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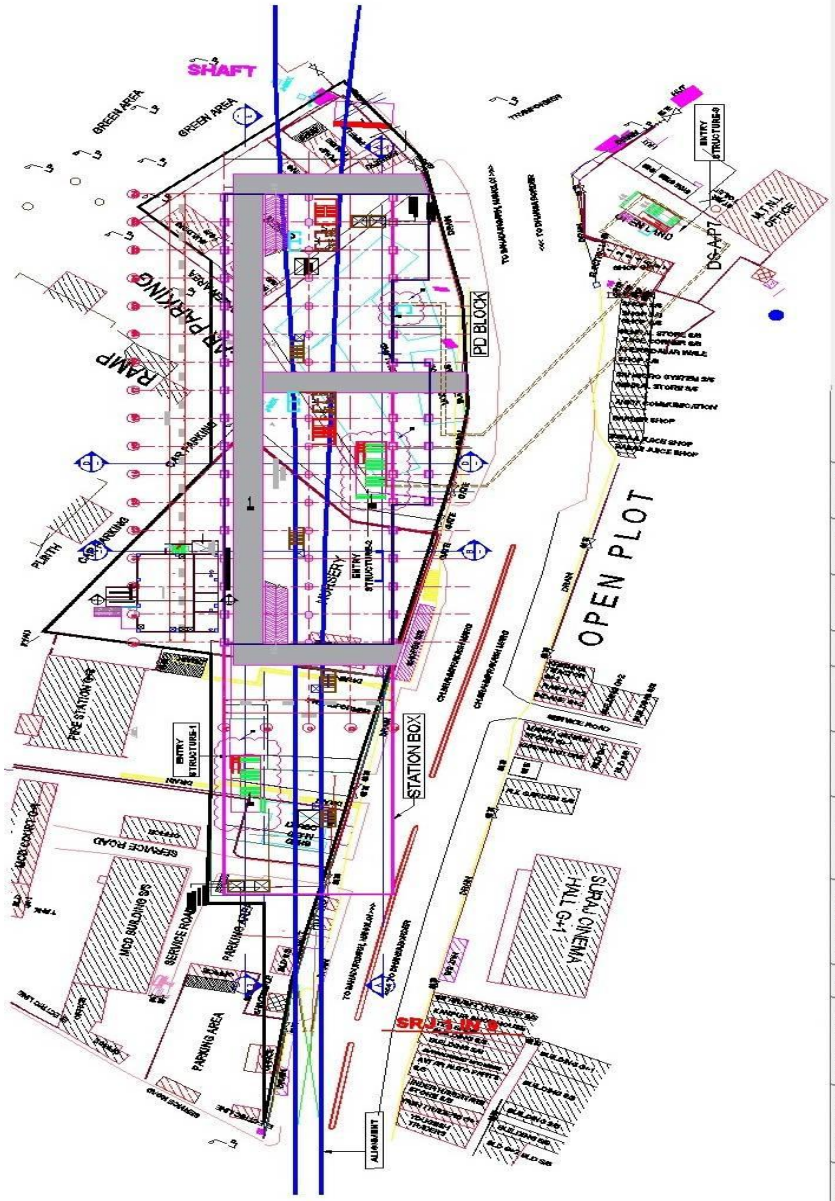
DELHI METRO RAIL CORPORATION LTD.

