there is a risk of architectural damage to buildings with plastered ceilings and walls. Some risk to ancient monuments and ruins.
1.0 to 2.0	Vibrations considered unpleasant by most people	U.S. Bureau of mines data indicates that vibration in this range will not harm most buildings. Most construction vibration limits are in this range
>3.0	Vibration is unpleasant	Potential for architectural damage and possible minor structural damage.

The underground tunneling of Delhi Metro Phase IV project will be carried out by Tunnel Boring Machine (TBM). TBM is the worldwide accepted machine having less impact of vibration. Continuous effect of vibration on the buildings can cause damage to the buildings. Building subjected to the vibration effect with more than 50 mm/s would receive structural damage. Historic buildings are more susceptible to vibration effect due to type of building material and design. Old structures generally lose structure strength over the period.

4.2.4 Impacts due to Project Operation

Along with many positive impacts, (Refer **Chapter 5**) the project may cause the following negative impacts during operation of the project due to the increase in the number of passengers and trains at the stations:

- Noise pollution,
- Water supply and sanitation at Stations,

- ❖ Pedestrainisation and traffic congestion issues
- ❖ Impact due to depot

A. Noise Pollution

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

i) *Wheel / Rail Noise* : Due to wheel /rail roughness
ii) Propulsion Equipment: Traction motors, cooling fans for TM, reduction gears etc.
iii) Auxiliary Equipment: Compressors, motor generators, brakes, ventilation systems, other car mounted equipment
iv) Elevated Structure Noise

- At low speed(<15 km/h) auxiliary equipment may predominate
- At speeds up to approx. 50 km/h, W/R noise predominates
- At speeds greater than 50 km/h, the propulsion equipment noise predominates
- For light weight steel elevated structures, the structure noise can predominate at all speeds above 15 km/h

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

i) **Train speed (V):** Car interior noise levels vary from 15 log 10 V to 40 log 10 V.

ii) **Type of Way structure:** Noise levels lowest on AG ballast and tie-welded track and highest for operations on light-weight structures and in tunnels with concrete track bed and no acoustic treatment.

iii) **Sound Insulations of car body:** Single leaf or Sandwich construction.

iv) **Type & Design of Mechanical Equipment:** Propulsion system & Auxiliary Equipment (A/c system, compressors and motor generator sets).

v) **Wheel and Rail conditions:** Rail corrugations and wheel flats can increase the noise levels by 10-15 dB(A)

Noise prediction has been done for the three corridors for different horizon years using Noise model and is presented in **Table 4.11.** The various inputs required for this model are: landuse type, type of source, source speed, number of trains per hour, cars per train, distance of source to receiver, number of trains during day time and night time, type of track (jointed or embedded), presence of barrier. Peak hour train operation is taken for prediction, considering the welded track, aerial structure. The maximum speed of the train is taken as 80km/hr and assumed that no barrier is present. If a corridor has two or more sections, section which has maximum number of train operation is taken for noise prediction. Graphical representation is shown in **Figure 4.4** through **4.9.** It is observed from the results that metro noise level will be in range of 80-85 dB(A) at 10 m distance, 74-81 dB(A) at distance of 20m and 72-78 dB(A) at 30m. Metro corridor is underground in congested residential areas where noise levels will come down due to reduction of vehicles. There are certain sensitive receptors like Hospitals, schools and colleges near to

elevated section. Noise barrier will be required at these sensitive receptors. Due to reduction of vehicular traffic, the road traffic noise is expected to come down. A list of sensitive receptors is given at **Annexure 4.2**.

Table 4.10: Noise Levels At Different Distances Db(A)

Horizon Year	Noise level, leq dB(A)	Distance from Metro Corridor (m)					
		5	10	20	30	40	50
2021	Janakpuri West - R.K. Ashram	86	82	77	75	73	71
	Aerocity – Tuglakabad	84	80	75	73	71	69
	Mukundpur-Maujpur	86	82	77	75	73	71
2031	Janakpuri West - R.K. Ashram	87	83	78	76	74	72
	Aerocity - Tuglakabad	85	81	76	74	72	70
	Mukundpur-Maujpur	87	83	78	76	74	72
2041	Janakpuri West - R.K. Ashram	88	84	79	77	75	73
	Aerocity - Tuglakabad	86	82	77	75	73	71
	Mukundpur-Maujpur	88	84	79	77	75	73

Figure 4.4: predicted noise levels db(a) janakpuri west – R.K. Ashram

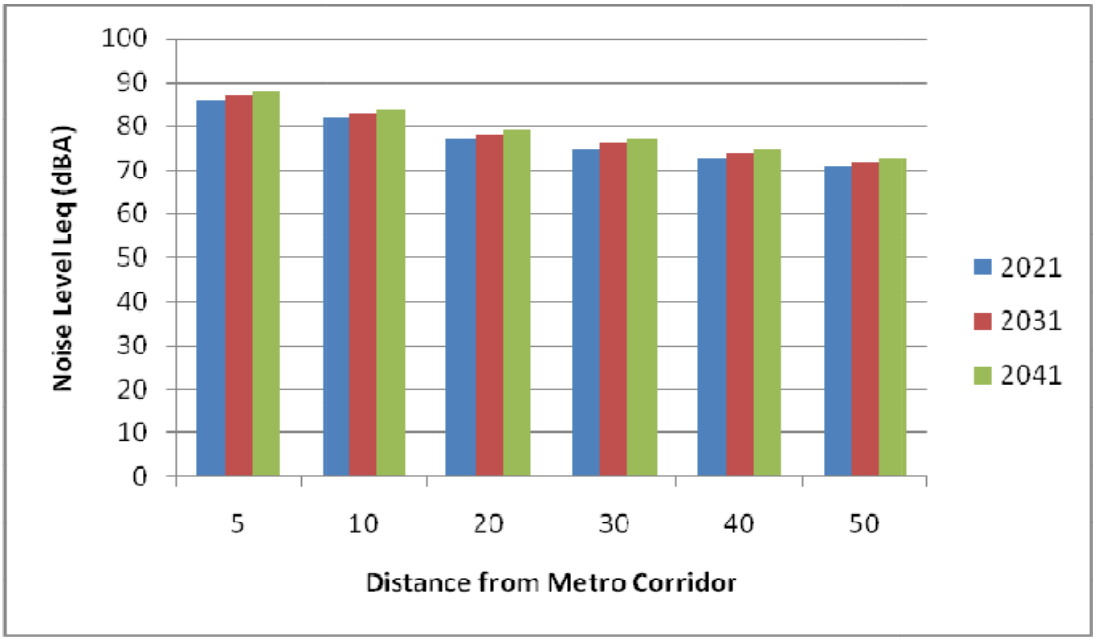


Figure 4.5: predicted noise levels db (a)
Aero city – tuglakabad

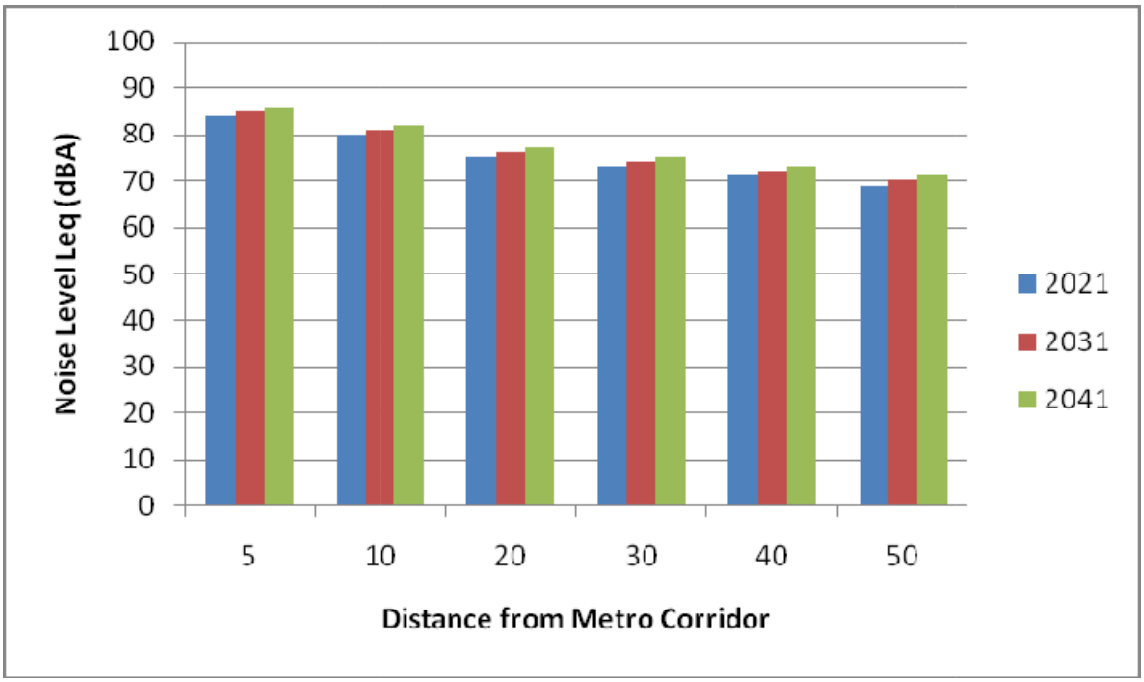
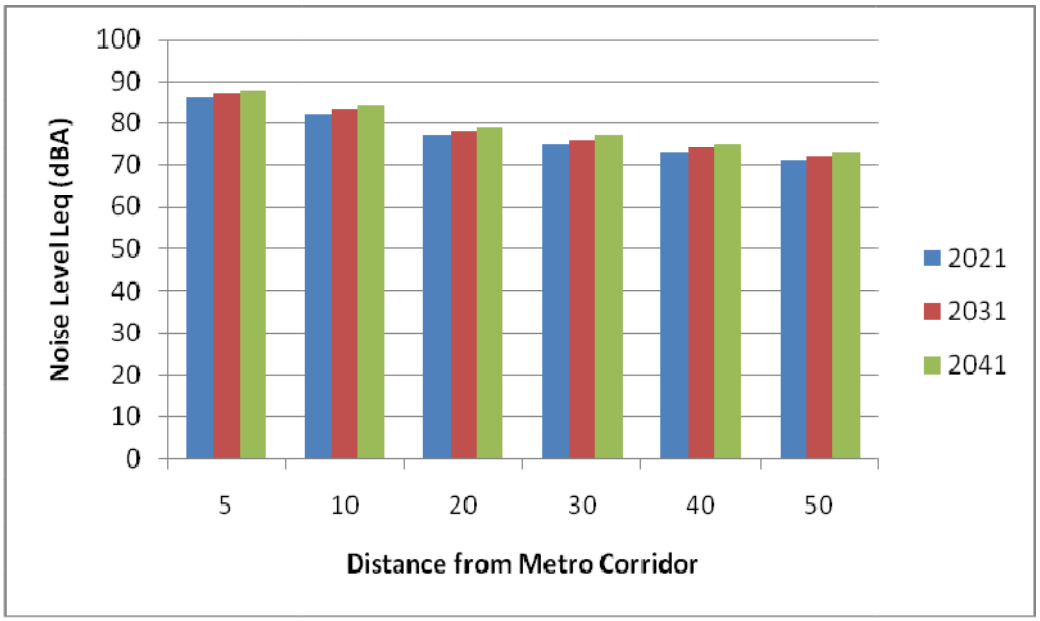


Figure 4.6: predicted noise levels db (a)
Mukundpur-maujpur



B. Water Supply and Sanitation

Public Health facilities such as water supply, sanitation and wash rooms are very much needed at the stations. The water demands will be on station for drinking, toilet, cleaning and also for other purpose like AC, chiller and other purposes. Water Demand is calculated and presented in

Table 4.12. Water should be treated before use upto WHO drinking water standards. The water requirement for the stations will be met through the public water supply system after taking necessary approvals.

Table 4.11: Water Requirement

S.No.	Particular	Water Demand (KLD)
1	In Underground station	1615
2	In Elevated stations	432
	Total	**2047**

C. Pedestrian Issues

There is an expectation that MRTS will increase the pedestrianisation in CBD. As has been demonstrated in several countries, notably in Western Europe and North America, pedestrian station of certain localities is a desirable change in CBDs of the city. While initial reactions of the residents or commercial establishments are sometimes unfavorable to the concept, in no case has dissatisfaction been expressed, or a reversal of Pedestrainisation instituted, once an area has been so developed. The benefits are seen to outweigh any disadvantages of increased movements for access etc. The main aim of MRTS system is to decongest the road traffic in Central Business Districts. The connections will further reduce the pedestrian number, which are available now on the roads.

As seen from Delhi Metro, once the metro services commence, it results in passenger rush at stations in turn, results in congestion around station vicinities. Essentially, the decongestion scheme should involve setting up of taxi and auto rickshaw stands, a halting space for public buses and other such facilities. These should be planned up within the vicinity of each station such that passengers get off the bus or park their two-wheeler within walking distance from the station and at the same time the locality does not see congestion due to such parking. Also, bus stops outside the stations should be moved about 50 metres away from the stations. No parking space has to be earmarked for vehicles outside any station. If anyone parks them, they should be towed away.

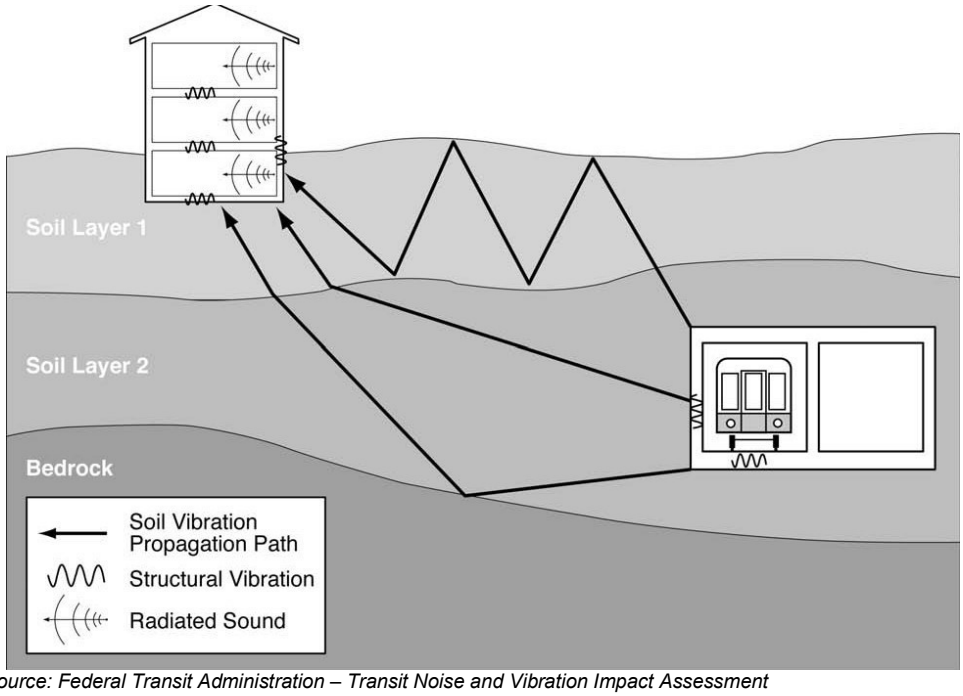
D. Visual Impacts

The introduction of MRTS implies a change in streets through which it will operate. An architecturally well designed elevated section can be pleasing to the eyes of beholders. Recent MRTS projects have attempted to incorporate this objective in their designs. Since a low profile would cause the least intrusion, the basic elevated section has been optimized at this stage itself.

E. Vibration Impact

During metro operation there will be vibration impact. It is presumed that underground metro operation may cause Ground Borne Vibration (GBV) on building above the tunnel. The propagation of ground borne vibration is illustrated in the diagram below:

Figure 4.7: Propagation of Ground Borne Vibration (GBV)



Source: Federal Transit Administration – Transit Noise and Vibration Impact Assessment

The sources of the vibration and noise induced by the metro trains are mainly the rolling stock, track and the interaction between them. The vibration of the transit structure excites the adjacent ground, creating vibration waves that propagate through the various soil and rock strata to the foundations of nearby buildings. The vibration propagates from the foundation throughout the remainder of the building structure. The intensity of vibration depends on operational and vehicle parameters, track system, geology and condition of receiving building.

Primarily effect of ground borne vibration will be rattling of window panes and rumble noise which cause annoyance to the occupants. However, it is not expected to cause any structural damage to the building as such. Based on Delhi Metro's previous experience, the intensity of vibration varies from 65 VdB to 90 VdB. As per International guidelines, humans start perceiving vibration from 65 VdB and it becomes an annoyance from 72 VdB. As per the guidelines of Research and Development Organisation (RDSO), 2015, GBV impact level shall be 72 VdB for residences and buildings where people normally sleep. If proper precaution is not taken to address this issue, it could cause severe discomfort to the occupants as well affect the working of sensitive equipments.

25 meters on either side from central of the tunnel is considered as shadow zone of ground borne vibration. If any building especially residential building falls within this zone precautionary measures need to be taken to mitigate the effect of ground borne vibration. In the case of sensitive building such as archeological buildings it is safe to keep a minimum horizontal distance of 60 meters from the tunnel. At certain stretches the alignment passes beneath residential areas where it is recommended to take mitigation measures as mentioned in the EMP.

4.3 EPILOGUE

Based on above negative impacts, a checklist of impacts has been prepared along with positive

impacts in **Chapter-5.** The net resultant impacts without management plans are also summarised. Themanagement plans to mitigate the negative impacts are reported in **Chapter-6.**

5. POSITIVE ENVIRONMENTAL IMPACTS

Based on project particulars **(Chapter - 2)** and existing environmental conditions **(Chapter - 3)**, potential impacts that are likely to result from the proposed DMRC Phase IV Part A development have been identified and wherever possible these have been quantified. This chapter deals with the positive impacts of the project. The introduction of DMRC Phase IV Part A will also yield benefits from non-tangible parameters such as saving due to equivalent reduction in road construction and maintenance, vehicle operating costs, less atmospheric air pollution and socio-economic benefits of travel time, better accessibility, better comfort and quality of life. However, all benefits cannot be evaluated in financial terms due to non-availability of universally accepted norms. The parameters such as economic growth, improvement in quality of life, reduction in public health problems due to reduction in pollution, etc have not been quantified.

Various positive impacts have been listed under the following headings:

- Employment Opportunities,
- Benefits to Economy
- Quick Service and Safety
- Reduction in Fuel consumption
- Less Air pollution
- Carbon Credits.

5.1 Employment Opportunities

The civil works of the project is likely to be completed in a period of 5 years. During this period manpower will be needed for various project activities. In post-construction phase, about 2170 people will be employed for operation and maintenance of the system. Thus, the project would provide substantial direct employment equal to the above number. In addition to these, more people would be indirectly employed for allied activities.

5.2 Benefits to Economy

In the present context, the project will streamline and facilitate movement of public from different parts of Delhi and NCR. This link will yield tangible and non tangible saving due to equivalent reduction in road traffic and certain socio-economic benefits. Introduction of this metro will result in the reduction in number of buses, usage of private vehicles. This in turn will result in significant social benefits due to reduction in fuel consumption, vehicle operating cost and travel time of passengers. With the development of the 3 corridors of Delhi Metro phase IV Part A project, it is likely that more people will be involved in trade, commerce and allied services. During public consultations participants expressed the view that Metro system will result in reduction in traffic congestion and travel time, improved connectivity, economy and infrastructure. Summary of EIA related outputs of public consultations is placed at **Annexure 5.1.** Minutes of consultations are placed at **Annexure 5.2.**

5.3 Quick Service and Safety

With the implementation six corridors of Delhi Metro Phase IV, travel time of passengers

travelling by other modes of vehicles in the absence of Metro will got reduced. Also, implementation of the metro will provide improved safety and lower number of accidents, injuries and accidental deaths. The reduced vehicles on road in turn will reduce accidents and increase safety of persons as per table below based on accident data of Delhi year 2011. During public consultations participants expressed the view that Metro system will result in reduction in personal safety of ladies and accidents.

Table 5.1: Road Safety Due To Phase IV

Particular	2021	2031	2041
Total Accidents saved	220	288	358
Number of fatal accidents saved	61	79	99
Number of persons killed saved	62	82	102
Number of person injured saved	218	286	356

Source: DPR, March 2019

5.4 Less Fuel Consumption

On implementation of the project, consumption of petrol, diesel and CNG will get reduced. The estimated numbers of vehicles trips that will be reduced due to construction 3 corridors of Delhi Metro Phase IV Part A are given in **Table 5.2**. Based on number of vehicle trips reduction, reduction in fuel consumption is reported in **Table 5.3.** It is estimated that about 3.486 million litres of diesel, 10.912 million litres of petrol and 14.846 million kg of CNG gas will be saved in year 2021. These reductions will increase to 5.683 million litres of diesel, 17.790 million litres of petrol and 24.203 million kg of CNG gas in year 2041. Net saving on fuel expenditure at current price level is given in **Table 5.4**. It is estimated savings will be of Rs 1258.921 million in year 2021, Rs 1647.490 million in year 2031 and Rs 2052.486 million in year 2041.

Table 5.2: Reduction in Vehicle Trips

Mode	2021	2031	2041
Bus	14260	18661	23248
Car	59156	77415	96446
2W	135565	177409	221021
Auto	10846	14192	17681
Total	**219827**	**287677**	**358396**

Table 5.3: Reduction in Fuel Consumption

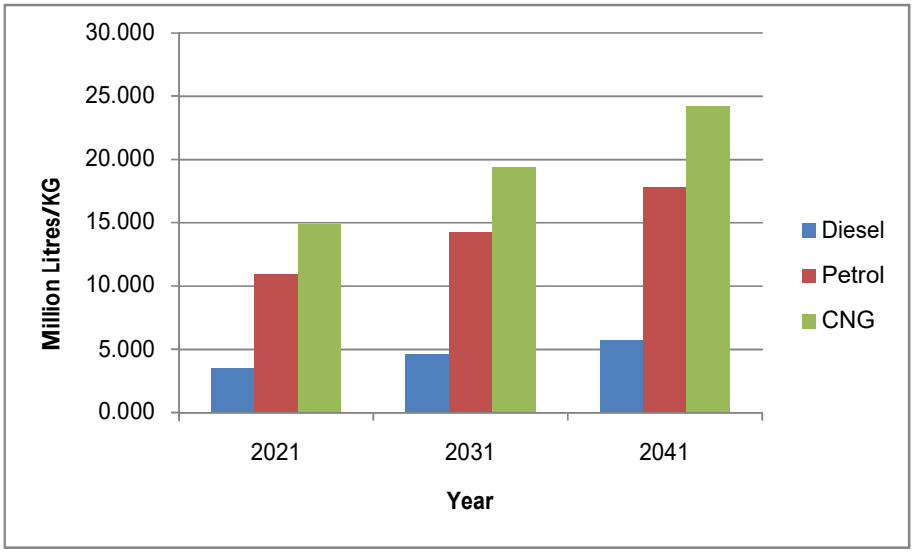
Year	Diesel (Million liters)	Petrol (Million liters)	CNG (Million Kg)
2021	3.486	10.912	14.846
2031	4.561	14.280	19.428
2041	5.683	17.790	24.203

Source: DPR, March 2019

Table 5.4: Net Saving On Fuel Expenditure (Rs Million)

Fuel	2021	2031	2041
Diesel	193.379	253.067	315.278
Petrol	798.314	1044.722	1301.545
CNG	267.228	349.701	435.662
Total	1258.921	1647.490	2052.486

Figure 5.1: Reduction in Fuel Consumption



5.5 Less Air Pollution

The major vehicular pollutants that define the ambient air quality are: Particulate matter, Nitrogen oxides, Carbon monoxide, Hydro Carbons and Carbon dioxide. In addition to the above pollution, un-burnt products like aldehydes, formaldehydes, acrolein, acetaldehyde and smoke are by products of vehicular emissions. The reduction of air pollutants with the present corridors are presented in **Table 5.5**. During public consultations participants expressed the view that Metro system will result in reduction in pollution.