FINAL REPORT

ENVIRONMENTAL IMPACT ASSESSMENT FOR NAJAFGARH-DHANSA BUS STAND EXTENSION OF DELHI METRO



March 2018

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ABBREVIATIONS

AC	AIRCONDITIONER
BIS	BUREAU OF INDIAN STANDARDS
BOD	BIOLOGICAL OXYGEN DEMAND
C&D WASTE	CONSTRUCTION AND DEMOLITION WASTE
CERD	CENTRE OR ENVIROMENT RESEARCH AND DEVELOPMENT
CGWA	CENTRAL GROUND WATER AUTHORITY
CMP	COMPREHENSIVE MOBILITY PLAN
CO2	CARBONDIOXIDE
COD	CHEMICAL OXYGEN DEMAND
dB(A)	DECIBLES
DFO	DIVISIOAL FOREST OFFICER
DG	DIESEL GENERATOR
DJB	DELHI JAL BOARD
DMRC	DELHI METRO RAIL CORPORATION LIMITED
DPCC	DELHI POLLUTION CONTROL COMMITTEE
EIA	ENVIROMENT IMPACT ASSESSMENT
EMP	ENVIRONMENT MANAGEMENT PLAN
ETP	EFFLUENT TREATMENT PLANT
GBH	GIRTH AT BREAST HEIGHT
IMD	INDIA METEOROLOGICAL DEPARTMENT
LED	LIGHT EMITTING DIODE
Leq	EQUALIZED LEVEL
MCD	MUNICIPL CORORATION OF DELHI
Mm3	MILLION CUBIC METERS
MOEF	MINISTRY OF ENVIRONMENT ANND FOREST AND CLIMATE
MRTS	MASS RAPID TRANSPORT SYSTEM
MSL	MEAN SEA LEVEL
MSW	MUNICIPAL SOLID WASTE
NABL	NATIONAL ACCREDITION BOARD FOR LABORATORIES
NGO	NON GOVERNMENT ORGANIZATION
NGT	NATIONAL GREEN TRIBUNAL
NOC	NO OBJECTION CERTIFICATE
OBC	OTHER BACKWARD CASTES
PAPs	PROJECT AFFECTED PERSONS
PM10	PARTICULATE MATTER LESS THAN 10MM SIZE
PM2.5	PARTICULATE MATTER LESS THAN 2.5 MM SIZE
ROW	RIGHT OF WAY
SDMC	SOUTH DELHI MUNICIPAL CORPORATION
SDMC	SOUTH DELHI MUNICIPAL CORPORATION
STP	SEWAGE TREATMENT PLANT
TBM	TUNNEL BORING MACHINE
TSS	TOTAL SUSPENDED SOLIDS
UG	UNDERGROUND

EXECUTIVE SUMMARY OF ENVIROMENT IMPACT ASSESSMENNT STUDY FOR NAJAFGARH- DHANSA BUS STAND METRO CORRIDOR

0.1 INTRODUCTION

High population growth rate of Delhi coupled with high economic growth has resulted in an ever increasing demand for transport creating excessive pressure on the city's existing transport system comprising mainly of the road transport comprises of public buses, private vehicles, autos and Taxis.

0.1.1 Objective and Scope of the Study

The objective of the study is to facilitate the Metro extension between Najafgarh and Dhansa Bus stand project by understandig the environmental impacts of proposed activity and take timely and effective measures for mitigation of negative impacts where required and to seek acceptance of funding agencies while applying for loan. The scope of EIA includes the impacts resulting from pre-construction, during construction and operation phases of the metro corridor in Delhi.

0.1.3 Approach and Methodology

DMRC has considered different alternatives. The final alternative was fixed based on Technical Feasibility, Socio-economic acceptability, and Environmental sustainability of Metro Corridor. The environmental study is carried out for the alignment finalized/ proposed by DMRC. The Consultant has documented the baseline data for various parameters physical, ecological and environmental. The impacts are assessed for various phases of project cycle. The impacts are categorized as negative and positive. The cost of management and monitoring programmes were estimated and budgeted for.

0.2 PROJECT DESCRIPTION

0.2.1 Transport Demand and Forecast

Traffic studies and forecasting the transport demand for metro corridors in Delhi has been carried out.

0.2.2 Proposed Metro Corridor

In view of increasing demand for mass transport, Delhi State Govt. and Delhi authorities desired that the extension of metro corridor shall be developed in the city.

0.2.2.1 Route Alignment

0.2.2.2 Route Length and Stations

The main alignment is between Najafgarh and Dhansa Bus stand in Najafgarh for 1.21 Km.

0.2.2.3 Rolling Stock Requirement

Being extension of already under construction Dwarka- Najafgarh corridor there will not be any additional requirement of rolling stock.

0.2.3 Construction Methodology

It is proposed to construct this section underground as it crosses densely populated residential area of Najafgarh Town in 36 months from Dec 17.

0.3 ENVIRONMENTAL BASELINE DATA

0.3.1 Environmental Scoping

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.

0.3.2 Land Environment

The Project area is situated in Delhi area. The average elevation of the project area is about 214 m and 219 m above the Mean sea level (a-MSL) along the corridor.

The area under study is part of the Yamuna Basin comprising the newer alluvium made up of fine to medium sand, silt, gravel, clay and kankar. The surface belts are admixed with wind-blown sediments or recent age. These alluvial sediments are known to be underlined by hard formations of Delhi system of rocks. Following is the general sequence of formations met with in the area:

Recent to Sub – Recent	:	Alluvium
Post-Delhi Intrusive	:	Pegmatic and basic intrusive
Algonkian (Delhi System)	:	Alwar Quartzites

The area around the proposed metro corridor consists mainly of newer alluvium made up of fine to medium sand and silt. Soils are mainly sandy silt of low to medium plasticity (CL) or Silty sand/Fine to medium sand (SM) non-plastic in nature.