Table 5.5: Pollution Reduction (Tons/Year)

Pollutant	Year		
	2021	2031	2041
Carbon Monoxide (CO)	795	1040	1296
Hydro-Carbons (HC)	406	531	662
Nitrogen Oxide (Nox)	553	723	901
Particulate Matter (PM)	18	24	30
Carbon Dioxide (CO_2)	85667	112107	139665

Source: DPR, March 2019

Figure 5.2:Net Saving On Fuel Expenditure (Rs Million)

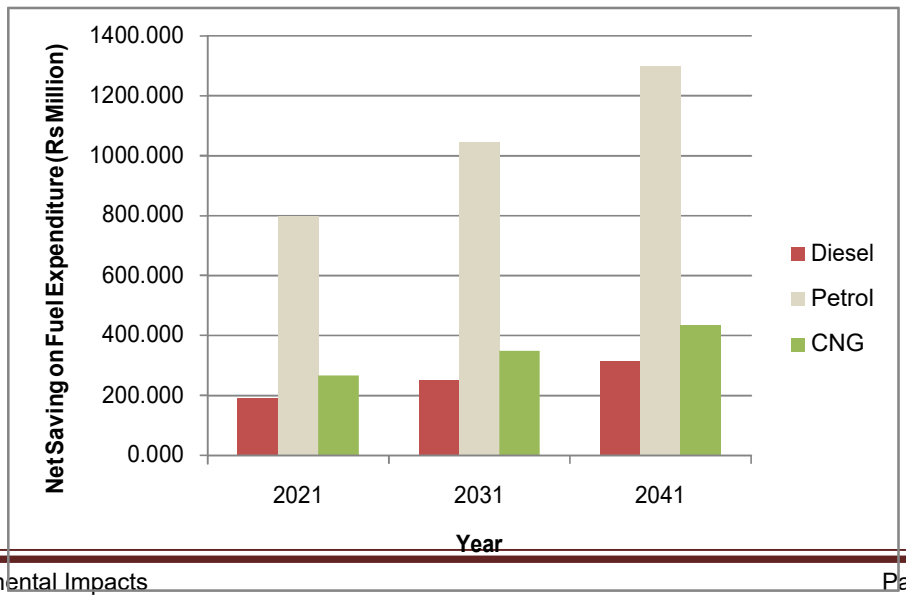


Figure 5.3:Pollution Reduction (Tons/Year)

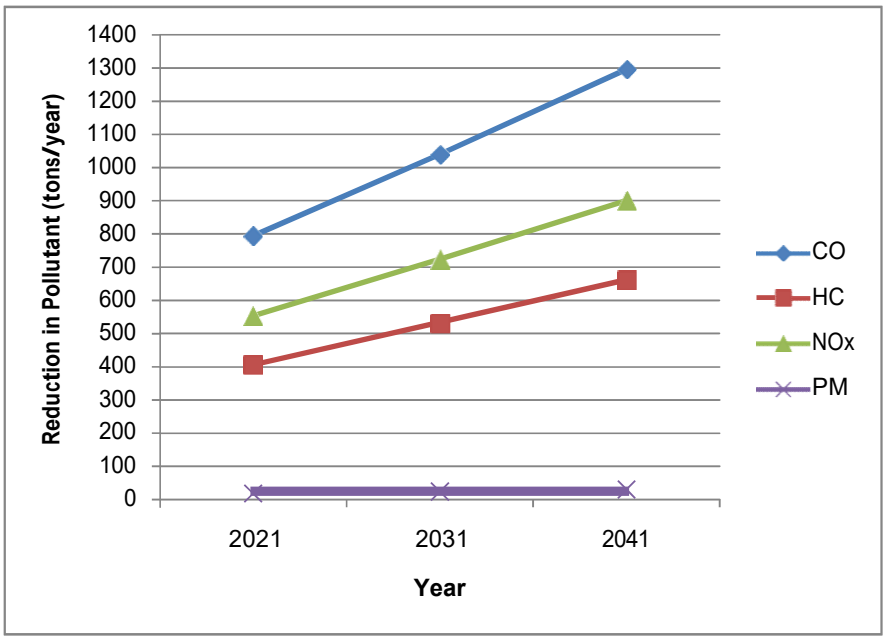
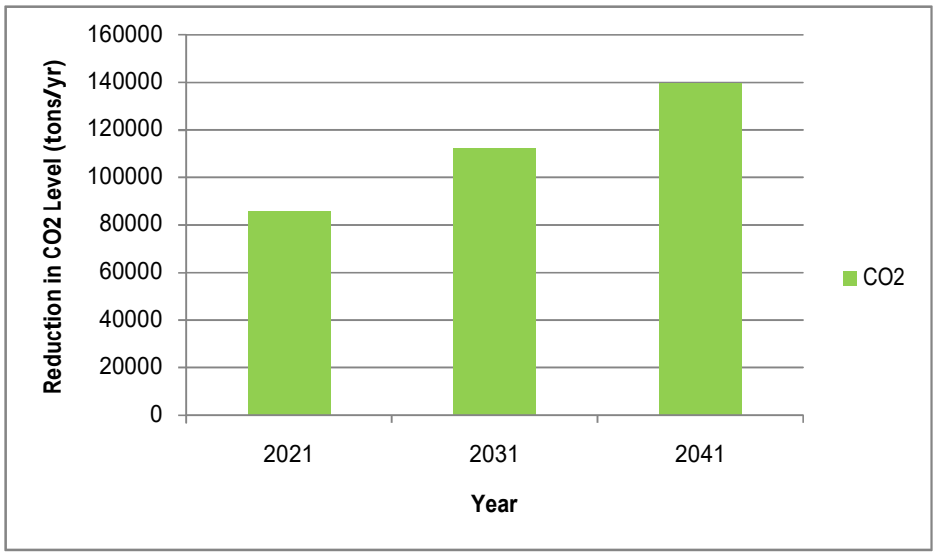


Figure 5.4:Reduction In Carbon Dioxide Levels (Tons/Year)



5.6 Carbon Credits

As nations have progressed we have been emitting carbon, or gases which result in warming of the globe. Some decades ago a debate started on how to reduce the emission of harmful gases that contributes to the greenhouse effect that causes global warming. So, countries came together and signed an agreement named the Kyoto Protocol. The Protocol was initially adopted on 11 December 1997 in Kyoto, Japan, and entered into force on 16 February 2005.

Under the Protocol, 37 countries commit themselves to a reduction of four greenhouse gases (GHG) (carbon dioxide, methane, nitrous oxide, sulphur hexafluoride) and two groups of gases (hydrofluorocarbons and perfluorocarbons) produced by them, and all member countries gave general commitments. At negotiations, 37 countries (including the US) collectively agreed to

reduce their greenhouse gas emissions by 5.2% on average for the period 2008-2012. This reduction is relative to their annual emissions in a base year, usually 1990. Since the US has not ratified the treaty, the collective emissions reduction of 37 Kyoto countries falls from 5.2% to 4.2% below base year.

Developed countries, mostly European, had said that they will bring down the level in the period from 2008 to 2012. In 2008, these developed countries have decided on different norms to bring down the level of emission fixed for their companies and factories.

A company has two ways to reduce emissions. One, it can reduce the GHG (greenhouse gases) by adopting new technology or improving upon the existing technology to attain the new norms for emission of gases. Or it can tie up with developing nations and help them set up new technology that is eco-friendly, thereby helping developing country or its companies 'earn' credits.

India, have the advantage because it is a developing countries. Any company, factories or farm owner in India can get linked to United Nations Framework Convention on Climate Change and know the 'standard' level of carbon emission allowed for its outfit or activity. The extent to which one is emitting less carbon (as per standard fixed by UNFCCC) one get credited in a developing country. This is called carbon credit. These credits are bought over by the companies of developed countries - mostly Europeans - The United States has not signed the Kyoto Protocol. Caron credits are measured in units of certified emission reductions (CERs). Each CER is equivalent to one ton of carbon dioxide reduction.

With the construction of 6 corridors of Delhi Metro Phase IV, Carbon credits of the tune of Rs 31.35 million in 2021, Rs 41.03 million in 2031 and Rs 51.12 million in 2041 can be earned due to reduction of vehicles at current price level.

5.7 CHECKLIST OF IMPACTS

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

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

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

Checklist is a list of environmental parameters or impact indicators which encourages the environmentalist to consider and identify the potential impacts. The checklist identifying anticipated environmental impacts is shown in **Table 5.6**.

Table 5.6: Checklist of Impacts

S. No.	Parameter	Negative Impact	No Impact	Positive Impact
A.	**Impacts due to Project Location**			
i.	Displacement of People	*		
ii.	Change of Land use and Ecology	*		
iii.	Loss of Cultural and Religious Structures		*	
iv.	Drainage & Utilities Problems	*		
B.	**Impact due to Project Design**			
i.	Platforms - Inlets and Outlets		*	
ii.	Ventilation and Lighting		*	
iii.	Railway Station Refuse	*		
iv.	Risk due to Earthquakes		*	
C.	**Impact due to Project Construction**			
i.	Soil Erosion, Pollution and Health risk	*		
ii.	Traffic Diversions and Risk to Existing Buildings	*		
iii.	Problems of Soil Disposal and Seepage Risk	*		
D.	**Impact due to Project Operation**			
i.	Oil Pollution	*		
ii.	Noise	*		
iii.	Water Demands	*		
iv.	Pedestrian Issues			*
v.	Visual Impacts			*
vi.	Employment Opportunities			*
vii.	Enhancement of Economy			*
viii.	Mobility			*
ix.	Safety			*
x.	Traffic Congestion Reduction			*
xi.	Less fuel Consumption			*
xii.	Less Air Pollution			*
xiii.	Carbon dioxide Reduction			*
xiv.	Reduction in Buses			*
xv.	Reduction in Infrastructure			*

6. ENVIRONMENTAL MANAGEMENT PLAN

The Delhi Mass Rapid Transit System (MRTS) Phase IV priority corridors will provide employment opportunity, quick mobility service and safety, traffic congestion reduction, less fuel consumption and air pollution on one hand and problems of muck disposal, traffic diversion, utility dislocation etc. on the other hand.

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

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

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

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

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

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

6.1 MITIGATION MEASURES

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

- Compensatory Afforestation

- Construction Material Management
- Labour Camp
- Welfare and safety of labour during construction
- Energy Management
- Hazardous Waste Management
- Housekeeping
- Utility Plan
- Archaeological and Historical Preservation
- Air Pollution Control Measures
- Noise Control Measures
- Vibration Control Measures
- Traffic Diversion/Management
- Soil Erosion Control
- Muck Disposal
- Construction and Demolition waste
- Draining of Water from Tunnel
- Water Supply, Sanitation and Solid Waste management
- Rain water harvesting
- Management Plans for Depot, and
- Training and Extension

6.1.1 Compensatory Afforestation

The objective of the afforestation programme should be to develop natural areas in which ecological functions could be maintained on a sustainable basis. The Department of Forests, Delhi Administration is responsible for the conservation and management of trees/forests in the project area. According to the results of the present study, it is found that about 11,121 trees are likely to be lost due to the project construvtion. As per the provision of the Delhi Preservation of Trees Act, 1994 and Government guidelines (Feb 2010), 10 tree saplings are to be planted for every tree felled. Hence 1,11,210 trees need to be planted. For cutting one tree, an applicant would have to deposit Rs 31,920 with the forest department in case of development and commercial projects. Out of 10 trees, 5 trees are planted by the Department of Forest and Wildlife using half of the security deposit for densification of the forest land/available in Gaon Sabha land. The rest plantation is to be raised and maintained by the user agency till the saplings are established as trees (5 years) and half of the security deposit is released after verification of the plantation.

Cost of Compensatory afforestation will be about Rs 35498 Lakh considering Rs 31,920/- per tree. On maturity of 1,11,210 trees, will absorb about 2,424 ton of CO_2 per year and will release 5,449 ton of Oxygen per year meeting oxygen demand of 18,987 persons per year.

6.1.2 Construction Material Management

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

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

6.1.3 Labour Camp

The Contractor during the progress of work will provide, erect and maintain necessary (temporary) living accommodation and ancillary facilities for labour to standards and scales approved by the DMRC. All temporary accommodation must be constructed and maintained in such a fashion that uncontaminated water is available for drinking, cooking and washing. Safe drinking water should be provided to the dwellers of the construction camps. Adequate washing and bathing places shall be provided, and kept in clean and drained condition. Construction camps are to the responsibility of the concerned contractors and these shall not be allowed in the construction areas but sited away. Adequate health care is to be provided for the work force.

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

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

Canteen Facilities: A cooked food canteen on a moderate scale shall be provided for the benefit of workers wherever it is considered necessary. The contractor shall conform generally to sanitary requirements of local medical, health and municipal authorities and at all times adopt such precautions as may be necessary to prevent soil pollution of the site.

First aid facilities: At every workplace, a readily available first-aid unit including an adequate supply of sterilized dressing materials and appliances will be provided. Suitable transport will be provided to facilitate taking injured and ill persons to the nearest hospital.

Day Crèche Facilities: At every construction site, provision of a day crèche shall be worked out so as to enable women to leave behind their children. At construction sites where 20 or more women are ordinarily employed, there shall be provided at least a hut for use of children under the age of 6 years belonging to such women. Huts shall not be constructed to a standard lower

than that of thatched roof, mud walls and floor with wooden planks spread over mud floor and covered with matting. Huts shall be provided with suitable and sufficient openings for light and ventilation. There shall be adequate provision of sweepers to keep the places clean. There shall be two maidservants (or aayas) in the satisfaction of local medical, health, municipal or cantonment authorities. Where the number of women workers is more than 25 but less than 50, the contractor shall provide with at least one hut and one maidservant to look after the children of women workers. Size of crèches shall vary according to the number of women workers employed.

Security: Security guards shall be deployed at construction sites as well as labour camps. In connection with their behaviour, they shall be subject to conditions of their employment and criminal liability. To ensure that security guard involved in the project will not violate safety of other individuals or local residents there will be an agreement of project contractor with security agency w.r.t rules and regulations, the guards will confined within site only, no arms will be provided to them and a formal training will be provided to them.

6.1.4 Welfare and safety of labour during construction

Construction works shall be executed as laid down in the Safety Health and Environment (SHE) Manual prepared by DMRC.
The SHE manual

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

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

The key elements of the SHE manual are as follows:

1. The unit responsible for co-ordinating and monitoring the Contractor's SHE performance;
2. Procedures for identifying and estimating hazards, and the measures for addressing the same; A list of SHE hazards anticipated
3. SHE training courses and emergency drills
4. SHE inspections to identify any variation in construction activities and operations, machineries, plant and equipment and processes against the SHE Plan and its supplementary procedures and programs: Planned General Inspection, Routine Inspection, Specific Inspection and Other Inspection
5. Safety Audit
6. SHE Auditto assess potential risk, liabilities and the degree of compliance of construction Safety, Health & Environmental plan and its supplementary procedures and programs against applicable and current SHE legalisation regulations and requirements of the employer.
7. Electrical Safety Audit External SHE Audit
8. SHE Communication to communicate the Safety, Occupational health and Environment management measures through posters campaigns / billboards / banners / glow signs being displayed around the work site
9. SHE Reporting –reports, minutes, inspection reports, audit reports

10. Accident reporting and investigation

i) Reports of all accidents (fatal / injury) and dangerous occurrences to the Employer

ii) Reporting to Govt. organisations

11. Investigations of Accidents and Dangerous Occurrences, Near misses and minor accidents

12. Prepare an Emergency Response Plan for all work sites including injury, sickness, evacuation, fire, chemical spillage, severe weather and rescue.

13. The Contractor will be required to conduct awareness programs and other measures to prevent infectious diseases spreading.

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

a) Housekeeping
b) Working at Height and Falling objects and Danger areas
c) Lifting Appliances
d) Launching Operation
e) Construction machinery, tools equipment - Safe worthiness
f) employ qualified electrical personnel on site and requirements of electrical equipment, distribution etc
g) Lighting
h) Exposure of worker to use of exhaust or harmful gases in confined locations
i) Fire prevention, protection and fighting system
j) Corrosive substances
k) Demolition
l) Excavation and Tunnelling
m) Traffic Management
n) Personal Protective Equipments (PPEs)
o) Reporting which will contain results of monitoring and inspection programs
p) Process of response to Inquiries, complaints and requests for information from private and governmententities
q) Physical fitness of workmen
r) Medical Facilities on site : Occupational Health Centre, Ambulance van and room HIV/ AIDS prevention and control
s) Exposure to Noise – prevention measures
t) Ventilation and illumination
u) Welfare measures for workers: latrine, canteen, drinking water, living accommodation, creches
v) Environmental issues during metro construction stage generally involve equity, safety and public health issues.

The construction agencies require complying with laws of the land, which include inter alia, the following:

- **Bonded Labour System (abolition) Act, 1976 (amended once in 1985):** An Act toprovide for the abolition of bonded labour system with a view to preventing the economic and physical exploitation of the weaker sections of the people and for matters connected therewith or incidental thereto.
- **Building and other construction worker's (Regulation of Employment and conditions of service) Act,1996:** The Act provides for regulating the employment and conditions of service of building and other construction workers and also provides for their safety, health and welfare measures and other matters connected therewith or incidental thereto.

- **Building and other Construction Worker's Welfare Cess Act, 1996:** The Act provides for levy and collection of cess on the cost of construction incurred by employers with a view to augmenting the resources of the Building and Other Constructions Workers Welfare Board. The Act provides for regulating the employment and conditions of service of building and other construction workers and also provides for their safety, health and welfare measures and other matters connected therewith or incidental thereto.
- **Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996:** The Rules provide for mandatory preparation of On-Site Emergency Plans by the industry and Off-Site Plans by the district collector and the constitution of four tier crisis groups at the centre, district, and local levels for the management of chemical disaster.
- **Child Labour (Prohibition and Regulation) Act 1986:** The Act prohibits employment of children below 14 years of age in certain occupations and processes and provides for regulation of employment of children in all other occupations and processes. Employment of child labour is prohibited in Building and Construction Industry.
- **Children Pledging of Labour Act,1933:** Pledging of Labour of children prohibited and penalty for parents/guardians pledging child labour prescribed
- **Contact Labour (Regulation and Abolition) Act, 1970 (amended once in 1986):** The Act provides for certain welfare measures to be provided by the contractor to contract labour.
- **Employee's Provident Fund and Miscellaneous Provisions Act, 1952 (amended 14 times 1953,1956,1957,1958,1960,1962,1963,1965,1971,1973,1976,1988,1996,1998):** It is an important piece of Labour Welfare legislation enacted by the Parliament to provide social security benefits to the workers . At present , the Act and the Schemes framed there under provides for three types of benefits -Contributory Provident Fund , Pensionary benefits to the employees/ family members and the insurance cover to the members of the Provident Fund.
- **Employees PF and Miscellaneous Provision Act 1952:** The Act provides for monthly contributions by the employer plus worker.
- **Employees State Insurance Act,1948 (amended 6times in 1951,1966,1970,1975,1984,1989):** This act envisage an integrated need based social insurance scheme that would protect the interest of workers in contingencies such as sickness, maternity, temporary or permanent physical disablement, death due to employment injury resulting in loss of wages or earning capacity. The Act also guarantees reasonably good medical care to workers and their immediate dependants.
- **Employers Liability Act, 1938 (amended 3times, in 1951 twice and 1970):** An Act to declare that certain defenses shall not be raised in suits for damages in respect of injuries sustained by workmen whereas it is expedient to declare that certain defenses shall not be raised in suits for damages in respect of injuries sustained by workmen.
- **Equal Remuneration Act, 1976(Amended once in 1987):** The Act provides for payment of equal wages for work of equal nature to Male and Female workers and not for making discrimination against Female employees.
- **Fatal accidents Act, 1855:** The objective of this act is to provide compensation to families for loss occasioned by the death of a person caused by actionable wrong.
- **Industrial Disputes Act, 1947:** The Act lays down the machinery and procedure for resolution of industrial disputes, in what situations a strike or lock-out becomes illegal and what are the requirements for laying off or retrenching the employees or closing down the establishment.
- **Industrial Employment (Standing Orders) Act; 1946:** The Act provides for laying down rules governing the conditions of employment.
- **Inter-State Migrant Workmen's (Regulation of Employment and Conditions of Service) Act, 1979:** The inter-state migrant workers, in an establishment to which this Act becomes applicable, are required to be provided certain facilities such as housing, medical aid, travelling expenses from home to the establishment and back, etc.
- **Maternity Benefit (Amendment Bill) Bill 2006:** The Act provides for leave and some other benefits to women employees in case of confinement or miscarriage, etc.

- **Minimum Wages Act, 1948 (amended 8 times in 1950, 1951, 1954, 1957, 1961, 1970, and 1986):** The employer is supposed to pay not less than the Minimum Wages fixed by appropriate Govemment.
- **Motor Transport Worker's Act,1961:** To provide for the welfare of motor transport workers and to regulate the conditions of their work.
- **Payment of Bonus Act, 1965 (amended 3times in 1976, 1980, 1995):** The Act provides for payments of annual bonus subject to a minimum of 83.3% of wages and maximum of 20% of wages.
- **Payment of Gratuity Act,1972 amended 5 times in 1984 twice,1987,1994,1999):** Gratuity is payable to an employee under the Act on satisfaction of certain conditions on separation if an employee has completed 5 years.
- **Payment of Wages Ac 1936 (amended 12 times in 1937 twice,1940,1951.1957,1960,1964,1971,1974,1976,1977,1982):** It lays down as to by what date the wages are to be paid, when it will' be paid and what deductions can be made from the wages of the workers.
- **Personal Injuries (Compensation Insurance) Act ,1970:** An Act to impose on employers a liability to pay compensation to workmen sustaining personal injuries and to provide for the insurance of employers against such liability.
- **The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 and the Cess Act of 1996:** All the establishments who carry on any building or other construction work and employs 10 or more workers are covered under this Act; the employer of the establishment is required to provide safety measures at the building or construction work and other welfare measures, such as canteens, first-aid facilities, ambulance, housing accommodation for Workers near the workplace, etc.
- **The Factories Act, 1948:** The Act lays down the procedure for approval of plans before setting up a factory, health and safety provisions, welfare provisions, working hours and rendering information-regarding accidents or dangerous occurrences to designated authorities.
- **Trade Unions Act, 1926:** The Act lays down the procedure for registration of trade unions of workers and employers. The trade unions registered under the Act have been given certain immunities from civil and criminal liabilities.
- **Workmen's Compensation Act 1923 (amended 4times in 1933,1959, 1962, 1995) :** This Act provides for compensation in case of injury by accident arising out of and during the course of employment.

6.1.5 Energy Management

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

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

- Optimizing the use of tools, plants and equipment to perform tasks with correct power.
- Optimizing cable size and joint can control voltage drops
- Use of energy efficient motors (90% efficiency or more) and pumps (at least 80% efficiency),
- Replacing inefficient lamps with the most efficient lamp for the purpose, taking into account size, shape, colour and output of the lamp.

- Replacing standard choke ballasts with high frequency electronic ballasts.
- Luminaries - retrofitting standard luminaries with high-efficiency spectacular reflectors or replacing standard luminaries with high-efficiency luminaries
- Adequate and uniform illumination level at construction sites suitable for the task,
- Use of energy efficient air conditioner.
- The engines shall be capable of delivering specified prime power rating of variable loads for PF of 0.8 lag with 10% overload available in excess of specified output for one hour in every 12 hours.
- Engine of DG set shall complies with CPCB norms
- Planning in advance and selecting location to receive and store material such that these are at the least distance from the place of use. Such an approach will result in less energy being consumed since optimum energy will be expended for transport of material.
- Maintenance schedule - setting up a maintenance schedule to clean and replace lamps on a regular basis.
- Promoting employees awareness on energy conservation
- Training staff on methods of energy conservation and to be vigilant to such opportunities
- The contractor shall design site offices for maximum daylight and minimum heat gain. The rooms shall be well insulated to enhance the efficiency of air conditioners and the use of solar films on windows may be used where feasible.

6.1.6 Hazardous Waste Management

Classification of waste as hazardous shall be in accordance with the Hazardous and Other Wastes (Management, Handling & Trans-boundary movement) Rules 2016. The contractor shall identify the nature and quantity of hazardous waste generated as a result of his activities and shall file an Application for obtaining authorization in “Form I” with Delhi Pollution Control Committee along with a map showing the location of storage area. Hazardous waste would mainly arise from the maintenance of equipment which may include used engine oils, hydraulic fluids, waste fuel, spend mineral oil/cleaning fluids from mechanical machinery, scrap batteries or spent acid/alkali, spend solvents etc. Outside the storage area, the contractor shall place a ‘display board’, which will display quantity and nature of hazardous waste on date. Hazardous Waste needs to be stored in a secure place. It shall be the responsibility of the contractor to ensure that hazardous wastes are stored, based on the composition in a manner suitable for handling storage and transport. The labeling and packaging is required to be easily visible and be able to withstand physical conditions and climatic factors. The storage of hazardous waste should not exceed 90 days and the contractor shall maintain a record of sale, transfer, storage of such waste and make these records available for inspection. The contractor shall approach only Authorized Recyclers for disposal of Hazardous Waste, under intimation to the DMRC. Used lubricants should be collected and stored in individual containers which are fully labeled in English and Hindi and stored in a designated secure place. These wastes should be sent to authorized re-cyclers, and the empty drums collected by appropriated companies for reuse or refill. The environmentally hazardous waste shall be stored in an impermeable surface with containment bounding to retain leaks, spills and ruptures.

6.1.7 Environmental Sanitation

Environmental sanitation also referred to as Housekeeping, is the act of keeping the working environment cleared of all unnecessary waste, thereby providing a first-line of defense against

accidents and injuries. Contractor shall understand and accept that improper environmental sanitation is the primary hazard in any construction site and ensure that a high degree of environmental sanitation is always maintained. Environmental sanitation is the responsibility of all site personnel, and line management commitment shall be demonstrated by the continued efforts of supervising staff towards this activity.

General environmental sanitation shall be carried out by the contractor and ensured at all times at Work Site, Batching Plant, Stores, Offices and toilets/urinals.

Towards this the Contractor shall constitute a special group of environmental sanitation personnel. This group shall ensure daily cleaning at work sites and surrounding areas and maintain a register as per the approved format by the DMRC.

Team of environmental sanitation squad shall carry out:

- Full height fence, barriers, barricades etc. shall be erected around the site in order to prevent the surrounding area from excavated soil, rubbish etc, which may cause inconvenience to and endanger the public. The barricade especially those exposed to public shall be aesthetically maintained by regular cleaning and painting as directed by the Employer. These shall be maintained in one line and level.
- The structure dimension of the barricade, material and composition, its colour scheme, logo and other details.
- All stairways, passageways and gangways shall be maintained without any blockages or obstructions. All emergency exits passageways, exits fire doors, break-glass alarm points, fire-fighting equipment, first aid stations, and other emergency stations shall be kept clean, unobstructed and in good working order.
- All surplus earth and debris shall be removed/disposed off from the working areas to officially designated dumpsites. Trucks carrying sand, earth and any pulverized materials etc. shall be covered while moving in order to avoid dust or odour impact.
- No parking of trucks/trolleys, cranes and trailers etc. shall be allowed on roads, which may obstruct the traffic movement.
- Roads shall be kept clear and materials like: pipes, steel, sand boulders, concrete, chips and brick etc. This material shall not be allowed on the roads to obstruct free movement of road traffic.
- Water logging or bentonite spillage on roads shall not be allowed.
- Proper and safe stacking of material are of paramount importance at yards, stores and such locations where material would be unloaded for future use. The storage area shall be well laid out with easy access and material stored / stacked in an orderly and safe manner.
- Flammable chemicals/compressed gas cylinders shall be safely stored.
- Unused/surplus cables, steel items and steel scrap lying scattered at different places within the working areas shall be removed to identify locations.
- All wooden scrap, empty wooden cable drums and other combustible packing materials, shall be removed from work place to identified locations.
- Empty cement bags and other packaging material shall be properly stacked and removed.
- The Contractor shall ensure that all his sub-contractors maintain the site reasonably clean through provisions related to environmental sanitation (house-keeping).

6.1.8 Utility Plan

The proposed Metro alignment run along major arterial roads of the city, which serve Institutional, Commercial and Residential areas. Large number of sub-surface, surface and overhead utility services, viz. sewers, water mains, storm water drains, telephone cables, electrical transmission lines, electric poles, traffic signals etc. already exist along the proposed alignment. These utility services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position. As such, these may affect construction and project implementation time schedule/costs, for which necessary planning/action needs to be initiated in advance. The Organizations / Departments responsible for concerned utility services are reported in Table 6.1.

Prior to the actual execution of work at site, detailed investigation of all utilities and location will be undertaken well in advance by making trench pit to avoid damage to any utility. While planning for diversion of underground utility services e.g. sewer lines, water pipe lines, cables etc., during construction of Metro, the following guidelines could be adopted:

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

- The elevated viaduct does not pose any serious difficulty in negotiating the underground utility services, especially those running across the alignment. In such situation, the spanning arrangement of the viaduct may be suitably adjusted to ensure that no foundation need be constructed at the location, where utility is crossing the proposed Metro alignment. In case of utility services running along the alignment either below or at very close distance, the layout of piles in the foundations shall be suitably modified such that the utility service is either encased within the foundation piles or remains clear of them.

Table 6.1: Organizations Responsible For Utilities And Services

S. No.	Organization/ Department	Utility/Services
1.	Delhi Jal Board	Sewerage and drainage lines. Water mains and their service lines, including hydrants and fountains etc, water treatment plants, pumping stations etc. in non NDMC area
2.	New Delhi Municipal Committee	Roads, surface water drains, nallahs, sewer lines, street lights, high mast lights etc. in NDMC area etc.
3.	Central Public Works Department	Roads, surface water drains, nallahs etc.
4.	NHAI	Roads, surface water drains, nallahs etc.
5.	NDPL and BSES	Power cables and their appurtenances, pole mounted transformers, power cables of 33 & 11KVs
6.	Mahanagar Telephone Nigam ltd. (MTNL)	Telecommunication cables, junction boxes, telephone posts, O.H. lines etc.

7.	Office of Commissioner of Police, Delhi	Traffic signal posts, junction boxes and cable connection etc.
8.	Reliance Mobile India Limited, Idea, Airtel and Tata Tele service India Limited	Telecommunication cables, junction boxes etc.
9.	Indraparastha Gas Limited	Gas Pipelines

6.1.9 Archaeological and Historical Preservation

Monuments located near the proposed alignment are listed in para 4.5.8. Prior to the initiation of construction, DMRC intends to review a resources protection plan for historic structures where it appears they may be affected by the project. This plan will be develop by the contractor in consultation with the Archaeological Survey of India (ASI) and other parties. This plan will identify the sensitive resources as well as specify the construction monitoring requirement. These requirements may include ground vibration monitoring and recording any component subjected to impact.

The tunnel for the metro network is being constructed by using the state of the art technology i.e. Tunnel Boring Machine (TBM) which gives negligible vibration. The stations are being constructed by cut and cover method which is widely accepted and the safest technique being adopted by metros in India and abroad. The above technology has been adopted successfully by DMRC in the past while carrying out works in the regulated/prohibited areas (ASI protected monuments) as well as close to public and private buildings.

Where the alignment, runs within the prohibited/regulated zone of the monuments, DMRC have to apply for No Objection Certificate (NOC) from Director of Archaeology, Archaeological Survey of India as per provision of National Monuments and Archeological Sites and Remains (Amendment & Validation Act 2010). In this regard DMRC has been obtained the NOC for 5 ASI monuments and for the rest of the 2 monuments is under process.

6.1.10 Air Pollution Control Measures

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

- The Contractor shall take all necessary precautions to minimize fugitive dust emissions from operations involving excavation, grading, and clearing of land and disposal of waste. He shall not allow emissions of fugitive dust from any transport, handling, construction or storage activity to remain visible in atmosphere beyond the property line of emission source for any prolonged period of time without notification to the Employer.

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

- The Contractor shall cover loads of dust generating materials like debris and soil being transported from construction sites. All trucks carrying loose material should be covered and loaded with sufficient free - board to avoid spills through the tailboard or sideboards.

- The temporary dumping areas shall be maintained by the Contractor at all times until the excavate is re-utilised for backfilling or as directed by Employer. Dust control activities shall continue even during any work stoppage.

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

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

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

- The Contractor shall design and implement blasting techniques so as to minimize dust, noise, and vibration generation and prevention fly rock.

6.1.11 Noise Control Measures

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

- Job rotation,
- Automation,
- Construction of permanent and temporary noise barriers,
- Use of electric instead of diesel powered equipment,
- Use of hydraulic tools instead of pneumatic tools,
- Acoustic enclosures should be provided for individual noise generating construction equipment like DG sets,
- Scheduling truck loading, unloading and hauling operation,
- Scheduling work to avoid simultaneous activities that generates high noise levels,
- Anti drumming floor and noise absorption material,
- Low speed compressor, blower and air conditioner,
- Mounting of under frame equipments on anti-vibration pad,
- Smooth and gradual control of door,
- Provision of GRP baffle on the via-duct for elimination of noise transmission,

- Provision of sound absorbing material in the supply duct and return grill of air conditioner,
- Sealing design to reduce the aspiration of noise through the gap in the sliding doors and piping holes, and
- Sound proof compartments control rooms etc.

Before start of work at site DMRC should: 1) implement a low-noise procurement policy (purchase and hire) for machinery and work equipment; 2) set desired noise-control requirements in the tender specifications (meeting national legislation as a minimum); 3) plan the work process to minimise worker exposure to noise; 4) implement a noise-control programme (for example, by planning, training, induction, site layout, maintenance activities).

Control: There will be three steps to the protection of workers from noise, using technical and organisation measures:

- Control the noise at source
- Collective measures, including work organisation;
- Personal hearing protection.

Control of noise at source: Such control measures will include:

- Using a machine with lower noise emissions;
- Avoidance of metal on metal impacts;
- Damping to reduce noise or isolating vibrating parts;
- Fitting silencers;
- Carrying out preventive maintenance: as parts become worn, noise levels can change.

Collective control measures: Actions should be taken to reduce the exposure to noise of all those who may be exposed, in addition to the steps above. On sites with more than one contractor, liaison between employers is essential. Collective measures will include:

- Isolating noisy procedures and restricting access to noisy areas;
- Interrupting the path of airborne noise through the use of noise enclosures and barriers;
- Using absorptive materials to reduce reflected sound;
- Controlling ground-borne noise and vibration by using floating slab measures;
- Organising work so that the time spent in noisy areas is limited;
- Planning to have noisy work done when as few workers will be exposed as possible;
- Implementing work schedules that control exposure to noise.

Personal hearing protection: Personal hearing protection should be used as a last resort.

- The personal hearing protection must be worn and its use enforced;
- It should be suitable for the job, type and level of noise, and compatible with other protective equipment;
- Workers should have a choice of suitable hearing protection, so that they can find the most comfortable;
- Taining should be given on how to use, store, and maintain the hearing protection

The workers employed in high noise level area could be employed in low noise level areas and vice-versa from time to time. Automation of equipment and machineries, wherever possible, should be done to avoid continuous exposure of workers to noise. At work places, where automation of machineries is not possible or feasible, the workers exposed to noise should be provided with protective devices. Special acoustic enclosures should be provided for individual noise generating equipments, wherever possible.

Workers in those sections where periodic adjustment of equipment/machinery is necessary, should be provided with sound proof control rooms so that exposure to higher noise level is reduced. During construction, there may be high noise levels due to pile driving, use of compressors and drilling machinery. Effective measures should be taken during the construction phase to reduce the noise from various sources. The noise from air compressor can be reduced by fitting exhaust and intake mufflers.

The pile driving operation can produce noise levels up to 100 dB (A) at a distance of 25-m from site. Safety precaution as stipulated in IS: 5121 (1969) 'Safety Code for Piling and other Deep Foundation' need to be adopted.

Noise level from loading and unloading of construction materials can be reduced by usage of various types of cranes and placing materials on sand or sandy bag beds.

The ballast-less track supported on two layers of rubber pads can reduce track noise and ground vibrations. In addition, providing skirting of coach shell covering the wheel will screen any noise coming from the rail wheel interaction as of propagating beyond the viaduct. Ambient noise levels at all locations are more than the noise standards.

It is proposed that during the operation phase, for the receptors which are being affected by metro operations (specially the sensitive receptors) noise barrier may be provided of height varying from 1m to 3m. It is proposed to install absorptive barrier Perforated Aluminium sheet or Perforated aluminium sheet with glass wool or mineral wool inside with a NRC value of 0.80, sturdy and weather resistant. A noise mapping study for the elevated section should be carried out to find out effect of metro operation on ambient noise level with and without adopting noise barriers. Noise barrier will be provided along the viaduct at all the sensitive receptors. The estimated cost of noise barrier is **Rs 1217.76 Lakh**.

6.1.12 Vibration Control Measures

The large forces between the wheel and the rail are the primary cause of vibration. These forces fluctuate in response to wheel and rail roughness over a wide range of frequencies. The main frequency band of train excitation is between 10Hz and 150Hz with a maximum range at approximately 30 to 50 Hz. In a building, the higher range of this frequency is noticeable as a rumbling noise that radiates from walls and floors commonly referred as ground borne noise. The building floors usually respond (resonance) with lower range of frequencies referred as ground borne vibration.

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

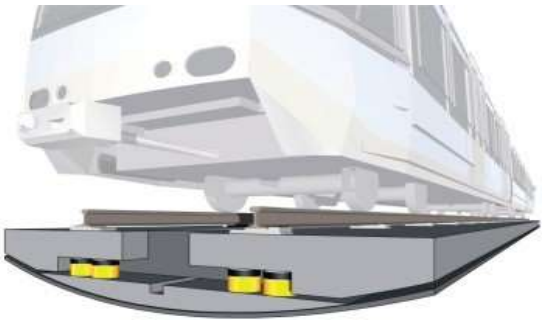
While designing the track structure for Mass Rapid Transit System all the above points have to be taken into consideration in the following ways:

- To prevent development of surface irregularities on the rail, a fairly heavy rail section of 60 kg/m, 90 UTS rail, supported at every 60 cms has been proposed. Further rail grinding at regular intervals by rail grinding machine and also lubrication of rail by vehicle mounted lubricator have been contemplated.
- Rails will be continuously welded and also will be laid to fine tolerances so that any

noise/vibration on account of track geometry could be reduced.

- The vibration generated from rail-wheel interaction will be greatly absorbed by the elastic fastening system proposed to be used.
- The lower vibration can be achieved by providing of bolster less type bogies having secondary air spring.
- In addition, locations where the alignment is close to sensitive/heritage structures, the contractor shall prepare a monitoring scheme prior to construction at such locations. This scheme shall include:
  - Monitoring requirements for vibrations at regular intervals throughout the construction period.
  - Pre-construction structural integrity inspections of historic and sensitive structures in project activity.
  - Information dissemination about the construction method, probable effects, quality control measures and precautions to be used.

Mass-spring system (MSS) should be used to reduce vibrations generated due to train movements and to protect the buildings at the surface. Mass Spring Systems (MSS) on the tracks prevent any kind of vibration from reaching the structures above these tunnels. MSS is the solution that helps in mitigating vibrations generated by the passing trains at the source itself. MSS elastically separates the track slabs in the tunnels or on the viaducts from the supporting structure. The material used for isolation is a microcellular Polyurethane Elastomer (e.g. - Sylomer from Getzner- Austria). Use of MSS helps in minimizing the transmission of vibrations (structure-borne noise) to the surrounding establishments in the vicinity of tracks. In addition MSS also effectively reduces the development of audible secondary airborne noise, which is caused by the vibration of buildings and other infrastructure component The mass- spring system, which uses soft steel coil springs in the concrete track slabs, helps in reducing vibrations and noise due to movements of train. MSS with a floating permanent way as shown in figures below:



6.1.13 Traffic Diversion/ Management

During such construction, traffic is most likely to be affected. Hence Traffic Diversion Plans are required in order to look for options and remedial measures so as to mitigate any traffic congestion situations arising out due to acquisition of road space during Metro construction. Any reduction of road space during Metro construction will result in constrained traffic flow. In order to retain satisfactory levels of traffic flow during the construction period; traffic management and engineering measures need to be taken. They can be road widening exercises, traffic segregation, one-way movements, traffic diversions on influence area roads, acquisition of service lanes, etc.

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

- 'Cut-and-Cover' method is proposed for construction of the underground stations. This means that the stretch between two points will have to be blocked during construction. However, temporary decking may be provided by blocking the road carriageway partially to permit traffic movement along the same stretch. Construction of switch- over-ramp also requires some road space.

- For elevated section wherever it is passing along the road, the requirement would be mainly along the central verge.

- As regards to the alignment cutting across a major traffic corridor, 'Continuous Cantilevered Construction Technology' would be applied to prevent traffic hold-ups or diversions of any kind.

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

Only temporary diversion plans will be required during construction of the Metro corridor. At the onset, all encroachments from road ROW will have to be removed. These encroachments vary from 'on-street' parking to informal activities. During the construction of works on underground section, it is proposed that temporary decking may be provided by blocking the road carriageway partially to permit 'through' as well as right-turning traffic movements. Total blockage of traffic along the underground section is not recommended.

Keeping in view the future traffic growth and reduction of carriageway due to Metro construction, implementation of traffic management/diversion plans shall become inevitable for ensuring smooth traffic movement and traffic diversion plans shall be formulated.

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

- All construction workers should be provided with high visibility jackets with reflective tapes at most of viaduct/tunneling and station works or either above or under right-of- way. The conspicuity of workmen at all times shall be increased so as to protect from speeding vehicular traffic.

  - ❖ Warn the road user clearly and sufficiently in advance.
  - ❖ Provide safe and clearly marked lanes for guiding road users.
  - ❖ Provide safe and clearly marked buffer and work zones
  - ❖ Provide adequate measures that control driver behavior through construction zones.
  - ❖ The primary traffic control devices used in work zones shall include signs, delineators, barricades, cones, pylons, pavement markings and flashing lights.
  - ❖ The contractor should hire a transportation consultant that carryout the traffic survey and suggest alternative routes for smooth flow of traffic.

6.1.14 Soil Erosion Control

Prior to the start of the relevant construction, the Contractor shall submit to the DMRC for approval, his schedules for carrying out temporary and permanent erosion/sedimentation control works as are applicable for the items of clearing and grubbing, roadway and drainage excavation, embankment/sub-grade construction and other structures across water courses, pavement courses and shoulders. He shall also submit for approval his proposed method of erosion/sedimentation control on service road and his plan for disposal of waste materials. Work shall not be started until the erosion/sedimentation control schedules and methods of operations for the applicable construction have been approved by the DMRC.

The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. The Contractor may be directed to provide immediate control measures to prevent soil erosion and sedimentation that will adversely affect construction operations, damage adjacent properties, or cause contamination of nearby streams or other watercourses. Such work may involve the construction of temporary berms, dykes, sediment basins, slope drains and use of temporary mulches, fabrics, mats, seeding, or other control devices or methods as necessary to control erosion and sedimentation.

The Contractor shall be required to incorporate all permanent erosion and sedimentation control features into the project at the earliest practicable time as outlined in his accepted schedule to minimize the need for temporary erosion and sedimentation control measures.

Temporary erosion/sedimentation and pollution control measures will be used to control the phenomenon of erosion, sedimentation and pollution that may develop during normal construction practices, but may neither be foreseen during design stage nor associated with permanent control features on the Project. Under no conditions shall a large surface area of credible earth material be exposed at one time by clearing and grubbing or excavation without prior approval of the DMRC.

The DMRC may limit the area of excavation, borrow and embankment operations in progress, commensurate with the Contractor's capability and progress in keeping the finish grading, mulching, seeding and other such permanent erosion, sedimentation and pollution control measures, in accordance with the accepted schedule.

Temporary erosion is sometimes caused due to the Contractor's negligence, carelessness or failure to install permanent controls. Sedimentation and pollution control measures then become necessary as a part of the work as scheduled or ordered by the DMRC, and these shall be carried out at the Contractor's own expense. Temporary erosion, sedimentation and pollution control work required, which is attributed to the Contractor's negligence, carelessness or failure to install permanent controls, will be performed as ordered by the DMRC.

6.1.15 Muck Disposal

Owing to paucity of space in the busy cities and for safety reasons, elaborate measures need to be adopted for collection, transfer, storage and disposal of excavated muck. Muck shall be collected in containers from the construction sites, transported and consolidated at dumping ground and then transferred to disposal sites. Dumping areas are essential to store the excavated earth temporarily for back filling at later date and final disposal.