Seismicity: Delhi is located in zone IV of seismic zoning map of India.

0.3.3 Water Environment

Water environment consists of water resources and its quality.

0.3.3.1 Water Resources

The water availability and its quality play a significant role in this 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 m 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.

0.3.3.2 Ground Water

The hydro-geological situation characterized by occurrence of alluvial formation and quartzitic hard rocks controls the availability of groundwater. It is estimated that ground water availability in Delhi is 292 Mm^3. Salinity and over exploitation have contributed to depletion and drastically affected the availability of water in different parts of the city.

0.3.3.3 Water Quality

Water quality is the physical, chemical and biological characteristics of water. The water quality in the area is beyond desirable limits but within permissible limits as per IS: 10500 except flouride.

0.3.4 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). The mean annual rainfall of project area was 714 mm between the years 1980-90. Over 75% of the rainfall is received during rainy season. The cooler season from December to February is followed by the summer season from March to June. The period from June to about the end of September constitutes the south-west monsoon season, and October and November form the post-monsoon season.

0.3.5 Air Environment

The monitoring results show that the concentration of PM_{10} exceeds the standards whereas other parameters are within permissible limits.

0.3.6 Noise Environment

The noise level in the area is higher than the standards.

0.3.7 Trees

A total of **189 trees** in the project area are to be felled. Trees have been found of common species like Pipal, Neem, Babool etc.

0.3.8 Socio- Economic Conditions

Socially and culturally Delhi is cosmopolitan in nature. Most of the people are working in service sector and industrial sector. The area has also witnessed a lot of migration from all parts of the country. People commute between different parts of the city very frequently for different purposes.

0.3.9 Socio-Economic Survey

A socio-economic survey was undertaken for the proposed corridor to assess the socio-economic conditions of project-affected families/people and to examine the impacts of the proposed land acquisition for the metro

alignment and station area. There can be two types of impacts on the PAPs. One is the displacement of residential house and another is displacement of commercial establishments

It has been found during socio-economic survey that any residential structure is not affected by the metro. Land is mainly required for construction of stations and allied services.

0.3.10 Archaeological Sites

The proposed alignment of Delhi metro does not pass through any of the Archaeological monument or heritage sites.

0.4.0 NEGATIVE ENVIRONMENTAL IMPACTS

0.4.1 General

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.

0.4.2 Environmental Impacts

This section identifies and appraises the negative as well as positive impacts on various aspects of the environment likely to result from the proposed development.

0.4.3 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:

- Change of Land use- Permanent Land Requirement = 9283.9 m^2 which is Govt land. Temporary land requirement is 2352.3 m^2 of Govt. land.
- Loss of trees/forest – 189 trees are likely to be felled leading to loss of CO_2 absorption – 32962 Kg and Oxygen generation - 74088 kg in 8 years.
- Impact on Historical and Cultural Monuments- None

0.4.4 Impacts Due To Project Design

- Platform inlets and outlets: No hazard is anticipated due to the proposed sizes of inlets, outlets and platform utilities.
- Ventilation and lighting: Care has been taken at design stage itself to avoid illuminating the stations which could attract birds during night. Maximum illumination level proposed is 200Lux which provides normal lighting.
- Risk Due to Earthquake: The project area lies in Zone IV of Bureau of Indian Standards (BIS) Seismic Zoning Map.

0.4.5 Impacts due to Project Construction

The most likely negative impacts related to the construction works are: -

- Although the extension corridor is underground but, during construction period, partial traffic diversions on road will be required. There is safe distance between buildings and proposed corridor except some which have to be acquired for the project.
- There would be air pollution due to increment of $PM_{2,5}$ and PM_{10} and increment of dust.
- Water pollution may be encountered due to construction activities.
- Dewatering may also be required at Undergroud station site.
- The water demand will increase during construction phase for meeting out drinking and domestic water requirement of workers. Water requirement for construction of Metro stations will also be required to be met.
- C&D waste such as concrete, stones and dirt generated during construction.
- Tunnel Boring Machine (TBM) would be used for the tunneling work during construction.
- 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

0.4.6 Impacts due to Project Operation

Along with many positive impacts, 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:

- Vibrations radiated from train operations and track structures generally constitute the major vibration sources.
- The water demands will be on station for drinking, toilet, cleaning and also for other purpose like AC, chiller and other purposes.
- The refuse from station includes Garbage, Rubbish, and Floor Sweepings. As per the available data from other Metros the solid waste generation is about 0.6 – 1.0 cum/day at udergroud station.