Disposal of excess soil will be permitted in low lying areas owned by land owning agencies. The

excess excavated soil will be reused at another site in consultation with DDA/other authority/agency. The excess soil disposal site will be those identified by land owning agency and communicated to DMRC. The transfer and disposal of surplus soil may create air pollution and leached water problem. To mitigate these problems following mitigation measure are proposed to be adopted:

1. The disposal sites will be cleaned and then treated so that leached water does not contaminate the ground water.
2. Material will be stabilized each day by watering or other accepted dust suppression techniques.
3. The height from which soil will be dropped shall be minimum practical height to limit the dust generation.
4. The stockpiling of earth in the designated locations with suitable slopes.
5. During dry weather, dust control methods such as water sprinkling will be used daily especially on windy, dry day to prevent any dust from blowing.
6. Sufficient equipment, water and personnel shall be available on dumping sites at all times to minimise dust suppression.
7. Dust control activities shall continue even during work stoppages.
8. The muck shall be filled in the dumping site in layers and compacted mechanically. Dumping sites on sloping ground shall be protected adequately against any possible slide/slope failure through engineering measures.
9. It is desirable to first clean the disposal area site for vegetation biomass exists over it. The faces and top should be treated/vegetated to avoid erosion. Once the filling is complete, the entire muck disposal area shall be provided with a layer of good earth on the top, dressed neatly, and covered with vegetation.
   Before excavation, the Contractor will be required to test the soil quality including heavy metals and the results will be compared with US EPA standards. If the soil is contaminated, the polluter will be responsible for treatment and disposal.

6.1.16 Construction and Demolition Waste

The construction and demolition waste can be managed by the following ways;

- Construction & Demolition (C&D) waste shall be stored at a designated area.
- The contractor shall be responsible for collection, segregation and storage of construction and demolition waste, as directed or notified by the concerned local authority in consonance with the Construction & Demolition Waste Management Rules, 2016.
- The contractor shall ensure that other waste does not get mixed with this waste and is stored and disposed separately.
- The contractor shall dispose C&D waste only at authorized processing facilities and ensure that there is no littering or deposition of construction and demolition waste so as to prevent obstruction to the traffic or the public or drains.
- The requirement of concrete/RCC/PCC waste disposal, generated from the entire contract shall be either when 15 Tonnes of C&D waste has been generated or such C&D waste has been stored for 15 days (irrespective of quantity), of the two whichever is earlier.
- A minimum of 10% of C&D recycled products shall be used for external development and road works for finishing contracts. Before accepting recycled products, the same shall be tested as per required specifications. The recycled materials products shall be used in non structural members like kerb stone, paver tiles in foot path, earth filling, use of bricks in non-load bearing partition walls, boundary walls, toe walls, recycled aggregates in lean concrete/PCC etc.

6.1.17 Draining of Water from Tunnel

Problems of water flow associated with tunneling are bound to take place where water table is low. In cut and cover type construction continuous pumping is an economical alternative.

The well point system is recommended for dewatering as the volume of water to be pumped out is not large. The deep well system is adopted where the water table has to be lowered over a large depth in a small area. The deep wells can be installed either inside or outside the diaphragm walls or inside the cut.

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

The dewatering can be achieved by:

- Leading the ground water to a sump by drains and pump out the water from the sump.
- To prevent loss of fines, inverted filter may have to be used.
- Dewatering as suggested above may not be effective in preventing sand flows. Lowering of the ground water by properly designed single or double stage well points will be effective in such cases.
- The construction of diaphragm walls of concrete along the side of channels, before the commencement of excavation will be required. The concrete walls are taken down to rest on bed rock or impervious strata or, in their absence, deep enough below the bottom of excavation, to serve as an effective cut off for the inflow of ground water into the proposed excavation. The trenches are made in lengths of 2.5 to 5m and kept continuously filled with a thiotropic material like Bentonite slurry, which has the effect of stabilising the trench and preventing any subsidence. As the excavation proceeds, concrete wall can be strutted mutually or anchored with surrounding rocks or soil with long tie rods.
- During operation phase, seepage water have to be drained along the side of walls (retaining). Proper drainage system need to be incorporated in design and implemented during construction phase.
- The pumped water from sump wells will be put into storm water drain to avoid any load to waste water treatment plants. These storm water drains finally join natural existing streams/nallahs.

6.1.18 Water Supply, Sanitation and Solid Waste Management

The public health facilities, such as water supply, sanitation and toilets are much needed at the stations. Water should be treated before use up to WHO drinking water standards. The collection and safe disposal of human wastes are among the most important problems of environmental health. The water carried sewerage solves the excreta disposal problems. The sewerage disposal systems should be adopted for sewage disposal. Drinking water and raw water requirement for underground and elevated stations shall be provided from municipal source.
Wastewater from station will either be treated by onsite STP or discharged to the existing

sewage network. The waste generated from stations is primarily solid waste comprising paper and plastic from eatables consumed by commuters. The waste shall be collected in bins marked for two types- bio-degradable and others. To avoid odour and the accumulation of fly-supporting materials, garbage containers shall be washed at frequent intervals. This shall be collected and transported to local municipal bins for onward disposal to disposal site by municipality.

During construction wastewater (e.g. wash water) from the concrete batching plant and Casting yard will be collected into a sedimentation tank (2 chamber), and the treated water will be reused on site (e.g. water sprinkling), No discharge will be allowed outside of the premises.

During construction there will be excessive usage of ground water. During operation, as mitigation measures rainwater harvesting will be carried out at stations. To avoid excess usage of water during construction following measures will be taken to reduce water consumption.

1. Recycle of water consumed in wheel washing.
2. Recharge of discarded water from RO plant should be explored where ever practically feasible.
3. Water from dewatering will also be used for ground water re-charge.

6.1.19 Construction of Bridge on River Yamuna

Following measures will be taken to avoid impacts on the environment

- No polluting vehicles, construction machineries and plants allowed
- Use of ready mix concrete for concreting
- Disposal of construction and demolition waste at recycling plant at Burari and using recycled material such as paver blocks in the project.
- Using of non polluting polymer in the pile foundation
- No use of hazardous materials which can contaminate water/soil
- No harm to aquatic flora and fauna
- Vehicles carrying construction materials and debris shall also be covered
- Construction material stored on the site shall be fully covered to avoid dispersal of dust in the air
- Environmental quality monitoring at site

6.1.20 Rain water harvesting

Seven out of the nine revenue districts of Delhi are considered critical in regard to ground water resources. Taking into account the depleting ground water resources in Delhi, Central Ground Water Authority had declared whole of South and South West districts of NCT Delhi as “Notified Areas” in August, 2000 and imposed prohibition and restriction in these districts on the construction and installation of any new structure for extraction of ground water resources to avoid further depletion and deterioration in water quality in the said districts. Central Ground Water Authority through its public notices issued between 3/2001 and 8/2004 has directed Group Housing Societies/ Institutions/ Schools/Hotels /industrial establishments/Farm Houses in South and South–West Districts and group housing societies located outside notified areas of NCT Delhi (where ground water levels are more than 8 meters below the ground surface) to adopt Roof top Rain water Harvesting systems in their premises. Ministry of Urban Development & Poverty Alleviation (Delhi Division), Govt. of India by its notification dated 28.7.2001 had made modification / additions in the building Bye laws 1983 as under:

i) Water harvesting through storing of water runoff including rain water in all new building on plots of 100 sq. meters and above will be mandatory. The plans submitted to the local bodies shall indicate the system of storm water drainage along with points of collection of the water in surface reservoirs or in recharge wells.

ii) All buildings having a minimum discharge of 10,000 liters and above per day shall incorporate waste water-re-cycling system. The recycled water should be used for horticultural purposes.

To conserve and augment the storage of groundwater, it has been proposed to construct roof top rainwater harvesting structure of suitable capacity at the elevated stations and in the elevated alignment. Each pillar can have inbuilt downpipes to collect the rainwater from the viaduct and into the underground tanks on the median. A recharge tank shall be constructed at suitable distance. The water collected will percolate down to the subsoil through numerous layers of sand, gravel and boulders. Total elevated length of the corridors is about 31 km. Annual rainfall of Delhi is 611.8mm per year. Considering a runoff coefficient of 0.85 the annual rainwater harvesting potential of elevated stations and elevated section is estimated as 1,65,605 cum.

6.2 TRAINING AND EXTENSION

The training for engineers and managers will be imparted by DMRC on regular basis to implement the environmental protection clauses of the tender document and to implement the best environmental practices during the construction phase. The course content can be drawn from past experiences of Delhi Metro. These training programs will be imparted through regular training workshops in which presentations will be made on a variety of issues pertaining to environmental management so as to sensitise the participants and raise their awareness on environmental issues in general and conditions of contract on environment, in particular. These programmes could be extended for the local population for their active participation in the project implementation. Apart from training, such programme should include guidelines for safety, methods of disaster prevention, action required in case of emergency, fire protection, environmental risk analysis etc. The cost involved for such programme is presented in **Table 6.2.**

Table 6.2: Cost for Training Programme

S. No	Item	Cost (Rs)
1	Curriculum Development and course preparation 1 months Rs.50000/month	50,000
2	5 Extension Officer (1 year) Rs.35,000/ month	21,00,000
3	Instructor 10 sessions of 10 days each	3,00,000
4	Demonstration/Presentation Aids	50,000
5	Material etc	50,000
Total		**25,50,000**

6.3 DISASTER MANAGEMENT

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

Preventive Action

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

Reporting Procedures

The level at which a situation will be termed a disaster shall be specified. This shall include the stage at which the surveillance requirements should be increased both in frequency and details. The Engineer-in-Chief should notify the officer for the following information:

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

Communication System

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

Emergency Action Committee

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

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

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

- Demarcation of the areas to be evacuated with priorities,

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

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

Success of an emergency plan depends on public participation, their response to warning notifications and timely action. Public has to be educated on the hazards and key role in disaster mitigation by helping in the planned evacuation and rescue operations.

It is essential to communicate by whom and how a declared emergency will be terminated. There should be proper notification to the public on de-alert signals regarding termination of the emergency. The notification should be clear so that the evacuees know precisely what to do when re-entering or approaching the affected areas.

6.4 EMERGENCY MEASURES

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

Emergency Lighting

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

Fire Protection

The building materials should be of appropriate fire resistance standard. For underground structures the fire resistance period should be at least 4 hours, and 2 hours for surface or over head structures. Wood shall not be used for any purpose, excluding artificial wood products, which are flame resistant. The materials which have zero surface burning characteristics need to be used. The electrical systems shall be provided with automatic circuit breakers activated by the rise of current as well as activated by over current. The design of a station will include provision for the following:

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

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

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

· Downstand bulkheads of a minimum depth of 600 mm to provide smoke containment. These will be provided around openings for escalators, lifts and stairs in underground stations,

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

· In enclosed public areas of above ground stations (e.g. a concourse located below a platform) arrangement for smoke extraction will be provided.

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

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

Fire of electrical origin, water cannot be used until the electric system has been made dead and earthened. For electrical fires, non-aqueous agents like ABC Power Chloro Bromo Methane or CO_2 gas are utilized for fire fighting. Fire extinguishers with these agents shall be liberally provided at static installations and on the rolling stock.
Generally there are often more casualties from smoke inhalation than from burning. Smoke need to be transported away from the site of the fire. In order to achieve this, both fresh air has to be introduced into the underground section and exhaust gases should be sucked out from other section.

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

A. Fire Prevention and Safety Measures

Fire prevention measures will be designed and implemented to minimize the risk of outbreak of fire by appropriate choice, location and installation of various materials and equipment. In

stations planning, potential sources of fire can be reduced by:

i. Fire Prevention

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

ii. Safety

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

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

B. Fire Alarm and Detection System

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

Manually operated call points shall be provided at every hydrant and nose reel points, station head wall, tail wall and other locations. Alarm bells shall be installed in each plant room complex at both platform and concourse level and shall be clearly audible at all points in the room/area.

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

Smoke probe units shall be installed in rooms/compartments. When an alarm point is operated, the fire pump shall start to operate automatically. A station fire control and indicating panel shall

be provided an installed in the station controllers room, for the control, indication and monitoring of the whole detection and fire fighting systems. While designing the fire fighting system, the zone of Delhi Fire Services shall be taken into account for linking with the same.

C. Fire Control Measures

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

D. Access for Fireman

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

Ventilation Shafts

The Environmental Control system for underground stations requires ventilation openings between various plants, plant rooms and the atmosphere. The tunnel vent shafts of approximately 20 sq. m. area will be constructed at each end of the stations. There shall be supply shaft and exhaust shafts of similar dimensions at the stations. Three mid shaft in Aerocity to Tughlakabad corridor may be required at three locations in between Mashoodpur to Kishangarh , Kishangarh to Mehrauli and Tigri to Anandmayee Marg and three mid shaft in Inderlok to Indraprastha corridor may be required at three locations in between Ajmal Khan park to Nabi Karam , Nabi Karam to New Delhi and Delhi Gate to Delhi Sachivalaya.

Emergency Door

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

6.5 SUMMARY OF ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The environmental impacts stemming out of the proposed project can be mitigated with simple set of measures, dealing with careful planning and designing of the metro alignment and structures. Adequate provision of environmental clauses in work contracts and efficient contract management will eliminate or reduce significantly all possible problems. A common problem encountered during implementation of environmental management plans of such projects is lack of environmental awareness among engineers and managers concerned with day to day construction activities, which can be solved through regular environmental training programs. A set of preliminary EMP is presented in **Table 6.3,** whichdefines actions to be undertaken during the design stage, pre-construction, construction and operation stage of the project. The effectiveness of environmental considerations will, however, depend on appropriate inclusion of these in the work contracts.

The major concern during the construction stage is that the contractors, due to lack of

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

In addition to that DMRC, should prepare and established Environmental and Health Policy and Procedures as per Phase III and that should become an integral part of contract document.

Operational phase mitigation would involve good environmental sanitation (housekeeping) practice at metro establishments including effective solid waste collection and disposal, wastewater disposal, upbringing of plantations and green area. Protection of earth slopes in landslide prone area would be a very important task. During the operation period, the metro operating unit will be required to confirm receipt of the construction period mitigation report through the PIU and prepare a follow on timetable of actions.

Table 6.3: Environmental Management Action Plan (Emp)

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
DESIGN PHASE				
Metro Alignment	The proposed corridor alignment was selected to minimise the land disturbance to avoid archaeological sites, temples and other environmentally sensitive areas in least.	During Design	DPR and design consultant	PIU
Cultural Heritage	Avoided by adjustment of alignment.	During Design	DPR and design consultant	PIU
Flood	Bridges shall be well designed	During Design	DPR and design consultant	PIU
Loss of Water Bodies	Utmost care taken to avoid alignment crossing water bodies	During Design	DPR and design consultant	PIU

Inadequate design provision for safety against seismological hazard	Make sure that design provides for safety of structures against worst combination of forces in the probability of an earthquake likely to occur in seismic zone-III.	DPR and detailed design stage	DPR and design consultant	PIU
PRE –CONSTRUCTION STAGE				
Water requirement	The requirement of water shall be for construction purpose etc., shall be planned and shall be arranged in order to avoid digging of Tube wells.	Pre construction stage	Contractor	PIU/EMP implementing agency
Disposal of final treated effluent from treatment plat	Options for final disposal shall be studied and the suitable disposal route shall be decided carefully to minimize the impact of receiving bodies. As far as possible zero discharge rules may be adopted.	During design stage / and pre construction of treatment plant	Contractor	PIU/EMP implementing agency
CONSTRUCTION PHASE				
Environmental Management and Monitoring	This will include institutional requirements, training, environmental management and monitoring	During and after construction	Contractor	PIU/EMP implementing agency
Dust	Water should be sprayed during construction phase, wherever it is required to avid dust. Vehicles delivering materials should be covered to reduce spills and dust blowing off the load.	During construction	Contractor	PIU/EMP implementing agency
Air Pollution	Vehicles and machinery are to be regularly maintained so that emissions conform to National and State AAQ Standards.Regulations covering emissions standards for ambient air quality are at **Annexure 1.4.** Construction equipment vehicle emission norms are given in **Annexure 6.1.**	Beginning with and continuing throughout construction	Contractor	PIU/EMP implementing agency
Equipment Selection maintenance and operation	Construction plants and equipment will meet recognized international standards for emissions and will be maintained and operated in a manner that ensures relevant air, noise, and discharge regulations are met.	During construction	Contractor	PIU/EMP implementing agency

Noise	Noise standard will be strictly enforced at construction sites. Workers in vicinity of strong noise will wear earplugs and their working time should be limited as a safety measure. At construction sites within 150m of sensitive receptors construction will be stopped from 22:00 to 06:00. Temporary noise barriers shall be installed for silence zones including schools and hospitals.	Beginning and through construction	Contractor	PIU/EMP implementing agency
Vibration	The vibration level limits at work sites adjacent to the alignment shall conform to the permitted values of peak p velocity as given in article project SHE Manual	Beginning and through construction	Contractor	PIU/EMP implementing agency
WATER				
Contamination from Wastes	All justifiable measures will be taken to prevent the wastewater produced in construction from entering directly into rivers and irrigation system	Throughout construction period	Contractor	PIU/EMP implementing agency
Wastage of water	Measures shall be taken to avoid misuse of water. Construction agency shall be instructed accordingly to follow strict procedures while using the water for construction and drinking	Beginning with and continuing throughout construction	Contractor	PIU/EMP implementing agency

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
	purpose.			
Sewerage disposal during construction at Service Centres	A minimum distance of any sewage or toilet facility from water sources should be 200 meters	Throughout construction period	Contractor	PIU/EMP implementing agency
Sanitation and Waste Disposal in Construction Camps	Sufficient measures will be taken in the construction camps, i.e. provision of garbage tank and sanitation facilities. Waste in septic tanks will be cleared periodically. Drinking water will meet Indian National Standards. Garbage will be collected in a tank and disposed of daily. Special attention shall be paid to the sanitary condition of camps. Camps will be located at a minimum distance of 200 m from water sources.	Before and during building of construction camps	Contractor	PIU/EMP implementing agency
SOIL				
Quarrying	Quarrying will be carried out at approved and licensed quarries only.	During construction	Contractor	PIU/EMP implementing agency
FLORA AND FAUNA				
Loss of trees and Avenue Plantation	Areas of tree plantation cleared will be replaced according to Compensatory afforestation Policy under the Forest Conservation Act. Trees will be planted against every tree cut as per norms.	After completion of construction activities	Forest Department	Forest Department
SOCIAL				
Loss of Access	Temporary access should be built at the interchange and other roads.	During construction	Contractor	PIU/ Traffic departme

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
				nt
Traffic jams and congestion	If there are traffic jams during construction, measures should be taken to relieve the congestion with the co-ordination of transportation and traffic police department	During construction	Contractor	PIU/ Traffic department
Safety with vehicles, people and livestock and signage	Safety education and fines. Allow for adequate traffic flow around construction areas Provide adequate signage, barriers and flag persons for safety precautions. Communicate to the public through radio, TV & newspaper announcements regarding the scope and timeframe of projects, as well as certain construction activities causing disruptions or access restrictions	During construction	Contractor	PIU/ Traffic department
Increase in disease Water-borne Insect-borne Communicable diseases	Make certain that there is good drainage at all construction areas, to avoid creation of stagnant water bodies. Provide adequate sanitation and waste disposal at construction camps. Provide adequate health care for workers and locate camps away from vulnerable groups	During construction At start-up Throughout construction	Contractor	PIU/EMP implementing agency
Location of camps depots and storage areas	Location of camps depots and storage areas shall be as per the contract specifications.	Throughout construction	Contractor	PIU/EMP implementing agency
OPERATION PHASE				
Noise and Vibration	Noise barriers shall be installed on viaduct at sensitive locations. The	After completion of	PIU/EMP implementi	PIU/EMP implemen

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implement ing Organizati on	Responsi ble Organiza tion
	public shall be educated about the regulations of noise and vibration pollution and its implications.	construction	ng agency	ting agency
WATER				
Oil pollution	Suitable treatment shall be taken for treatment oil before discharging the wastewater specially in depot areas.	During operation of the treatment plant	PIU/EMP implementi ng agency	PIU/EMP implemen ting agency
Maintenance of Storm Water Drainage System	The urban drainage systems will be periodically checked and cleared so as to ensure adequate storm water flow.	Beginning and end of monsoon	PIU/EMP implementi ng agency	PIU/EMP implemen ting agency
Disposal of final treated effluent from treatment plat	Options for final disposal shall be studied and the suitable disposal route shall be decided carefully to minimize the impact of receiving bodies. As far as possible zero discharge rules may be adopted.	During operation of the treatment plant	PIU/EMP implementi ng agency	PIU/EMP implemen ting agency
SOCIAL				
Safety and noise disturbance s	New buildings should be prohibited within 50 m of the edge of carriageway. No new schools and hospitals should be allowed within 200 m of carriageway.	Throughout and after project development period.	Planning Departmen t /PIU	PIU/EMP implemen ting agency

7. ENVIRONMENTAL MONITORING PLAN

7.1 PRE-CONSTRUCTION PHASE

The environmental monitoring programme is a vital process of any Environmental Management Plan (EMP) of development project for review of indicators and for taking immediate preventive action. This helps in signalling the potential problems resulting from the proposed project activities and will allow for prompt implementation of corrective measures. Environmental monitoring should be an integral part of works towards better environmental management of air, noise, vibration, water quality etc both during construction and in operation phases of the project. Generation of dust and noise are two main issues during any large construction activity. Degradation of water quality is another. The parameters monitored in pre- construction, construction and operation phase are based on the need to evaluate the deviation of environmental conditions from baseline environmental conditions due to construction and operation of the Metro. The environmental monitoring will be required during both construction and operational phases. The following parameters are proposed to be monitored:

- Water Quality, Air Quality,
- Noise and Vibration,
- Environmental Sanitation and Waste Disposal,
- Ecological Monitoring and Afforestation,
- Workers Health and Safety

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

7.2 CONSTRUCTION PHASE

During construction stage environmental monitoring will be carried out for air quality, noise levels, vibrations, water quality and ecology. At this stage it is not possible to visualize the exact number of locations where environmental monitoring must be carried out. However keeping a broad view of the sensitive receptors and also the past experience an estimate of locations has been made and are summarized in **Table 7.1**. These numbers could be modified based on need when the construction actually commences.

7.2.1 Water Quality

Since water contamination leads to various water related diseases, the project authorities shall establish a procedure for water quality surveillance and ensure safe water for the consumers. The water quality parameters are to be monitored during the entire period of project construction to ensure that water is safe for drinking purpose. Monitoring should be carried out by NABL certified private or Government agency. Water quality should be analyzed following the procedures given in the standard methods. Parameters for monitoring will be as per BIS: 10500. The monitoring points could be ground and surface water. The purpose of monitoring quality of water is to ensure that output water meets standards for drinking and construction during construction phase.

7.2.2 Air Quality

Air quality is regularly monitored by Delhi Pollution Control committee at number of places in Delhi. In addition to these, air quality should be monitored at the locations of baseline monitoring. The parameter recommended is Particulate Matter ($PM_{2.5}$ and PM_{10}), SO_2, NO_X, CO and HC. The contractor will be responsible for carrying out air monitoring during the entire construction phase under the supervision of DMRC.

7.2.3 Noise and Vibration

The noise and vibration will be monitored at construction sites for entire phase of construction by the site contractor and under the supervision of DMRC.

7.2.4 Ecological Monitoring

The project authority in coordination with the Department of Forest shall monitor the status of ecology/trees along the project corridor at least once in a year during construction phase in order to maintain the ecological environment and to monitor the survival rate of planted trees. The plantation/afforestation of trees by Department of Forest Government of Delhi will be review once in a year during construction phase.

7.2.5 Soil Quality

Soils quality monitoring is to be carried out at underground stations to ascertain the presence of soil polluting chemicals due to construction activities. The parameters required to be monitored are: pH, Sodium, Potassium, Chloride, Nitrogen, Phosphorous, Organic Matter, Heavy Metals (Mercury, Cadmium, Arsenic, Cyanide, lead, chromium), Oil and Grease. The monitoring is to be carried out by contractor through NABL accredited private or government agency.

7.2.6 Workers health and safety

Monitoring of health risk issues that might arise throughout the project life time will be done. Epidemiological studies at construction sites will be performed to monitor the potential spread of diseases. Regular inspection and medical checkups shall be carried out to workers health and safety monitoring. Any reoccurring incidents such as irritations, rashes, respiratory problems etc shall be recorded and appropriate mitigation measures shall be taken. Contractor will be the responsible person to take care health and safety of workers during the entire period of the construction and project proponent is responsible to review/audit the health and safety measures/plans. The monitoring Schedule for Water Air, noise, vibration, and water are presented in **Table 7.1.** The estimated cost for monitoring during construction is 117 Lakh.

Table 7.1: Construction Stage Monitoring Schedule

ITEMS	DESCRIPTION
Air	
Parameters to be monitored	$PM_{2.5}$ and PM_{10}, SO_2, NO_X, CO and HC
Locations and frequency	2x24 Hour, twice in a month at 15 locations for 5 years.
Standard	National Ambient air quality standards, 18th November 2009
Responsible organisation	Contractor through NABL accredited lab
Noise	
Parameters to be monitored	Leq, L_{90}, L_{50},L_{10}, L_{max}, L_{min} (for both day and night).
Locations and frequency	24 hours once a week at 15 locations for 5 years.
Standard	The Noise Pollution (Regulation and Control) Rules, 2000

Responsible organisation	Contractor through NABL accredited lab
Vibration	
Parameters to be monitored	ppV
Locations and frequency	24 hours once a week at 8 locations for 5 years.
Standard	ISO 8041:1990 (Day time and night time)
Responsible organisation	Contractor
Water	
Parameters to be monitored	pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids, Chlorides, Nitrates, Sulphates, Iron, Calcium, Total Nitrogen, Lead, Total Phosphates, oils and grease.
Locations and frequency	Once in a six months at 10 locations for 5 years.
Standard	CPCB (BIS 10500:2012)
Responsible organisation	Contractor through NABL accredited lab
Soil Quality	
Parameters to be monitored	pH, Sodium, Potassium, Chloride, Nitrogen, Phosphorous, Organic Matter, Heavy Metals (Mercury, Cadmium, Arsenic, Cyanide, lead, chromium), Oil and Grease
Locations and frequency	Once in a six months at 10 locations for 5 years.
Responsible organisation	Contractor through NABL accredited lab

7.3 OPERATION PHASE

Even though the environmental hazards during the operation phase of the project are minimal, the environmental monitoring will be carried out for air, noise, vibration, water and ecology during operation phase of the project. The parameters monitored during operation will be Particulate Matter ($PM_{2.5}$ and PM_{10}), SO_2, NO_X, CO and HC for air. Drinking water quality parameters will be monitored as per BIS 10500 to ensure that output water meets standards for drinking. Input and output water of treatment plants will be monitored to check the performance of the treatment plants so that water can be used for horticulture. The monitoring schedule is presented in **Table 7.2**. The estimated cost for monitoring during operation is 40.59 Lakh. The monitoring program shall be conducted by an external agency certified by NABL under the supervision of Delhi Metro. Project Operator i.e. DMRC will be responsible for successful environmental monitoring of the proposed project during operation phase.

Table 7.2: Operation Stage Monitoring Schedule

ITEMS	DESCRIPTION
Air	
Parameters to be monitored	$PM_{2.5}$ and PM_{10}), SO_2, NO_X, CO and HC
Locations and frequency	2x24 Hour, once in a month at 8 locations for 3 years.
Standard	National Ambient air quality standards,18th November 2009
Responsible organisation	DMRC
Noise	
Parameters to be monitored	Leq, L90, L50,L10, Lmax, Lmin (for both day and night).
Locations and frequency	24 hours four time a year for 1st year and that than once a year at 8 locations for 3 years.
Standard	The Noise Pollution (Regulation and Control) Rules, 2000
Responsible organisation	DMRC
Vibration	
Parameters to be monitored	ppV

Locations and frequency	24 hours four time a year for 1st year and that than once a year at 8 locations for 3 years.
Standard	ISO 8041:1990 (Day time and night time)
Responsible organisation	DMRC
Water	
Parameters to be monitored	pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids, Chlorides, Nitrates, Sulphates, Iron, Calcium, Total Nitrogen, Lead, Total Phosphates, oils and grease.
Locations and frequency	Once a year at 5 for 3 years.
Standard	CPCB (BIS 10500:2012)
Responsible organisation	DMRC

The results of Air quality, water quality, waste water, vibration will be submitted to management quarterly during construction phase and semi annually during operation phase. Frequency and number of locations of monitoring shall be reviewed upon feedback during operation. The reporting formats of these results are presented at **Annexure 7.1.**

7.4 STRENGTHING OF ENVIRONMENTAL DIVISION

Delhi Metro has an Environment Division. This division needs to be strengthening at the initial stage of the Phase IV project itself due to increase in metro network. The division should be strengthening with an Environmental Officer and an Environment Engineer. The task of the division would be to supervise and coordinate studies, environmental monitoring and implementation of environmental mitigation measures, and it should report directly to Chief Engineer of the project authority. Organizational setups for Environmental Monitoring during construction and operation phase are shown in **Figure 7.1** and **Figure 7.2.** Progress of the division should be reviewed by an Environmental Advisor once in a year. The environmental Advisor should be an experienced expert familiar with environmental management in similar projects. Costs for the first ten years (including 10% annual increase has been) given **Table 7.3**.

Table 7.3: Environmental Division Costs

S No	ITEM	COST (Rs)
A	**Capital Cost**	
	Office Furnishings (Computer, furniture etc) LS	2,00,000
B	**Recurring Cost**	
	Man Power Cost (For 12 months)	
	Environmental Officer @ Rs. 70,000/month	8,40,000
	Environmental Engineer/Assistant @50000/month	6,00,000
	Office Maintenance and consumables @ Rs. 10,000/month	1,20,000
C	**Sub Total (A+B)**	**17,60,000**
	Miscellaneous and unforeseen expenses, LS (10 % of C)	1,76,000
	Total cost for establishment of cell for 1 Year	**19,36,000**
	Total cost for 10 years with 10% annual increase	**1,78,11,200**

Figure 7.1: Organizational Setup during Construction Phase

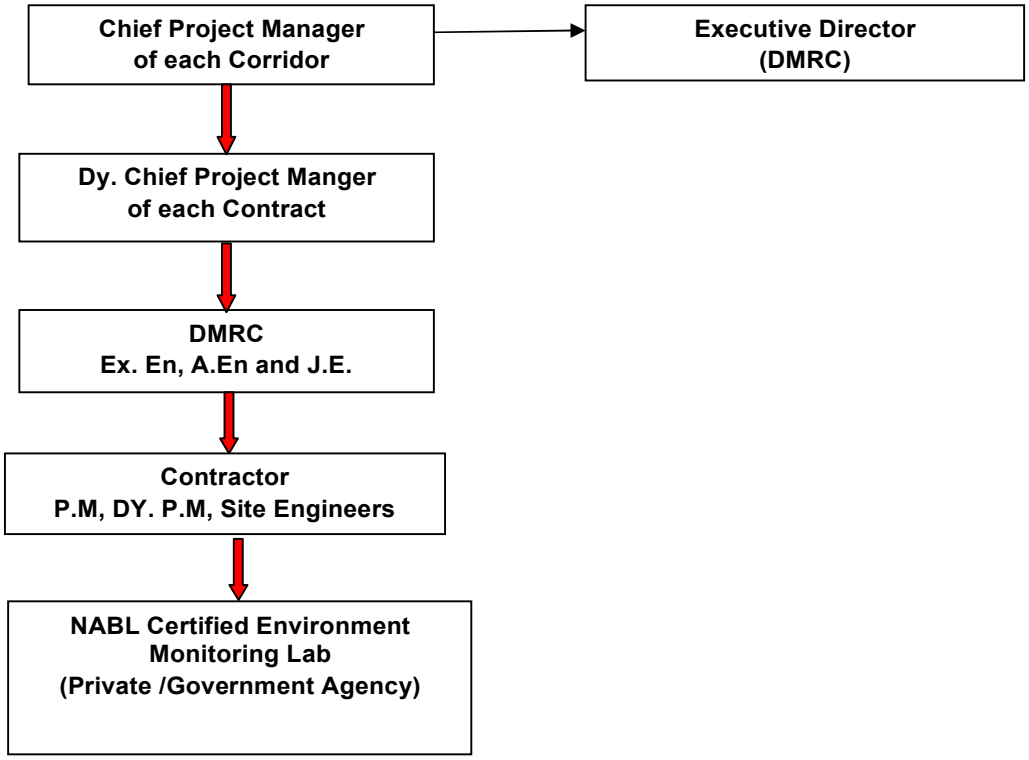
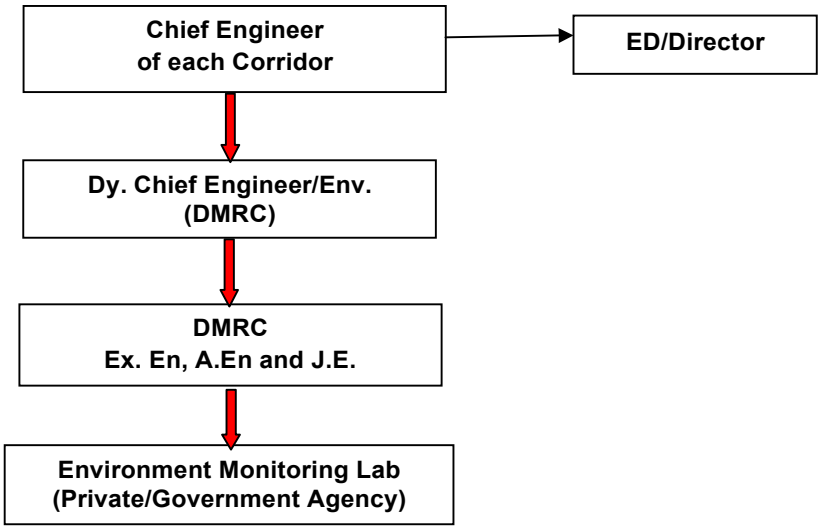


Figure 7.2: Organizational Setup during Operation Phase



8. COST ESTIMATES

8.1 SUMMARY OF COSTS

Estimated cost of measures for environmental management and monitoring are presented in **Table 8.1.**

Table 8.1: Environmental Costs

S. No.	Item	Cost (Rs. Lakh)
1	Compensatory Afforestation	35498.23
2	Noise barriers on viaduct during operation	1217.76
3	Monitoring of Air, Noise, vibration, Water, wastewater and solid waste during construction and operation	157.59
4	Strengthening of Environment Division	178.11
5	Training And Extension	25.50
	Total	**37077.19**

Annexure 1.1

DRINKING WATER QUALITY STANDARDS (IS 10500:2012)

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

A

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

A-

Annexure 1.2

EFFLUENT DISCHARGE STANDARDS (INLAND SURFACE WATER)

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

S.No.	Parameter	Unit	Standards
27	Phenolic compounds (as C_6H_5OH), Max.	mg/l	1.0
28	Radioactive Materials □ Emitters, □curie/ml, Max. □ Emitters, □curie/ml, Max.	mg/l	 10^{-7} 10^{-6}
29	Bio-assay test	mg/l	90% survival of fish after 96 hours in 100% effluent
30	Manganese (as Mn)	mg/l	2.0
31	Iron (as Fe)	mg/l	3.0
32	Vanadium (as V)	mg/l	0.2
33	Nitrate Nitrogen	mg/l	10.0

Annexure 1.3

TOLERANCE LIMITS FOR INLAND SURFACE WATER QUALITY

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

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

Annexure 1.4

NATIONAL AMBIENT AIR QUALITY STANDARDS

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

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

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

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

Annexure 1.5

NATIONAL AMBIENT NOISE STANDARDS

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

Source: Central Pollution Control Board

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

7 Night time shall mean from 10.00 p.m. to 6.00 a.m.

8 Silence zone is an area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority

9 Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

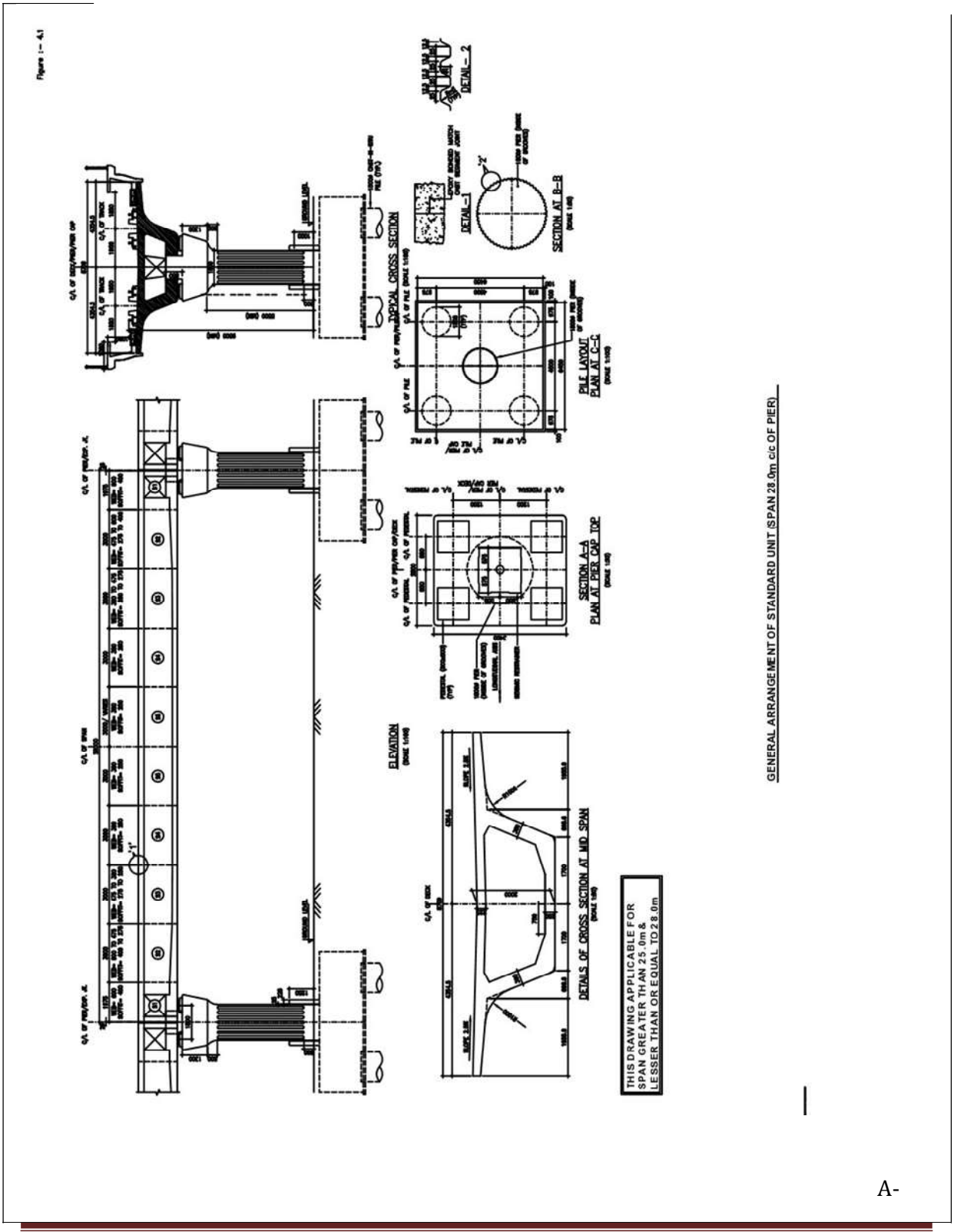
* dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.

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

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

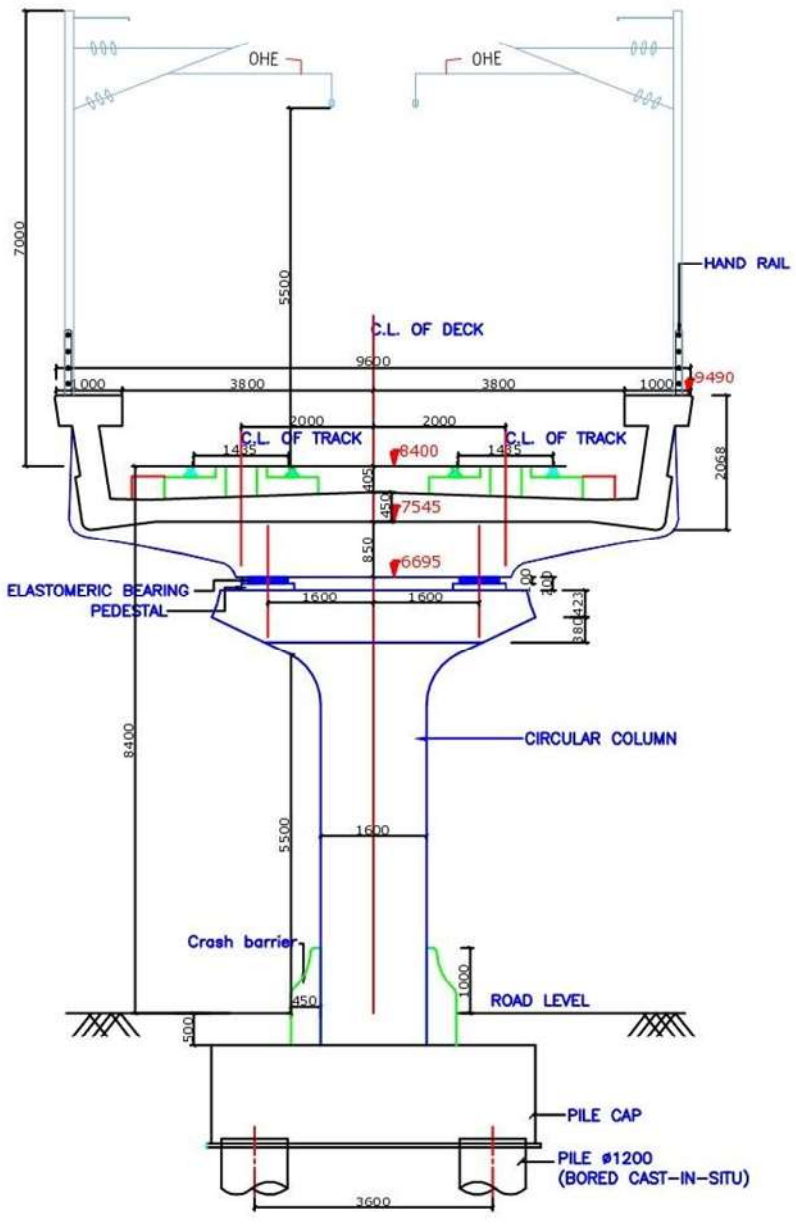
Leq: It is an energy mean of the noise level over a specified period

General Arrangement of Standard Unit (span 28 m c/c of Pier)



A-

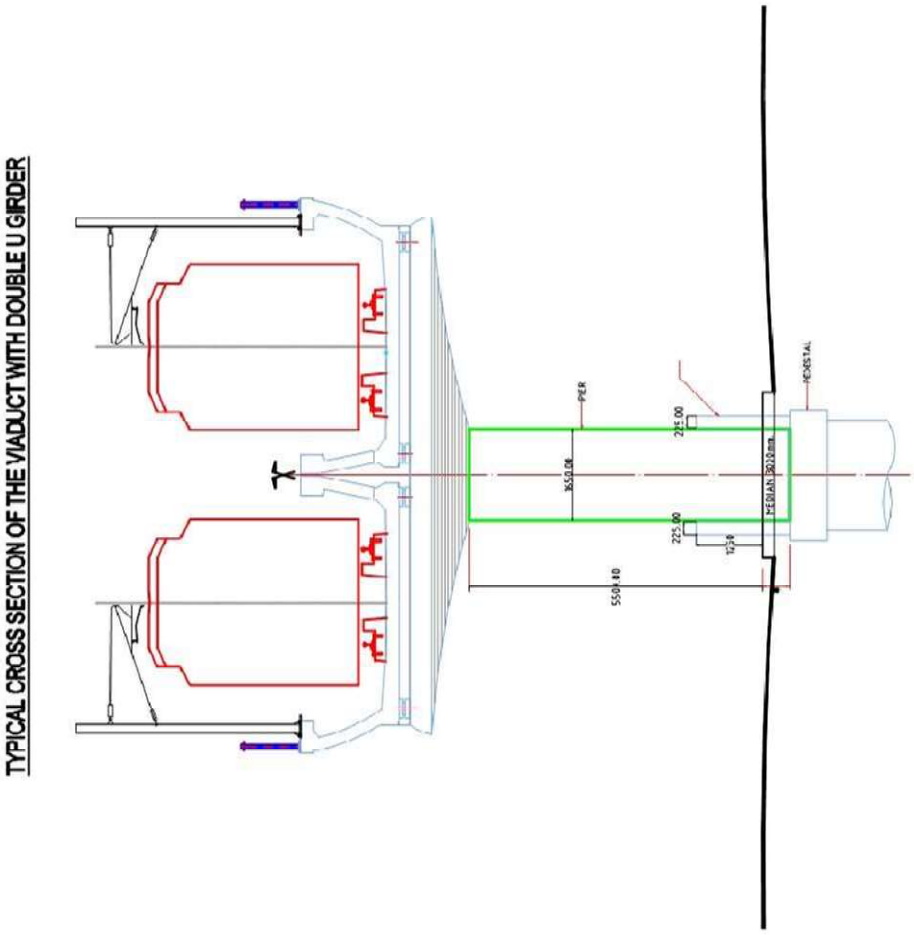
Typical Section of Viaduct with U Girder