0.5 POSITIVE ENVIRONMENTAL IMPACTS

The introduction of this alignment 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. Employment Opportunities: About 500 persons are likely to work during peak period of construction activity. In operation phase of the project about 35 persons per kilo meter length of the corridor, ie (approx. 40

persons) will be employed for operation and maintenance of the proposed system.In a nut shell, positive impacts include:

- Enhancement of Economy
- Mobility.
- Traffic Congestion Reduction.
- Reduced Fuel Consumption.
- Reduced Air Pollution.

0.6 ENVIRONMENTAL MANAGEMENT PLAN

0.6.1 Management Plans

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.

0.6.2 Mitigation Measures

Mitigation measures have to be adopted during construction at all the construction sites including Batching Plant and Casting Yards on all the aspects.

Compensatory Afforestation: According to the results of the present study, it is found that 189 trees are likely to be lost due to the project. Saplings would be planted for growing 1890 trees. Compensatory afforestation programme will be finalized in consultation with Forest Authorities by DMRC.
Construction Material Management: The scheduling of material procurement and transport shall be linked with construction schedule of the project. Care shall be taken to avoid spillage of material during construction.
Labour Camp: All temporary accommodation must be constructed and maintained in such a fashion that uncontaminated water is available for drinking, cooking and washing.

Energy Management: Use of energy efficient motors and pumps; Use of energy efficient lighting, which uses energy efficient luminaries.

Hazardous Waste Management: 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 has to be disposed off to authorized agents.
Environmental Sanitation: General environmental sanitation shall be carried out by the contractor and ensured at all times at Work Site, Construction Depot, Batching Plant, Labour Camp, Stores, Offices and toilets/urinals.
Utility Plan: Utility services shall be kept operational during the entire construction period and after completion of project.
Air Pollution Control Measures: The Contractor shall take all necessary precautions to minimise fugitive dust emissions from operations involving excavation, grading, and clearing of land and disposal of waste. The

Contractor shall use construction equipment so as to minimize or control of air pollution. Contractor's transport vehicles and other equipment shall conform to emission standards fixed by Statutory Agencies. The Contractor shall carry out periodical checks and undertake remedial measures including replacement so as to operate within permissible norms.

Construction and Demolition Waste: Opportunities for reducing C&D waste focus on three approaches, typically expressed as **Reduce-Reuse-Recycle**. An effort shall be made to recover embedded energy and to recycle the maximum quantity of C & D Waste to manufacture tiles, curb stones, paver block etc. There shall be no disposal of any waste along river, storm water drains, nallahs or any other water body or depression. Rather C & D waste shall be collected and sent to an authorized waste recycling facility

Noise Control Measures: During construction the exposure of workers to high noise levels especially near the machinery need to be minimized. This could be achieved by: Job rotation; Automation; Use electric instead of diesel powered equipment; Use hydraulic tools instead of pneumatic tools; Acoustic enclosures should be provided for individual noise generating construction equipment like DG sets,

Traffic Diversion/Management: In order to retain satisfactory levels of traffic flow during the construction period; traffic management and engineering measures need to be taken. They can be traffic segregation, one-way movements, traffic diversions on influence area roads, acquisition of one lane, etc. Maintenance of diverted roads in good working condition to avoid slow down and congestion shall be a prerequisite during construction period.

Soil Erosion Control: The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. Immediate control measures would be provided to prevent soil erosion and sedimentation that will adversely affect construction operations, damage adjacent properties, or cause contamination of nearby streams or other watercourses.

Sanitation and Solid Waste management:

During Construction

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 drinking water standards. The sewerage disposal systems should be adopted for sewage disposal. The water for domestic consumption shall be sourced from Delhi Municipal Corporation supply or alternatively designated borewells may be installed with due permission from (CGWA)/ Delhi jal Board, the statuatory authority prior to installation of borewell as per guidelines of 2015.

Solid waste shall be stacked at designated place and when sufficient quantity accumulates it shall be disposed off through covered trucks to land fill site designated and authorized by Delhi Authority.

During Operations

Practically, public facilities at stations may be designated to any NGO who may provide public conveniences at the metro station. They shall be responsible for upkeep and management of the utilities.

Solid waste will be generated at station to the tune of 0.6 – 1.0 m^3/Day. The storage containers for this purpose need to be designed.