A-

Typical Cross Section of Viaduct with Double U Girder

Fig. 4.3



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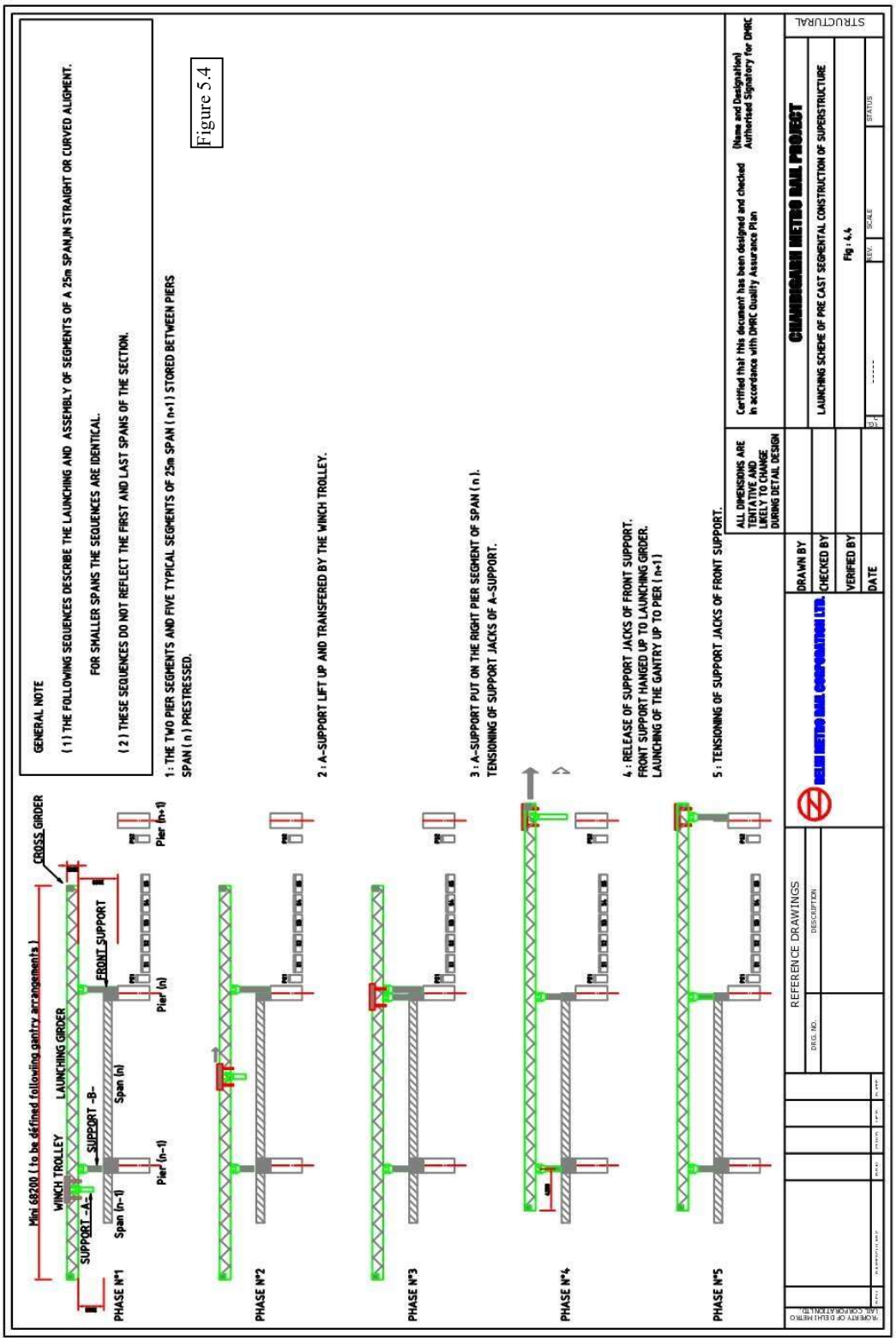
GENERAL NOTE
(1) THE FOLLOWING SEQUENCES DESCRIBE THE LAUNCHING AND ASSEMBLY OF SEGMENTS OF A 25m SPAN,IN STRAIGHT OR CURVED ALIGMENT.
FOR SMALLER SPANS THE SEQUENCES ARE IDENTICAL.
(2) THESE SEQUENCES DO NOT REFLECT THE FIRST AND LAST SPANS OF THE SECTION.
1 : THE TWO PIER SEGMENTS AND FIVE TYPICAL SEGMENTS OF 25m SPAN (n+1) STORED BETWEEN PIERS SPAN (n) PRESTRESSED.
2 : A-SUPPORT LIFT UP AND TRANSFERED BY THE WINCH TROLLEY.
3 : A-SUPPORT PUT ON THE RIGHT PIER SEGMENT OF SPAN (n). TENSIONING OF SUPPORT JACKS OF A-SUPPORT.
4 : RELEASE OF SUPPORT JACKS OF FRONT SUPPORT. FRONT SUPPORT HANGED UP TO LAUNCHING GIRDER. LAUNCHING OF THE GANTRY UP TO PIER (n+1)
5 : TENSIONING OF SUPPORT JACKS OF FRONT SUPPORT.
Mini 69200 (to be defined following gantry arrangements)
CROSS GIRDER
WINCH TROLLEY
LAUNCHING GIRDER
SUPPORT -A-
SUPPORT -B-
FRONT SUPPORT
Span (n-1)
Span (n)
Pier (n-1)
Pier (n)
Pier (n+1)
PHASE N°1
PHASE N°2
PHASE N°3
PHASE N°4
PHASE N°5
ALL DIMENSIONS ARE TENTATIVE AND LIKELY TO CHANGE DURING DETAIL DESIGN
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DELHI METRO RAIL CORPORATION LTD.
DRAWN BY
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DATE
REFERENCE DRAWINGS
DRG. NO.
DESCRIPTION
CHANDIGARH METRO RAIL PROJECT
LAUNCHING SCHEME OF PRE CAST SEGMENTAL CONSTRUCTION OF SUPERSTRUCTURE
Fig : 4.4
REV.
SCALE
STATUS
STRUCTURAL
GOVERNMENT OF DELHI METRO RAIL CORPORATION LTD.

Figure 5.4

A-

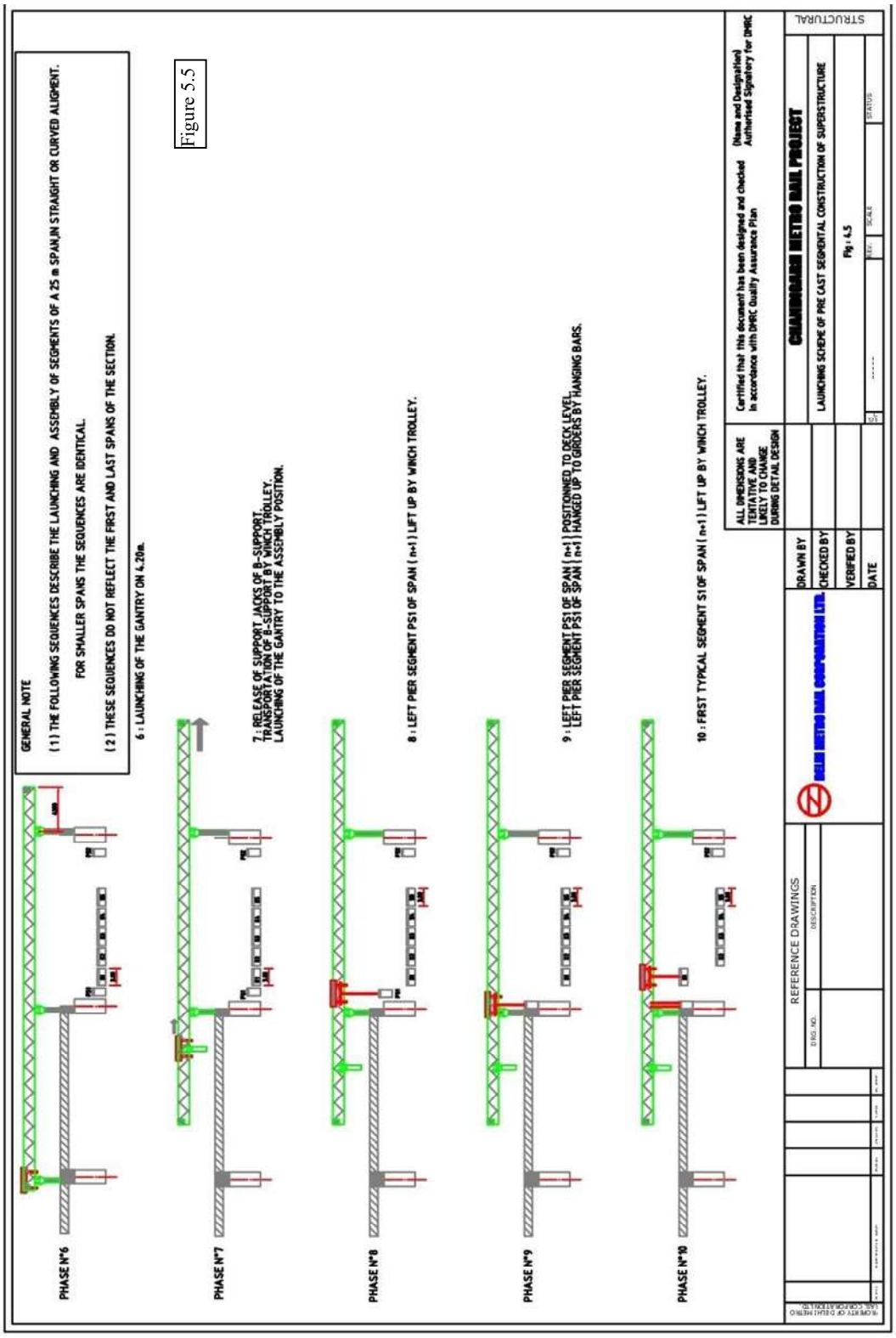
GENERAL NOTE
(1) THE FOLLOWING SEQUENCES DESCRIBE THE LAUNCHING AND ASSEMBLY OF SEGMENTS OF A 25 m SPAN,IN STRAIGHT OR CURVED ALIGMENT.
FOR SHALLER SPANS THE SEQUENCES ARE IDENTICAL.
(2) THESE SEQUENCES DO NOT REFLECT THE FIRST AND LAST SPANS OF THE SECTION.
6 : LAUNCHING OF THE GANTRY ON 4.20m.
7: RELEASE OF SUPPORT JACKS OF B-SUPPORT.
TRANSPORTATION OF B-SUPPORT BY WINCH TROLLEY.
LAUNCHING OF THE GANTRY TO THE ASSEMBLY POSITION.
8 : LEFT PIER SEGMENT PS1 OF SPAN (n+1) LIFT UP BY WINCH TROLLEY.
9 : LEFT PIER SEGMENT PS1 OF SPAN (n+1) POSITIONNED TO DECK LEVEL.
LEFT PIER SEGMENT PS1 OF SPAN (n+1) HANGED UP TO GIRDERS BY HANGING BARS.
10 : FIRST TYPICAL SEGMENT S1 OF SPAN (n+1) LIFT UP BY WINCH TROLLEY.
PHASE N°6
PHASE N°7
PHASE N°8
PHASE N°9
PHASE N°10
ALL DIMENSIONS ARE TENTATIVE AND LIKELY TO CHANGE DURING DETAIL DESIGN
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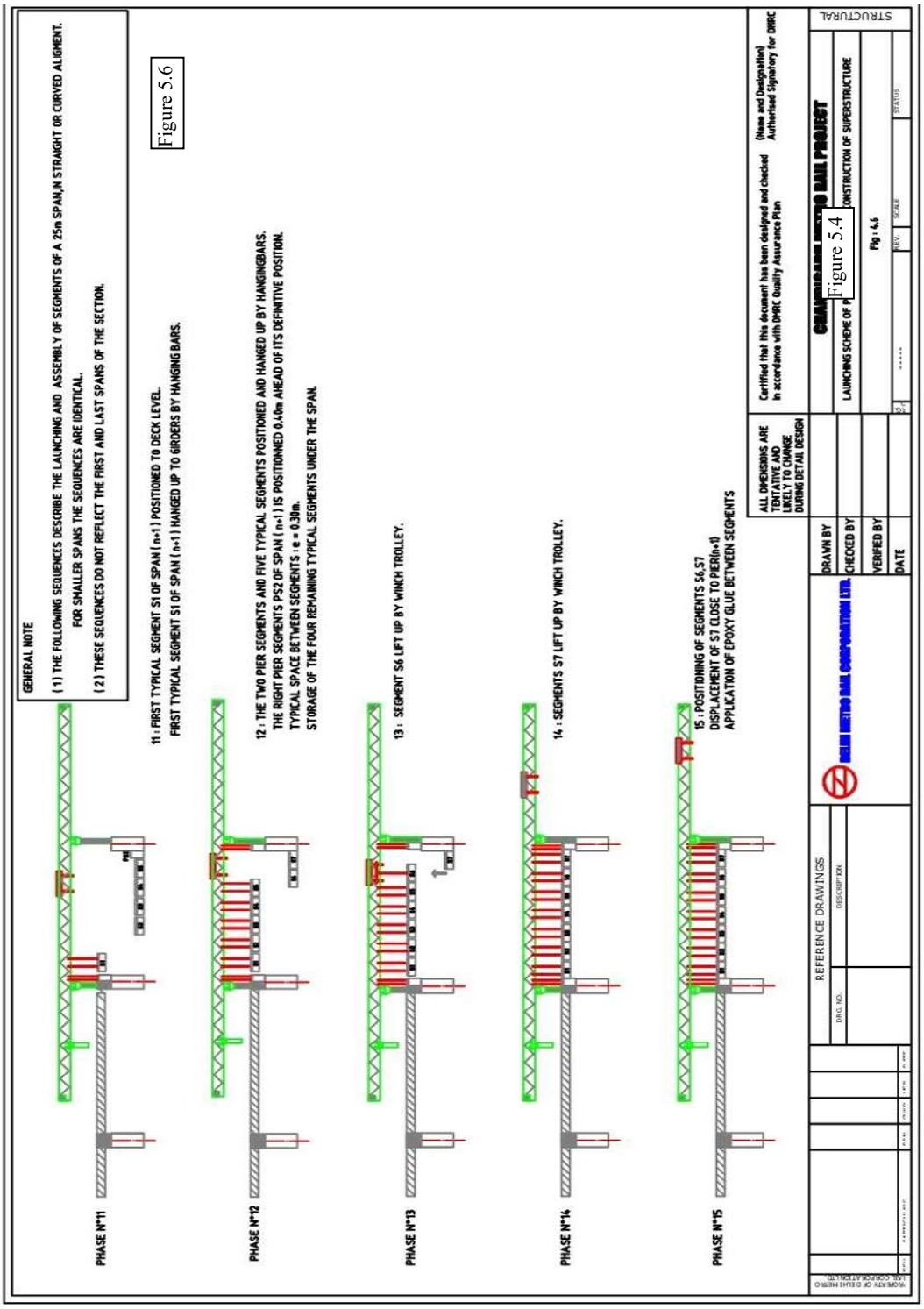
Fig : 4.5
REV.
SCALE
STATUS
STRUCTURAL

Figure 5.5

A-


GENERAL NOTE
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FOR SMALLER SPANS THE SEQUENCES ARE IDENTICAL.
(2) THESE SEQUENCES DO NOT REFLECT THE FIRST AND LAST SPANS OF THE SECTION.
11 : FIRST TYPICAL SEGMENT S1 OF SPAN (n+1) POSITIONED TO DECK LEVEL.
FIRST TYPICAL SEGMENT S1 OF SPAN (n+1) HANGED UP TO GIRDERS BY HANGING BARS.
12 : THE TWO PIER SEGMENTS AND FIVE TYPICAL SEGMENTS POSITIONED AND HANGED UP BY HANGINGBARS.
THE RIGHT PIER SEGMENTS PS2 OF SPAN (n+1) IS POSITIONNED 0.40m AHEAD OF ITS DEFINITIVE POSITION.
TYPICAL SPACE BETWEEN SEGMENTS : e = 0.30m.
STORAGE OF THE FOUR REMAINING TYPICAL SEGMENTS UNDER THE SPAN.
13 : SEGMENT S6 LIFT UP BY WINCH TROLLEY.
14 : SEGMENTS S7 LIFT UP BY WINCH TROLLEY.
15 : POSITIONING OF SEGMENTS S6,S7
DISPLACEMENT OF S7 CLOSE TO PIER(n+1)
APPLICATION OF EPOXY GLUE BETWEEN SEGMENTS
PHASE N°11
PHASE N°12
PHASE N°13
PHASE N°14
PHASE N°15
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LAUNCHING SCHEME OF P
CONSTRUCTION OF SUPERSTRUCTURE
Fig : 4.4
STRUCTURAL
REFERENCE DRAWINGS
DRG. NO.
DESCRIPTION
Figure 5.6
Figure 5.4

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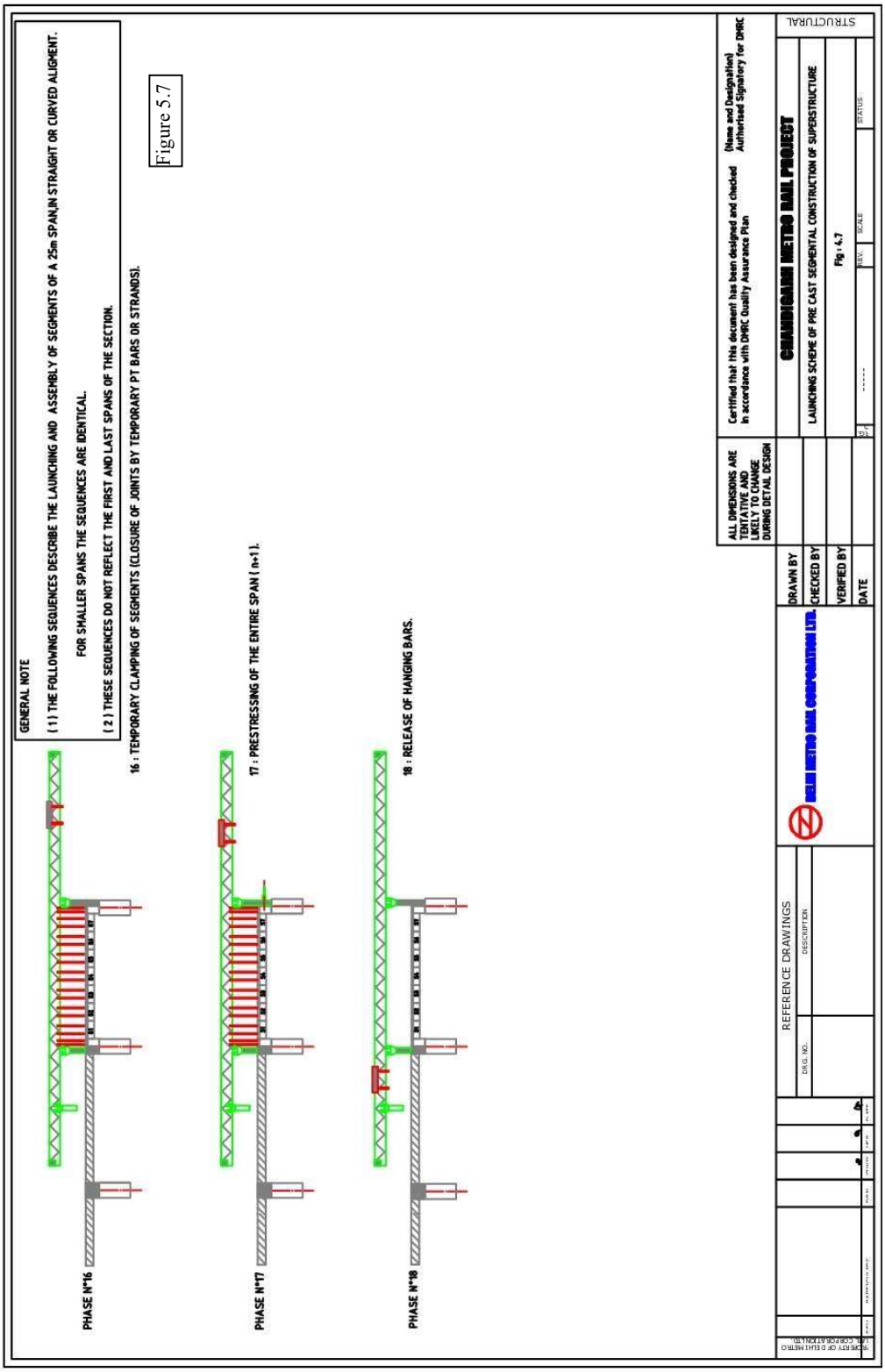
GENERAL NOTE
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FOR SMALLER SPANS THE SEQUENCES ARE IDENTICAL.
(2) THESE SEQUENCES DO NOT REFLECT THE FIRST AND LAST SPANS OF THE SECTION.
16 : TEMPORARY CLAMPING OF SEGMENTS (CLOSURE OF JOINTS BY TEMPORARY PT BARS OR STRANDS).
17 : PRESTRESSING OF THE ENTIRE SPAN (n+1).
18 : RELEASE OF HANGING BARS.
PHASE N°16
PHASE N°17
PHASE N°18
Figure 5.7
ALL DIMENSIONS ARE TENTATIVE AND LIKELY TO CHANGE DURING DETAIL DESIGN
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LAUNCHING SCHEME OF PRE CAST SEGMENTAL CONSTRUCTION OF SUPERSTRUCTURE
Fig : 4.7
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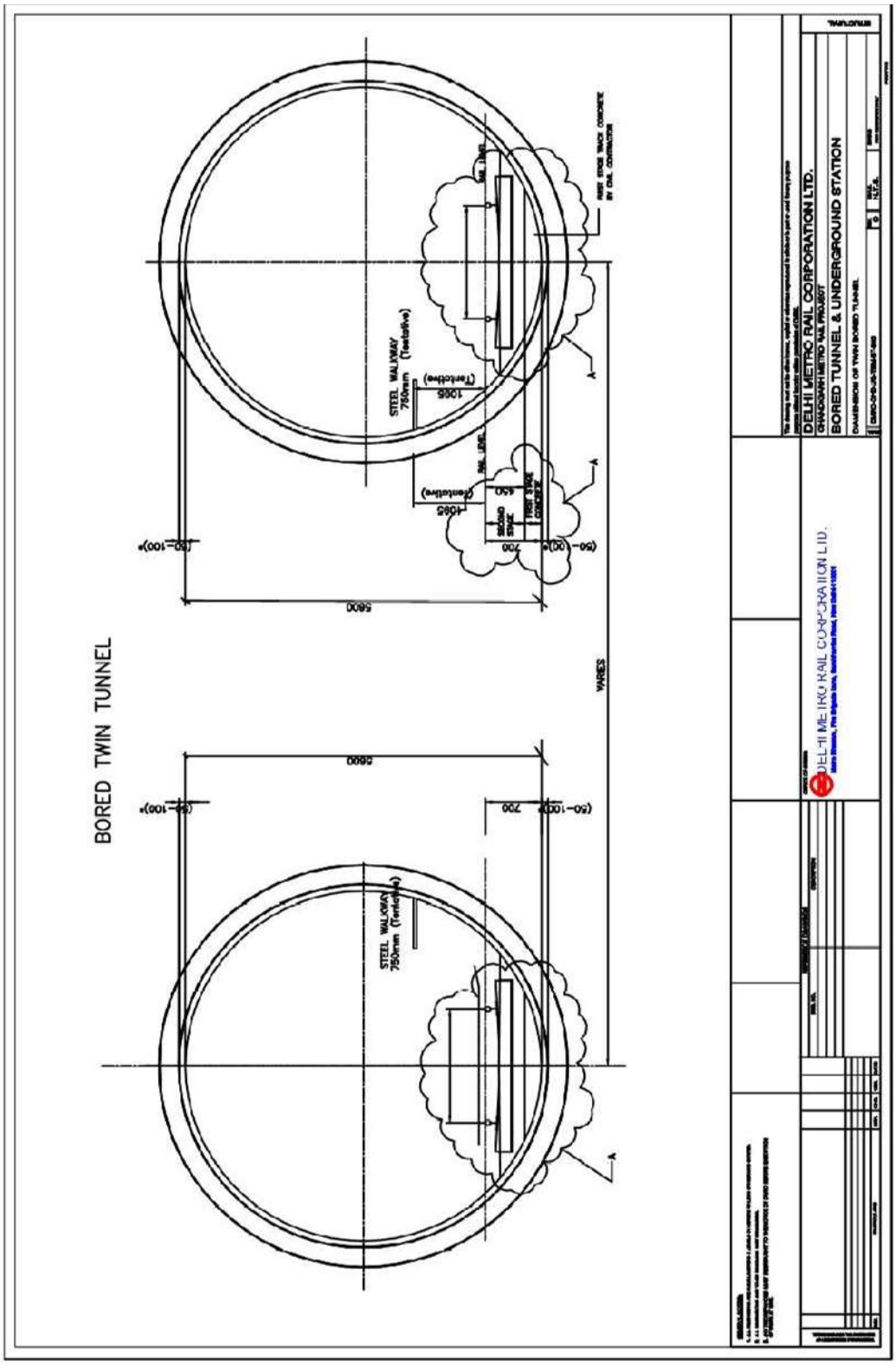
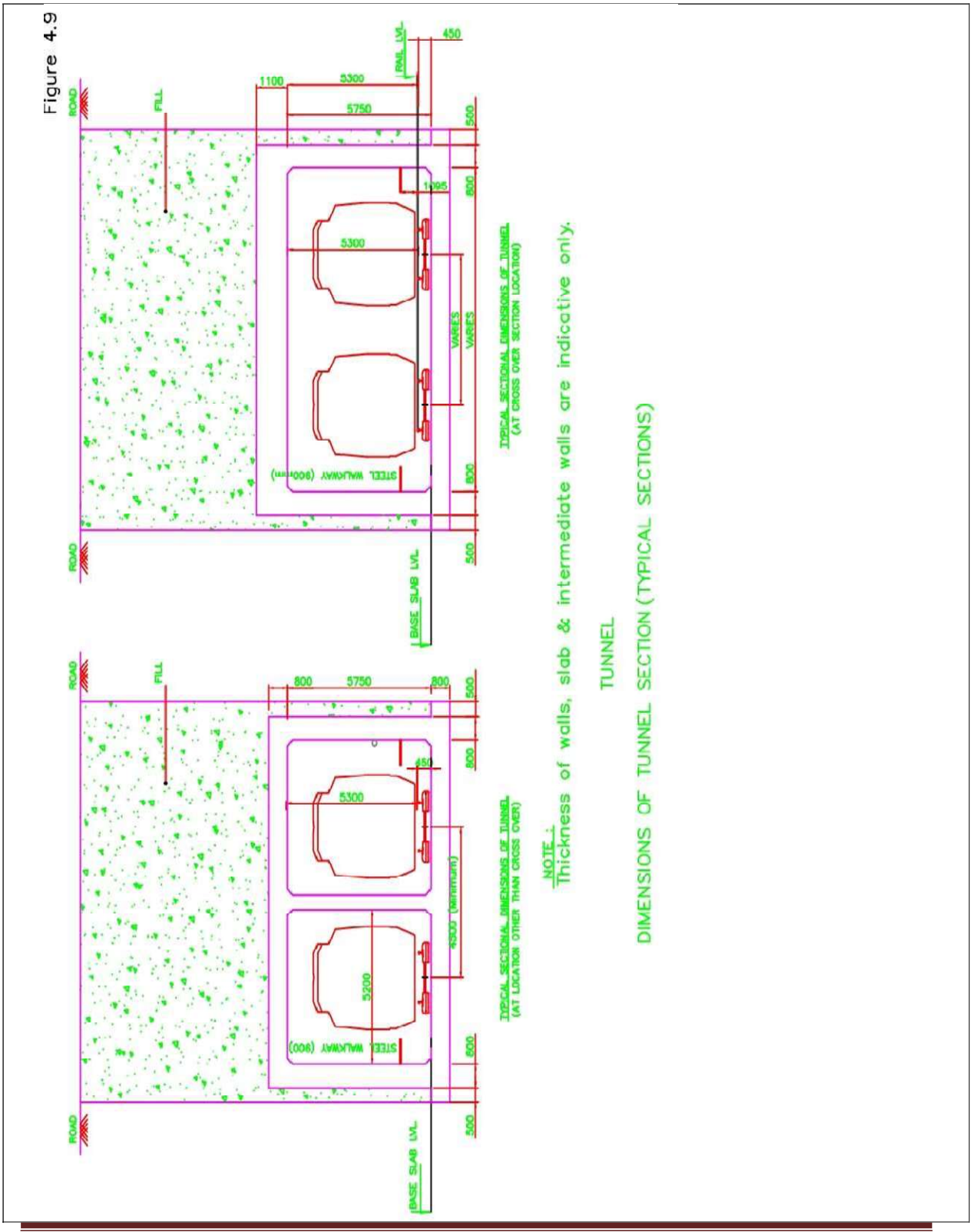
Dimension of Twin Bored Tunnel



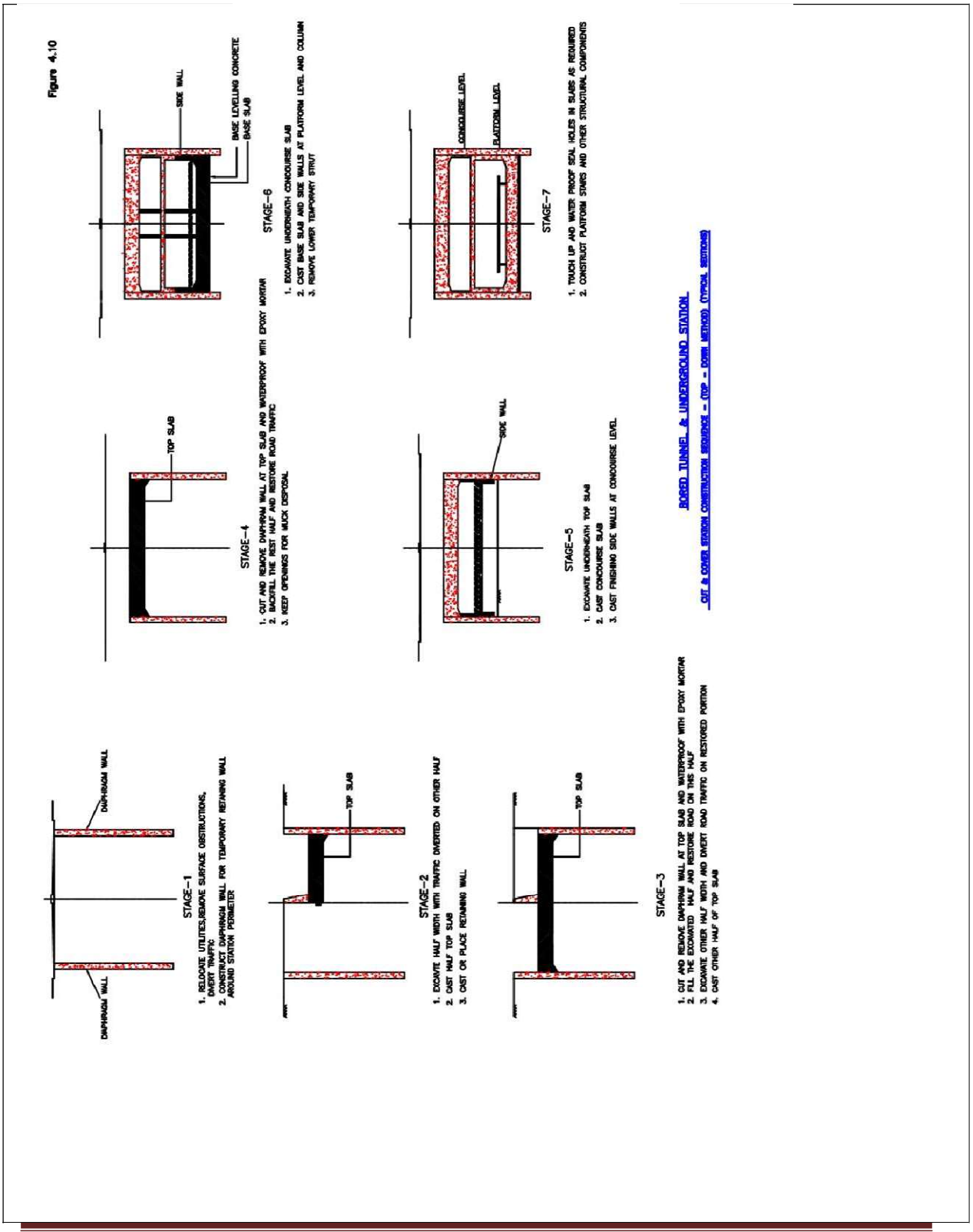
A-

Dimension of Tunnel Section



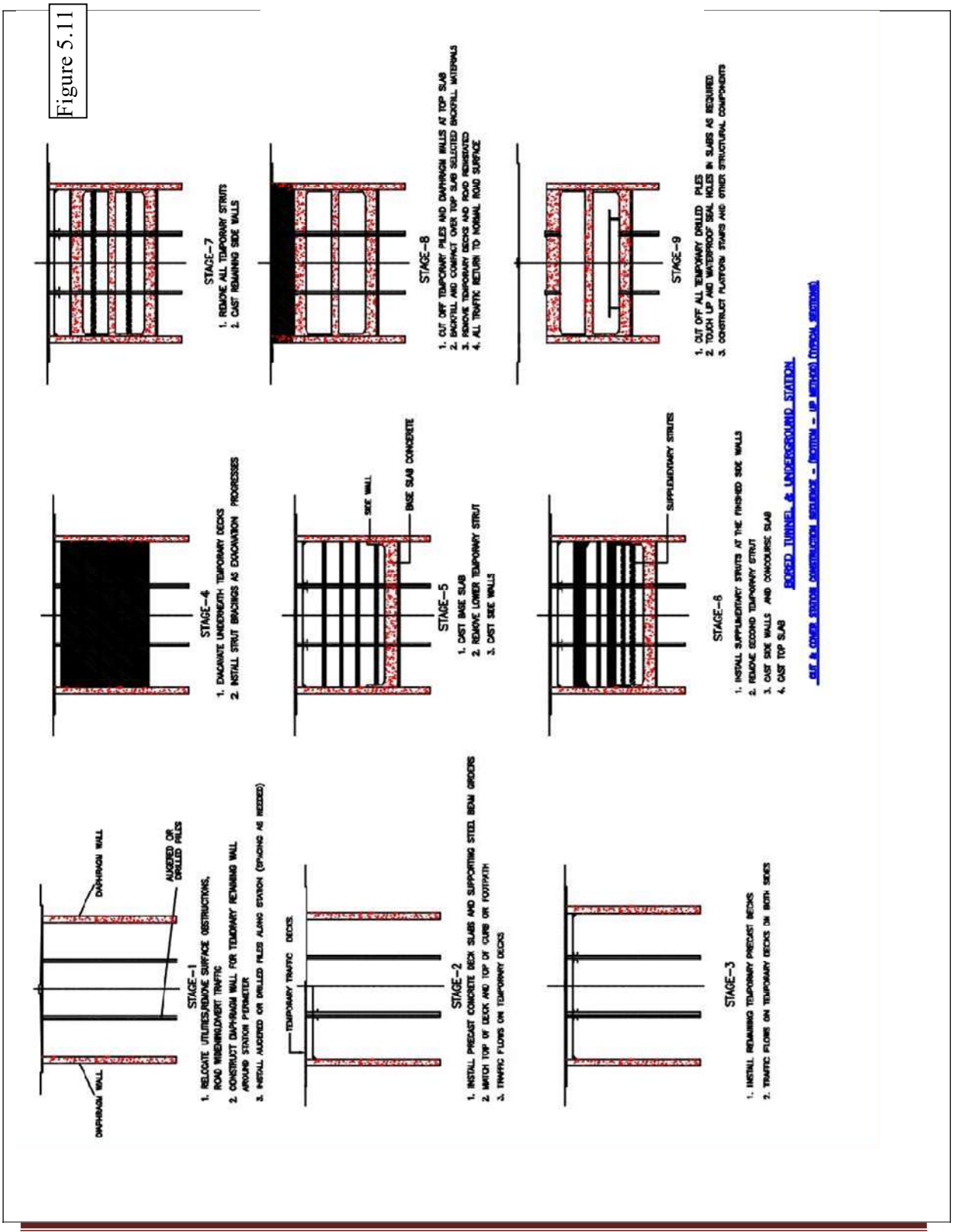
A-2.9

Bored Tunnel and Underground Station

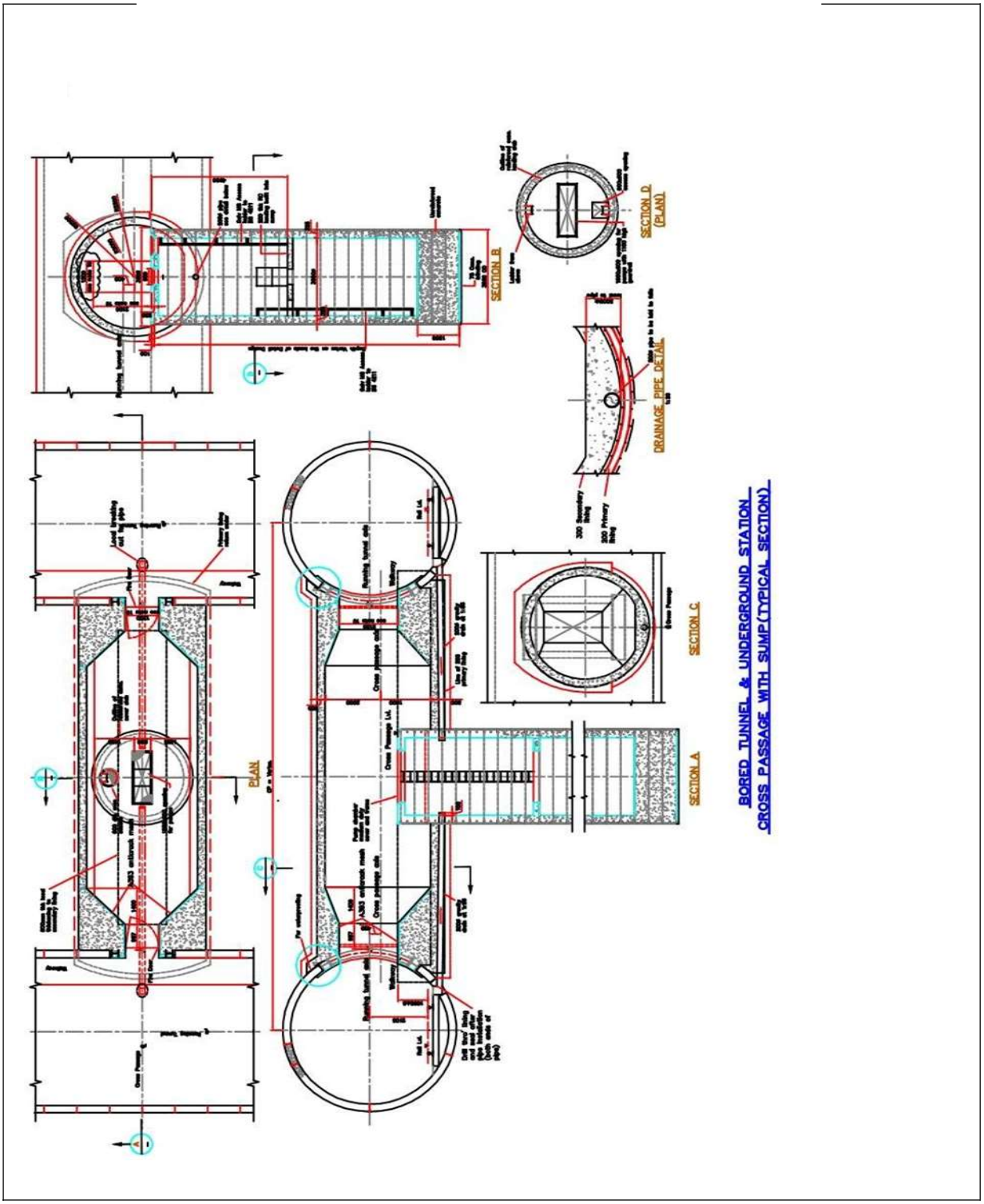


Bored Tunnel and Underground Station

Figure 5.11



Bored Tunnel and Underground Station (Cross Passage with



A-

Annexure 4.2

DETAILS OF SENSITIVE RECEPTORS

AEROCITY (UG) TO TUGHLAKABAD (UG)

S. No.	Sensitive Receptor	Location (Chainage)	RHS/ LHS	Section (U/g-El)	Distance from Edge of viaduct *(m)
1	Temple	10820.108M TO 10834.643M	LHS	U/g	NA
2	School	10955.315 TO 11008.259M	RHS	U/g	NA
3	School	12465.504M TO 13189.884M	RHS	El	29
4	Gurudwara	13189.884M TO 14063.014M	RHS	El	14
5	Temple	13189.884M TO 14063.014M	RHS	El	32
6	Church	14063.014M TO 17639.304M	LHS	El	52
7	Hospital	14063.014M TO 17639.304M	LHS	El	98
8	Hospital	14063.014M TO 17639.304M	LHS	El	46
9	School	14063.014M TO 17639.304M	LHS	U/g	NA
10	Temple	17639.304M TO 18927.934M	LHS	U/g	NA
11	School	17639.304M TO 18927.934M	LHS	U/g	NA
12	Hospital	17639.304M TO 18927.934M	RHS	U/g	NA
13	Temple	18927.934M TO 20002.184M	LHS	U/g	NA

*NA-Receptors at Underground stretch will not have impact of noise during operation

JANAKPURI WEST TO R.K. ASHRAM

S. No.	Sensitive Receptor	Location (Chainage)	Remark (RHS/ LHS)	Section (U/g-El)	Distance from Edge of viaduct *(m)
1	School	(-)488.27M TO 987.0M	LHS	U/g	NA
2	Hospital	(-)488.27M TO 987.0M	LHS	U/g	NA
3	Temple	(-)488.27M TO 987.0M	RHS	U/g	NA
4	Temple	987.0M TO 1836.60M	LHS	U/g	NA
5	Temple	987.0M TO 1836.60M	LHS	U/g	NA
6	Temple	1836.60M TO 3076.2M	LHS	U/g	NA
7	Temple	3076.2M TO 4400.00M	CENTER	U/g	NA
8	Temple	3076.2M TO 4400.00M	CENTER	U/g	NA
9	Mosque	3076.2M TO 4400.00M	RHS	U/g	A- NA
10	Temple	3076.2M TO 4400.00M	RHS	U/g	NA
11	Temple	3076.2M TO 4400.00M	RHS	U/g	NA
12	Temple	3076.2M TO 4400.00M	RHS	U/g	NA

S. No.	Sensitive Receptor	Location (Chainage)	Remark (RHS/ LHS)	Section (U/g-El)	Distance from Edge of viaduct *(m)
13	Temple	3076.2M TO 4400.00M	RHS	U/g	NA
14	Temple	3076.2M TO 4400.00M	RHS	U/g	NA
15	School	3076.2M TO 4400.00M	RHS	U/g	NA
16	Temple	4400.00M TO 5592.30M	LHS	U/g	NA
17	Hospital	4400.00M TO 5592.30M	LHS	U/g	NA
18	Temple	4400.00M TO 5592.30M	RHS	U/g	NA
19	Temple	5592.30M TO 6450.90M	LHS	U/g	NA
20	Temple	5592.30M TO 6450.90M	LHS	U/g	NA
21	Temple	5592.30M TO 6450.90M	RHS	U/g	NA
22	College	5592.30M TO 6450.90M	RHS	U/g	NA
23	Institute	5592.30M TO 6450.90M	RHS	U/g	NA
24	College	6450.90M TO 7372.90M	RHS	U/g	NA
25	Temple	6450.90M TO 7372.90M	RHS	U/g	NA
26	Temple	7372.90M TO 8291.80M	LHS	El	8
27	Mosque	7372.90M TO 8291.80M	LHS	El	42
28	Institute	7372.90M TO 8291.80M	LHS	El	74
29	Temple	7372.90M TO 8291.80M	RHS	El	11
30	Temple	14699.70M TO 16227.50M	LHS	El	30
31	Institute	14699.70M TO 16227.50M	LHS	El	43
32	Temple	14699.70M TO 16227.50M	RHS	El	3
33	Institute	18301.90M TO 19545.70M	LHS	El	43
34	School	20445.50M TO 21358.70M	LHS	El	43
35	Hospital	20445.50M TO 21358.70M	LHS	El	45
36	School	20445.50M TO 21358.70M	RHS	El	45
37	Institute	22304.30M TO 23271.60M	RHS	El	8
38	Hospital	24463.90M TO 25136.80M	LHS	El	49
39	School	24463.90M TO 25136.80M	LHS	El	45
40	School	26403.30M TO 27311.50M	RHS	El	15
41	School	27311.50M TO 28432.580M	LHS	El	40
42	Hospital	27311.50M TO 28432.580M	LHS	El	104
43	Gurudwara	27311.50M TO 28432.580M	LHS	El	196
44	Temple	27311.50M TO 28432.580M	RHS	El	26
45	School	27311.50M TO 28432.580M	RHS	El	31