Rain water harvesting: it has been proposed to construct roof top rainwater harvesting structure of suitable capacity at suitable locations.

Tree Protection: There is requirement of felling of trees. An attempt shall be made to minimize the tree felling. As remediation of tree felling it is suggested to plant ten trees for each tree felled. Moreover DMRC would chalk out the plantation programme in close coordination with Forest Authorities by making the payment for plantation work including after care for three years.

Training and Extension: The training for engineers and managers is to 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.

Disaster Management: 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 Engineer-in-Chief should notify for the following information:

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

Communication System: An efficient communication system is absolutely essential for the success of any disaster management plan. The damage areas need to be clearly identified and provided with temporary and fool 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. Emergency Action Committee will prepare the evacuation plan and procedures for implementation based on local needs and facilities available

Emergency Measures: The emergency measures are adopted to avoid any failure in the system such as lights, fire, means of escape etc.

0.7.0 ENVIRONMENTAL MONITORING PLAN

0.7.1 Construction Phase

Item	Parameter	Frequency and Duration	Locations
Air	PM_{10}	2×24hours Twice/month During entire civil construction stage or even later, if directed by DMRC	2 locations
Water	Ground-water quality (IS 10500:1991)	Once / 6months During entire civil construction stage or even later, if directed by DMRC	1 location
Noise	Noise Level (Leq, L_{90}, L_{50}, L_{10}, Lmin and Lmax)	24hours Once/ week During entire civil construction stage or even later, if directed by DMRC	2 locations
Ecology	Felled and planted trees	Once a year till all trees that were to be planted by MCD on behalf of DMRC, are planted	All the trees felled and newly planted

0.7.2 Operation Stage Monitoring Schedule

Item	Parameter	Frequency and Duration	Locations
Air	PM_{10}	2×24hours Once/month For 3years	1 locations
Water	Surface/ Groundwater quality(IS 10500: 1991)	Once/ year For 3years	1 location
Noise	Noise Level (Leq)	24hours Once/year For 3years	2 locations (Sensitive Receptors along the elevated section)

0.7.3 Establishment of an Environmental Division

DMRC already has established an Environmental Management Cell. Hence, an additional set-up for environmental management is not recommended.

0.8.0 SUMMARY OF COSTS

A provision of Rs. 52.80 Lakh has been suggested towards the cost of environment management. The compensation for loss of land, fire control,

information systems and contractor's obligations has been incorporated in project costs. The Environmental management plan should be implemented in phases so that optimum benefit could be achieved and should be synchronized with the construction schedules.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

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, as on 1st March, 2011, was worked out at 16.75 millions as against 9.42 millions on 1st March, 1991. The corresponding percentage at All-India level has been worked out at 21.34%**.** During years 1901 to 1911 the decennial growth of Delhi was 11.13% and it increases to 106.58% in 1941-1951. Thereon it steadily decreased. The decennial growth reduces to 46.87% in 1981-1991, 1991-2001 decennial growth rises to 52.34%, However in 2001- 2011the decennial growth was 20.94% .

North – West district are the most populated districts in Delhi with a population of 2.847 million and 2.258 million respectively. However North – East, Central and East are the densely populated with 29,395; 25,760 and 22,637 people /km^2. According to Census 2011, the density of population in Delhi is worked out at 9,294 persons per sq. km. as against 6,352 persons in 1991. Density of population at All-India level has been worked out at 324 persons per sq. km. in 2001. The density of population in Delhi is highest in the country.

1.2 LEGAL, POLICY AND INSTITUTIONAL FRAME WORK

The need for a well-developed legal mechanism to conserve resources, protect the environment and ensures the health and well being of the people in India is more than ever before. Keeping pace with international laws, the Ministry of Environment and Forest enacted Environmental Protection Act in 1986. Over the years, the Government of India has framed several policies and promulgated number of Acts, Rules and Notifications aimed at management and protection of the environment. The available national and state level legal Acts and Legislation referred during the study are:

- The Water (Prevention and Control of Pollution) Act, No. 6 of 1974 (Amendment 1988).
- The Water (Prevention and Control of Pollution) Cess Act No.36 of 1977, (Amendment), 1992 and No. 19 of 2003.
- The Water (Prevention and Control of Pollution) Cess Rules, 1978, 1991.
- The Air (Prevention and Control of Pollution) Act No. 14 of 1981, amended 1987.
- Noise Pollution (Regulation and Control) Rules, SO 123 (E) dt 14-02-2000, SO 1046 (E) Dt 22-11-2000, and amendments SO 1088 (E) Dt 11-10-2002, SO 1088 (E) dt 13-07-2006, SO 1569 (E) Dt 19-09-2006 and SO 50 (E) dt 11-01-2010.