*NA-Receptors at Underground stretch will not have impact of noise during operation

A-

MUJUNDPUR TO MAUJPUR

S. No.	Sensitive Receptor	Location (Chainage)	Remark (RHS/ LHS)	Section (U/g-El)	Distance from Edge of viaduct* (m)
1	Temple	53680.040M TO 55166.20M	LHS	El	5
2	SCHOOL	53680.040M TO 55166.20M	LHS	El	56
3	School	53680.040M TO 55166.20M	LHS	El	60
4	Hospital	53680.040M TO 55166.20M	LHS	El	64
5	Hospital	53680.040M TO 55166.20M	LHS	El	61
6	Hospital	53680.040M TO 55166.20M	LHS	El	61
7	Hospital	53680.040M TO 55166.20M	LHS	El	61
8	Hospital	53680.040M TO 55166.20M	LHS	El	60
9	Temple	53680.040M TO 55166.20M	RHS	El	14
10	Temple	55166.20M TO 56621.80M	LHS	El	53
11	School	55166.20M TO 56621.80M	LHS	El	53
12	Institute	55166.20M TO 56621.80M	LHS	El	59
13	Institute	55166.20M TO 56621.80M	RHS	El	8
14	School	55166.20M TO 56621.80M	RHS	El	7
15	School	55166.20M TO 56621.80M	RHS	El	7
16	Temple	55166.20M TO 56621.80M	RHS	El	7
17	Temple	56621.80M TO 57714.70M	LHS	El	45
18	School	56621.80M TO 57714.70M	LHS	El	47
19	School	56621.80M TO 57714.70M	RHS	El	16
20	Church	63883.20M TO ABOVE	LHS	El	31

*NA-Receptors at Underground stretch will not have impact of noise during operation

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Annexure 5.1

Locations of Public Consultations along corridors of Delhi Metro Phase IV

Sl. No.	Date public consultation was conducted	Location public consultation was conducted
1	14 August 2013	Azadpur
2	23 August 2013	Peeragarhi
3	23 August 2013	Khanpur
4	23 August 2013	Rangpuri village Mahipalpur
5	2 Sept.2013	Jagatpur Village
6	2 Sept.2013	LNJP Hospital
7	10 Sept.2013	Sheikh Sarai
8	10 Sept.2013	Andrews Ganj
9	7 Oct. 2013	Bawana Industrial Area
10	7 Oct.2013	Anajmandi Narela

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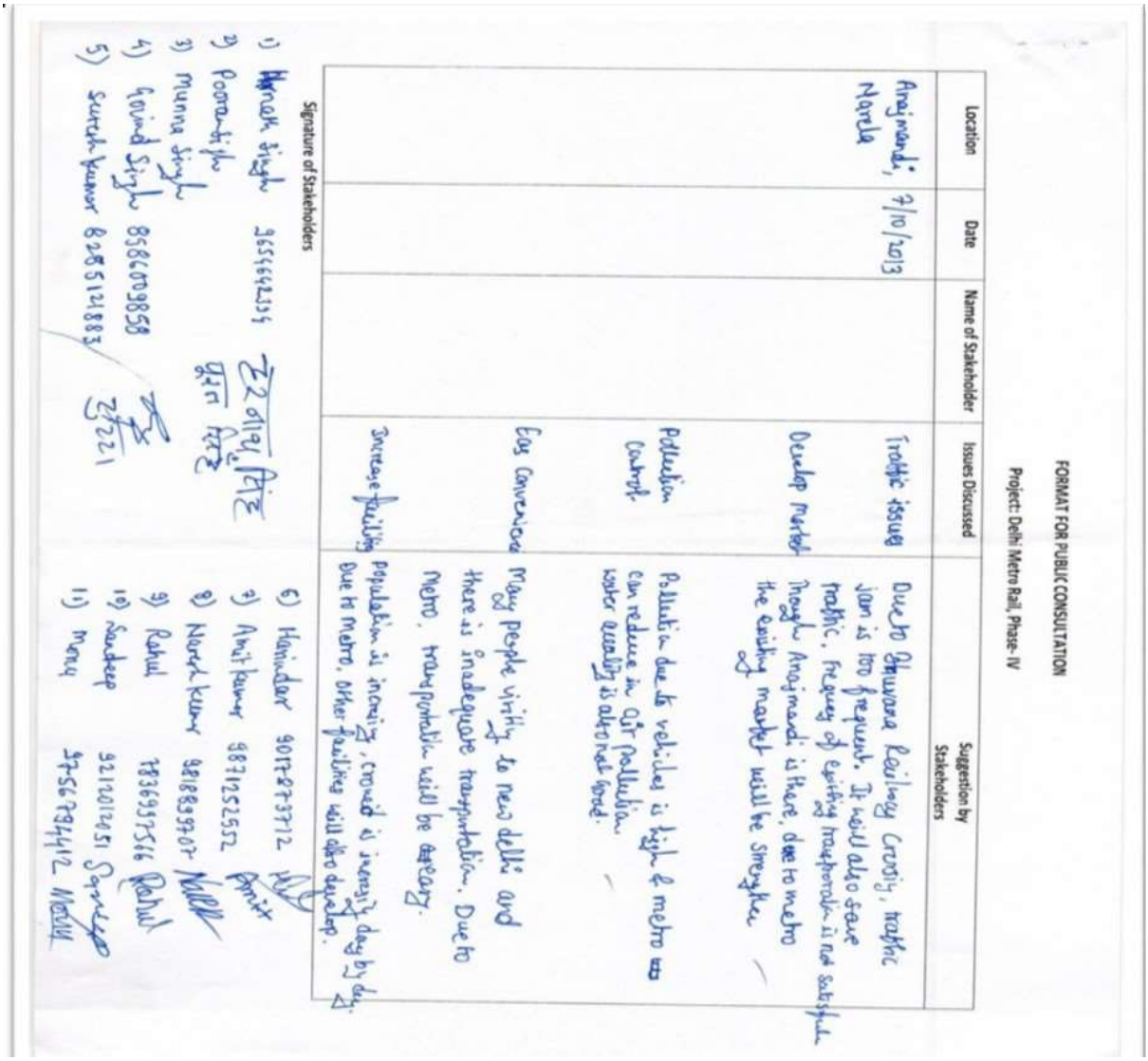
Annexure 5.2

Public Consultation relating to environmental benefits of Delhi Metro Phase IV



FORMAT FOR PUBLIC CONSULTATION

Project: Delhi Metro Rail, Phase-IV

Location	Date	Name of Stakeholder	Issues Discussed	Suggestion by Stakeholders	Signature of Stakeholders
Anajmandi, Narela	7/10/2013		Traffic issues	Due to Bhawana Railway Crossing, traffic jam is too frequent. It would also cause traffic. Frequency of existing transportation is not satisfactory. Though Anajmandi is there, due to metro the existing market will be strengthen	1) Manak Singh 9654442334 2) Poonam Jha 3) Munna Singh 4) Govind Singh 8586009858 5) Suresh Kumar 8285124883
			Develop Market		
			Pollution Control	Pollution due to vehicles is high & metro can reduce in Air Pollution. Water quality is also not good.	
			Eco Conscious	Many people visiting to New Delhi and there is inadequate transportation. Due to Metro, transportation will be necessary.	
			Increase facility	Population is increasing, crowd is increasing day by day. Due to Metro, other facilities will also develop.	6) Harinder 9017877712 7) Amit Kumar 9871252552 8) Naresh Kumar 9818859707 9) Rahul 7838997546 10) Sandeep 9210010451 11) Manu 9756794412

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Annexure-6.1

FORMAT FOR PUBLIC CONSULTATION

Project: Delhi Metro Rail, Phase- IV

Location	Date	Name of Stakehoider	Issues Discussed	Suggestion by Stakeholders
Peeragarhi	14/8/2015		Easy transportation	Travelling will be as easier. Currently existing transportation facility is not adequate, traffic Jam is routine issue.
			Improvement in Metro Route.	Need to connect both Punjabi bagh metro station underground for pedestrian.
			Saving of time	Metro helps in saving of time
			Traffic Jam	At this place, traffic Jam is ~~heavy~~ routine phenomena and there is urgent need of metro. (traffic Jam in Madipur) Haiderpur square traffic Jam
			Route Change	Rithala to Mangolpuri connect by metro.
			Improvement in metro Route.	The metro route will be good if it will be from Ghevara to Bavana & Narela.

Signature of Stakeholders

Sachin 9810748247

Pawan - 9868377907.

Manak Singh 9212891262

Naveen Kumar 9540658044

Ashok kumar 9911022907

S.P. Mishra Ji 9910892634

M.D. Hussain 9310314308

Sunil Ji 9268982425

Meenu

Annai 8802956 1744

Arun 9710786317

FORMAT FOR PUBLIC CONSULTATION

Project: Delhi Metro Rail, Phase- IV

Location	Date	Name of Stakeholder	Issues Discussed	Suggestion by Stakeholders
Azadpur	14/08/2013		Time saving	In order to reach Uttam nagar and other areas crowded ~~bus~~ buses overloaded and its problem for every one.
			Convenient transport	Existing mode of transport is not enough Buses are overcrowded.
			Waiting time	Industrial area is in Narela. waiting time is too much ranges from 30-60 minutes. Overcrowded bus is make commutation difficult.
			Improvement in corridor	Narela to Sindhu border, there is need to extend corridor

Signature of Stakeholders

1) Surendra Kumar [signature]
2) Pradeep Jain
3) Babloo
4) Aakash 7291080754 [signature]
5) Ravi 7503807215 [signature]
6) Ali 837707713 [signature]

Ravikant Sir 9708366711 [signature]
Shiv kumar 9643790861 [signature]
Pappu Yadav 9601801482 [signature]
Rohit Kumar ——
Pramod 8375871845 [signature]

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FORMAT FOR PUBLIC CONSULTATION

Project: Delhi Metro Rail, Phase- IV

Location	Date	Name of Stakeholder	Issues Discussed	Suggestion by Stakeholders
Khanpur	23/8/2016		Heavy traffic	from Sangam Vihar to Saket Metro, heavy traffic affects. Saket is around 3km from here. Many people coming from khanpur going to Gurgaon. They are facing transportation problem.
			Waiting time too high	Existing transportation is not adequate and heavy traffic jam make the things worst.
			Polluction	Metro can save us from Pollution.
			Passenger load is high	No. of passenger is too high & relied only on Bus services is not enough
			Time saving	Due to traffic Jam & inadequate transportation
			Development of local place	Due to metro local place, economy will develop.

Signature of Stakeholders

1. Neeraj Kumar Mishra 9871040444
2. Mayank Kumar 8287072283
3. Dharmender Singh 9512814176
4. Rohit 9818586274
5. Akbar Khan 8882439908
6. Kuldeep Ji 9813982405
7. Jaiprakash 9467022536
8. S.K. Sharma 9871097098
9. Ajay Shreevastav 8826286143
10. Raja

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FORMAT FOR PUBLIC CONSULTATION

Project: Delhi Metro Rail, Phase- IV

Location	Date	Name of Stakeholder	Issues Discussed	Suggestion by Stakeholders
Rangpuri Village, Mahipalpur	23/08/2013		Easy transportation	It will easier to communicate commute vasant kunj, mahipalpur, Tuglakabad, Safdarjung
			Waiting time	Waiting time for Badarpur is too much. Time saving
			Pollution issue	Due to metro, pollution due to other vehicles will be reduced. At present due to diesel vehicles pollution level is too high.
			Heavy traffic	Mahipalpur to Chattarpur crowd heavy crowd particularly at peak hours. Metro will help to reduce traffic upto great extent.
			Compensation	Adequate compensation should be given where land will be taken for metro purpose.

Signature of Stakeholders

1. Devender Sis 9871488572
2. Vinod 9716184427
3. A Hashrad Ali 9310443854
4. Sartaj 9818553460
5. Vinod kumar 8595327070
6. Praveen Chauhan 9716590072
7. Ambika Prasad 8130843467
8. Ranjeet Roy Chouhe 9871425747
9. Dev 8860471462
10. Raman 7877763701

S.K

FORMAT FOR PUBLIC CONSULTATION

Project: Delhi Metro Rail, Phase- IV

Location	Date	Name of Stakeholder	Issues Discussed	Suggestion by Stakeholders
Jagatpur village	2/03/2013		Increased Facilities	If metro will be there, other infrastructure will also build up
			Metro Route improvement	As there is huge population residing in the area of Buradi, Jagatpur village, Surghat, Loni Border, West karawal nagar, Biharipur, the route need to be changed from West Karawal Nagar. [Jagatpur-Sonia Vihar-Jagatpur Village. This route will cover the both side populat
			Students Mobility	Many of the Civil service aspirant students are staying in Jagatpur a village & surrounding areas.
			Inadequate transportati.	There is no existing transportation. DTC is not available.

Signature of Stakeholders

1) Satbir Singh 9818208390
2) Phulsingh Ji 8802135339
3) Ajay Kumar 9866748699
4) Satish Kaushik 9811935455
5) Vipul Gautam 9555167007
12) Harisingh 9210808396
13) Kuldeep Singh 9711816346
6) Satyaprakash 9811587086
7) Ravindra 8010[illegible]579121
8) Kumar Parveen 9871108182
9) Amit kumar 9599911370
10) Vikas Sir 9891565700
11) Manish Sir 9990042854

FORMAT FOR PUBLIC CONSULTATION

Project: Delhi Metro Rail, Phase-IV

Location	Date	Name of Stakeholder	Issues Discussed	Suggestion by Stakeholders
Sheikh Sarai	10/9/2017		Waiting time is	Presently only Bus is there, waiting time is too much
			Time saving	It takes too much time to go anywhere from the place. Metro is fast & safe
			Public transport increase.	Bus service is too low, and there is urgent need of Metro. There is no bus stand, not capable
			Inadequate transportation	This area is connected to industrial area, Okhla, Kalka, Lajpatnagar, Faridabad, Mahipalpur. these all industrial area should be connected to this place
			Metro can reduce Pollution	The commuting population is too high for community from Badarpur, Kalkaji, Saket port. There are several Colleges etc, which increase the travellers manifold.

Signature of Stakeholders

1. Walhawan 011-29253131
2. Kamal Nath 9953033245
3. Devendra 9650911458
4. Harish 9911672457
5. Sanjay 9821912144
6. Jagdish 8826333539
7. Bahadur 9716258598
8. Abhishek Bhatar 9971743132
9. Priya 9211787852
10. Arif ali Arif
11. Daljit singh 9150585763

FORMAT FOR PUBLIC CONSULTATION

Project: Delhi Metro Rail, Phase IV

Location	Date	Name of Stakeholder	Issues Discussed	Suggestion by Stakeholders
LNJP Hospital	2/08/2013			People coming from all areas of delhi
			Congested area	The existing area is already congested and after metro, it will again more congested.
			public convenience	The existing traffic is too much, and people have to waste their time to reach the hospital. People coming Rohini, Najafgarh, Gurgaon
				Due to existing congestion underground metro
			Easy transportation	Buses are not frequent, waiting time is too much. Easy convenience
				Connectivity to different areas

Signature of Stakeholders

1) Pradeep Khan [illegible] [illegible]
2) Deepak Kumar [illegible] [illegible]
3) Pawandeep Singh [illegible] [illegible]
4) G.K. Sharma [illegible] [illegible]
5) Harish [illegible] [illegible]
6) Mahender [illegible] [illegible]
7) Abhishek [illegible] [illegible]
8) Sudeep [illegible] [illegible]
9) Narayan [illegible] [illegible]
10) Mahesh Malhotra [illegible] [illegible]
11) Sunil [illegible] [illegible]
12) Dinesh [illegible]

FORMAT FOR PUBLIC CONSULTATION

Project: Delhi Metro Rail, Phase- IV

Location	Date	Name of Stakeholder	Issues Discussed	Suggestion by Stakeholders
Andrews Ganj	10/9/2019		Inadequate transport	There are to many school colleges around and the existing travelling system is inadequate.
			Easy travelling	From Saket Nagar to Andrews ganj.
			Improvement in Route	From Noida to andrewsganj metro is required. Travelling time is too much from Noida to andrewsganj
			Safe mode of travelling for ladies	Buses & other modes of transportation is not safer for ladies. metro is safer than other modes of transportation.
			Time saving	As compare to other mode of transport metro will save time. waiting time is too much ½ hr-1 hr
			Reduction in pollution.	Due to heavy traffic, there is too much pollution.
			Heavy traffic Jam	Due to heavy traffic Jam in MG Road, it is difficult to commute Here.

Signature of Stakeholders

1. Himanshu
2. Rajeev
3. Vishal 8587070761
4. Anil 8950627016
5. Akash 9540093224
6. Heena Khan 9540274[illegible]
7. Sumit Verma 9868037476
8. Farah 8802240311
9. Gulshan Madi
10. M.P. Gupta 9871717524
11. P N Chadda 9582253277

FORMAT FOR PUBLIC CONSULTATION

Project: Delhi Metro Rail, Phase- IV

Location	Date	Name of Stakeholder	Issues Discussed	Suggestion by Stakeholders
Bawana Industrial area	7/10/2013		Increase connectivity	Transportation through metro will be benefited, nearby villages & distant places like Rohini. Due to Industrial area many people came here and it will be helpful for smooth transportation.
			Decrease in accident	Due to Industrial area, there is lot of people commute & hence there is high cases of accident.
			Develop local economy	Due to Improvement in transportation, local economy will boost.

Signature of Stakeholders

1) Murari मुरारी 9718808997
2) Monu 9310814771
3) Umesh umesh 9654931103
4) Deepak दीपक 7114950182
5) Ashok kumar 9711886374
6) Nagendra Nath 9718808357
7) Shiv Bahadur Shiv Bahadur 9716326140
8) Raj kumar 8467355347
9) Madan 9552311183
10) Vicky 8654442703
11) Yogesh
12) Pranay kumar 9971333171

Annexure 6.1

EMISSION STANDARDS FOR CONSTRUCTION EQUIPMENTS

In India Emission standards for diesel construction machinery were adopted on 21st September 2006, and are denoted as Construction Equipment Vehicles, or CEV. The standards are structured into two tiers:

- Bharat (CEV) Stage II – These standards are based on the EU Stage I requirements, but also cover smaller engines that were not regulated under the EU Stage I.
- Bharat (CEV) Stage III – These standards are based on US Tier 2/3 requirements.

The standards are summarized in the following table:

Emission Standards for Construction Equipment Vehicle (CEV)

Bharat Stage Norms	Category	Effective date	Test cycle	CO (g/kWh)	HC (g/kWh)	NOx (g/kWh)	HC+NOx (g/kWh)	PM (g/kWh)	80% of full load smoke (m^{-1})
-	-	18.01.96	ISO 8178-4 "C1" 8 mode cycle	14.00	3.50	18.00	-	-	3.25
-	-	28.07.00	ISO 8178-4 "C1" 8 mode cycle	14.00	3.50	18.00	-	-	3.25
BS-II	kW<8	01.10.08	ISO 8178-4 "C1" 8 mode cycle for Variable Speed Engines or	8.00	1.30	9.20	-	1.00	3.25
	8 ≤ kW<19			6.60	1.30	9.20	-	0.85	
	19 ≤ kW<37	01.10.07		6.50	1.30	9.20	-	0.85	
	37 ≤ kW<75		ISO 8178-4 "D2" 5 mode cycle for Constant Speed Engines	6.50	1.30	9.20	-	0.85	
	75 ≤ kW<130			5.00	1.30	9.20	-	0.70	
	130 ≤ kW<560			5.00	1.30	9.20	-	0.54	
BS-III	kW<8	01.04.2011	ISO 8178-4 "C1" 8 mode cycle for Variable Speed Engines or	8.00	-	-	7.50	0.80	3.25
	8 ≤ kW<19			6.60	-	-	7.50	0.80	
	19 ≤ kW<37			5.50	-	-	7.50	0.60	
	37 ≤kW<75		ISO 8178-4 "D2" 5 mode cycle for Constant Speed Engines	5.00	-	-	4.70	0.40	
	75 ≤kW<130			5.00	-	-	4.00	0.30	
	130 ≤kW<560			3.50	-	-	4.00	0.2	

The Road Transport Highways Ministry has issued a draft notification regarding emission standards for construction equipment vehicles, and agricultural tractors on 29th August, 2017.

Every diesel driven agricultural tractor and construction equipment vehicle and combine harvester shall be so manufactured that it complies with the following standards of gaseous pollutants emitted by them when tested on following duty cycle:

- For variable-speed engines, the 8-mode test cycle or the corresponding ramped modal cycle, and the Non Road Transient Cycle (NRTC).
- For constant-speed engines, the 5-mode test cycle or the corresponding ramped modal cycle.
- Emissions (g/kWh) shall be measured over Non Road Steady Cycle (NRSC) and Non Road Transient Cycle (NRTC) test cycle as per test applicability mentioned in Table 1

and Table 2. For NRTC test cycle, composite weighted emissions shall be computed by weighing the cold start results 10 per cent and the hot start results 90 per cent. Weighted composite results shall meet the limits.

Table 1

Bharat Stage (CEV/TREM) -IV

Applicable emission limit for Non Road Steady Cycle (NRSC) and Non Road Transient Cycle (NRTC)test cycle

	Applicable with effect from	CO	HC	NOx	PM	Test Cycle*
Category, kW		g/ kWh				
37 ≤P < 56	1st October, 2020	5.0	4.7 (HC+NOx)		0.025	NRSC & NRTC
56 ≤P < 130		5.0	0.19	0.4	0.025	
130≤P < 560		3.5	0.19	0.4	0.025	

*Test cycle as described in AIS: 137and as amended from time to time.

Table 2

Bharat Stage (CEV/TREM)- V

Applicable emission limit for Non Road Steady Cycle (NRSC) and Non Road Transient Cycle (NRTC)test cycle

	Applicable with effect from	CO	HC	NOx	PM	PN	Test cycle
Category, kW		g/ kWh				#/kWh	
P < 8	1st October, 2023	8.0	7.5 (HC+NOx)		0.4	----	NRSC
8 ≤P < 19		6.6	7.5 (HC+NOx)		0.4	-----	
19 ≤P < 37		5.0	4.7(HC+NOx)		0.015	1×10^{12}	NRSC and NRTC
37 ≤P < 56		5.0	4.7 (HC+NOx)		0.015	1×10^{12}	
56 ≤P < 130		5.0	0.19	0.4	0.015	1×10^{12}	
130 ≤P < 560		3.5	0.19	0.4	0.015	1×10^{12}	
P > 560		3.5	0.19	3.5	0.045	-----	NRSC

Annexure 7.1

MONITORING FORMAT

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

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
PM_{10}						

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

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

B. Water Quality (effluent / Wastewater / Ambient Water Quality)

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

3. Noise / Vibration

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

4. Solid Waste

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

5. 5 Format for Flora Monitoring Report

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