- Municipal Solid Waste Rules, 2016, No. 1357 E dt 08094-2016.
- The Environment (Protection) Act, 1986 (29 of 1986 dt 23/5/1986), amended 1991.
- The Environment (Protection) Rules,1986.
- The Indian Forest Act, 1927.
- Forest (Conservation) Act, 1980, amended 1988.
- Forest (Conservation) Rules, 2003.
- The Wild Life (Protection) Act 1972, Amendment, 2002
- C& D Waste Management Rules 2016. GSR 317 E dt 29-03-2016
- Hazardous Substances Management GSR. 347(E) Dt 01-08-1996, GSR 616(E) Dt 20-09-2006 and GSR 1(E) Dt 23-12-2016

1.3 ENVIRONMENTAL CATEGORIZATION AND CLEARANCES

The proposed project does not pass through any Wildlife Sanctuary, National Park, or any other environmentally sensitive or protected areas. The proposed project comprises three alignments viz., between Najafgarh and Dhasa Mor. The alignment is proposed underground. The proposed project will bring in many benefits to the area. There is potential for environmental impacts on the ambient environment.

Requirement of Environmental Clearance

As per provisions of the EIA Notification, 14 September 2006 as amended up to 1st December 2009, any person who desires to undertake any new project in any part of India or the expansion or modernization of any existing industry or project listed in Schedule-I of the said notification shall submit an application to the Ministry of Environment and Forests, Government of India in accordance with the guidelines issued by the Central Government in the Ministry of Environment and Forests from time to time. Metro Rail project is not included in the Schedule-I of the EIA Notification, 2006. Thus, the project does not require an environmental clearance certificate from the Ministry of Environment and Forests, Government of India.

Requirement of Forest Clearance

As per Indian "Forests Conservation Act (1980), every project requiring diversion of forest land for non-forestry purposes require forest clearance from MoEF. The forestry clearance is granted through two-stage process: Stage 1 refers, in principle agreement, to the project proposal in which usually the conditions relating to transfer, mutation and declaration as RF/ PF under the Indian Forest Act, 1972, of equivalent non-forest land for compensatory afforestation and funds for raising compensatory afforestation thereof are stipulated. Stage II involves formal approval under the Act after receipt of

compliance report from the State Government in respect of the stipulated conditions. Since alignment is not passing through any forest land and no diversion of forest land is involved in the proposed project, no forest clearance is required for this project.

Required Clearances/Permissions

For the proposed project, required clearances/ permissions related to environment have been summarized below.

Table 1.1: Permissions/Clearances Required for the Project

S. No.	Permissions/ Clearances	Acts / Rules / Notifications / Guidelines	Concerned Agency	Responsibility
A. Pre-construction Stage				
1	Permission for felling of trees	Forest Conservation Act (1980) Procedural Guidelines developed by the Department of Environment, GoM; Tree removal will be guided as per state government rules.	DFO/District Collector	DMRC
B. Implementation Stage				
2	Consent to operate hot mix plant, crushers, batching plant	Air (Prevention and Control of Pollution) Act 1981	DPCC	Contractor
3	Permission for withdrawal of groundwater	Environment (Protection) Act, 1986	Central Ground Water Authority/DJB	Contractor
4	Permission for sand mining from river bed	Environment (Protection) Act, 1986	Mining Department/ MoEF	Contractor
5	Authorization for handling and storage of Hazardous Waste	Hazardous Waste (Management and Handling) Rules 2016	DPCC	Contractor
6	Disposal of bituminous and other wastes	Hazardous Waste (Management and Handling) Rules 2016	DMRC may authorize to use local solid waste disposal	Contractor
7	Consent for disposal of sewage from labour camps.	Water (Prevention and Control of Pollution) Act 1974	DPCC	Contractor

8	Pollution Under Control Certificate	Central Motor and Vehicle Act 1988	Department of Transport, Govt. of Delhi authorised centres	Contractor
9	Roof Top Rain Water Harvesting (RWH)	Central Groundwater Authority (CGWA) Guidelines	Central Ground Water Authority/ DMRC/DJB	Contractor
10	Permission for groundwater extraction for drinking purpoes	Environment (Protection) Act, 1986	CGWA/DJB	Contractor
11	Employing Labour/ workers	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	District Commissione	Contractor

1.4 OBJECTIVE AND SCOPE OF THE STUDY

The objective of the Environment and Social Impact Assessment study is to facilitate the DMRC evaluate the environmental impacts of its proposed activity. DMRC proposes to apply for loan to seek financial support from multilateral funding agencies. Thus, the objective of the study is to conduct Environmental Impact Assessment as per requirement of multilateral funding agencies. The scope of EIA includes the impacts resulting from pre-construction, during construction and operation phases of the proposed metro alignment in Delhi. In addition, it is proposed to establish environmental baseline and safeguard measures for protection of environment for sustainable development during project cycles.

1.5 APPROACH AND METHODOLOGY

The DMRC has considered different alternative corridors. 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 and minimal disturbance to ecology/biodiversity. In the analysis of alternatives, a comparison of scenario with and without the project has also been made. The final alternative was fixed based on Technical Feasibility, Socio-economic acceptability, and Environmental sustainability for Metro Corridor. The environmental study is carried out for the alignment proposed by DMRC. The approach is to follow the sequence of steps adopted in an EIA study. The basic concept is to ascertain the existing

baseline conditions and assess the impacts as a result of construction and operation of the project. The changes likely to occur in different components of the environment viz. physical, biological / ecological, environmental and socio-economic etc. have been studied, analyzed and quantified, wherever possible. The identification of parameters for data generation and impact assessment are important. The analysis of assessment depends upon the reliable data generated/ available on environmental attributed. This study has documented the baseline data for various parameters of physical, ecological and environmental pollution (air, water and noise). 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 programmes were estimated and budgeted for. The approach for the study is presented in **Figure-1.1.**

The standard methodology for the data collection, impact assessment and formulation of management plans is adopted. The national acts, legislation and laws along with guidelines were consulted with a view to ensuring compliance with various requirements. Environmental baseline data for environmental attributes from primary and secondary sources were collected and compiled. The primary sources include site visits, visual inspection, field studies, monitoring and analysis. The secondary sources include the books, reports, maps and documents from various government and non-government organizations on subject matter. The methodology 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 mainly as urban human settlements, roads, Trees and water bodies.

Water Resources in the project were considered in terms of precipitation, surface run off; quantity and quality of water.

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

Terrestrial **Ecology** was also studied.

1.5.2 Environmental Impact Assessment

The objective of the study is to assess the impacts as a result of construction of the proposed metro corridor. The changes likely to occur in different

components of the environment were studied and analyzed. 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 get an idea about resultant impacts. The environmental impact of the project includes changes in land use, soil, erosion, water quality, air quality and noise levels etc. On the other hand, the project will provide higher living standard, better quality of life, less travel time, better connectivity and transport facilities.

1.5.3 Environmental Management Plan

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 with respect to pre-project stage. An environmental management strategy/ plan is developed to mitigate the adverse impacts. Efforts are made to enhance the quality of environmental attributes.

1.5.4 Environmental Monitoring

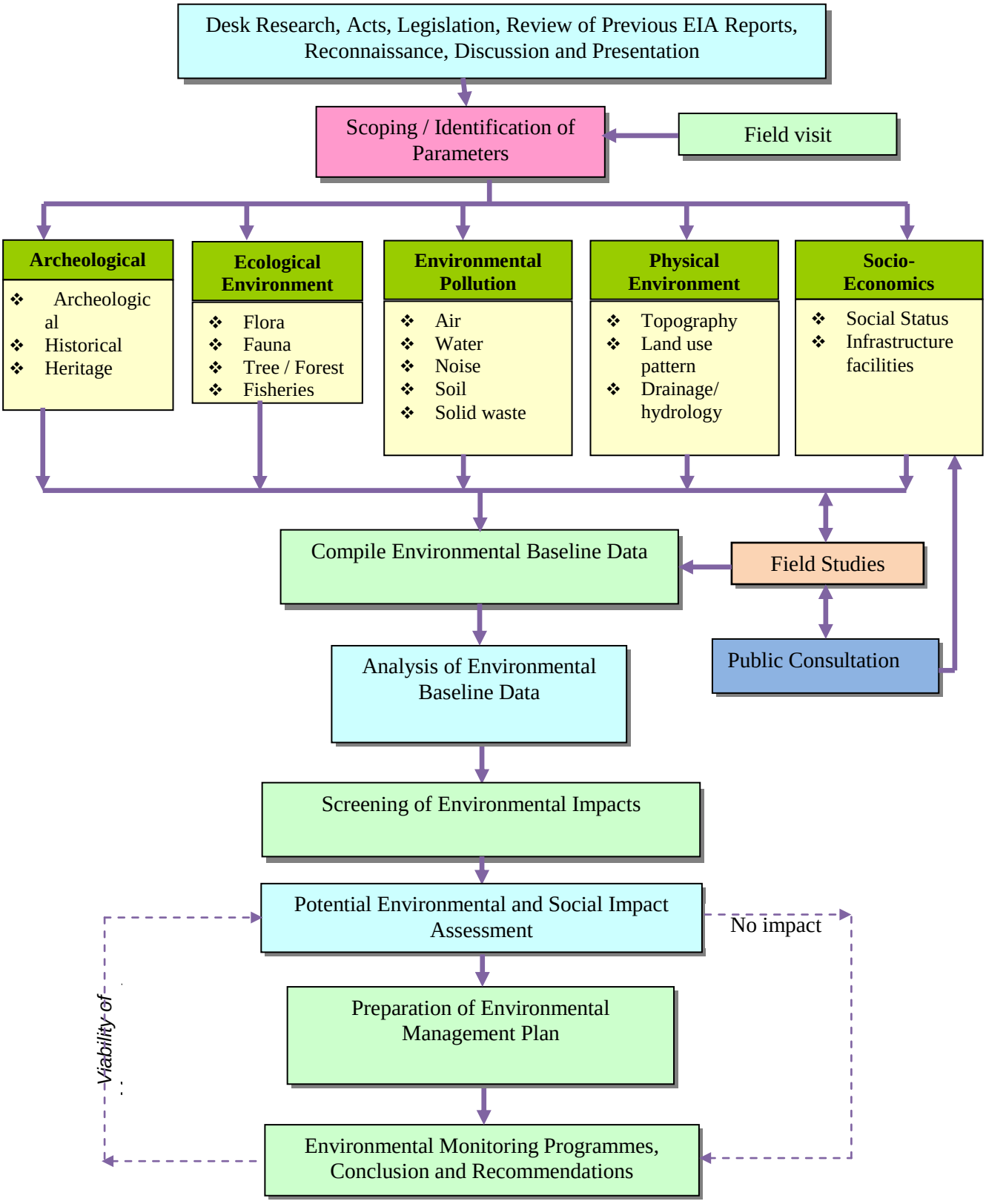
Monitoring would indicate any environmental problem, which has come up due to an ongoing activity. This will facilitate to assess the effectiveness of management / mitigation measures.

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** summarises environmental baseline conditions including physical, biological and socio-economic parameters and pre-project environmental constraint such as air pollution, problems related to public health and traffic congestion. Potential negative and positive impacts are presented in **Chapters-4 and 5** presents analysis of alternatives. 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 Metro corridor in Delhi. The positive impacts included employment opportunities, mobility, traffic congestion reduction, fuel savings, reduced air pollution etc.

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.** This also includes the cost of disaster management plans and emergency information systems.

FIGURE 1.1 METHODOLOGY FOR THE EIA STUDY



CHAPTER 2

PROJECT DESCRIPTION

2.0 TRANSPORT SITUATION IN DELHI

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. Vehicle population in Delhi is highest among all metropolitan cities (Bombay, Calcutta, Delhi and Madras). As on February 2011 there are 6,844,527 private and commercial vehicles registered in Delhi.

2.1 PROJECT AREA

This metro aligment is located in Delhi between Najafgarh (Delhi Gate) and Dhansa Bus stand. The proposed alignment would serve the area by providing better connectivity to people coming from and going to the rural area between Dhansa Mor and upto Haryana Border. The maintenance Depot is not proposed for this corridor and it is proposed to use the existing Depot at Najafgarh. This metro corridor is proposed in **Delhi** to cater the requirement of the city for a length of about 1.21 Km. The total alignment in this corridor will be under ground entirely. The Metro corridor will have standard Guage alignment.

2.2 PROPOSED METRO CORRIDOR

Metro corridor is proposed in Delhi between Delhi Gate at Najafgarh and Dhasa Mor at Najafgarh. This proposed corridor extension will be underground. The route aligmet of extension of Metro line from Najafgarh to Dhansa Bus stand is planned underground as it passes through built up area and underground station is proposed at Dhansa Bus stand. The most part of the alignment falls in heavily built up area.

2.3 LOCATION OF STATIONS

There will be 1 station in the propsed extension at Dhansa Bus Stand having centre line at chainage 4938.23m for Dn line and 4950.33m for Up line.

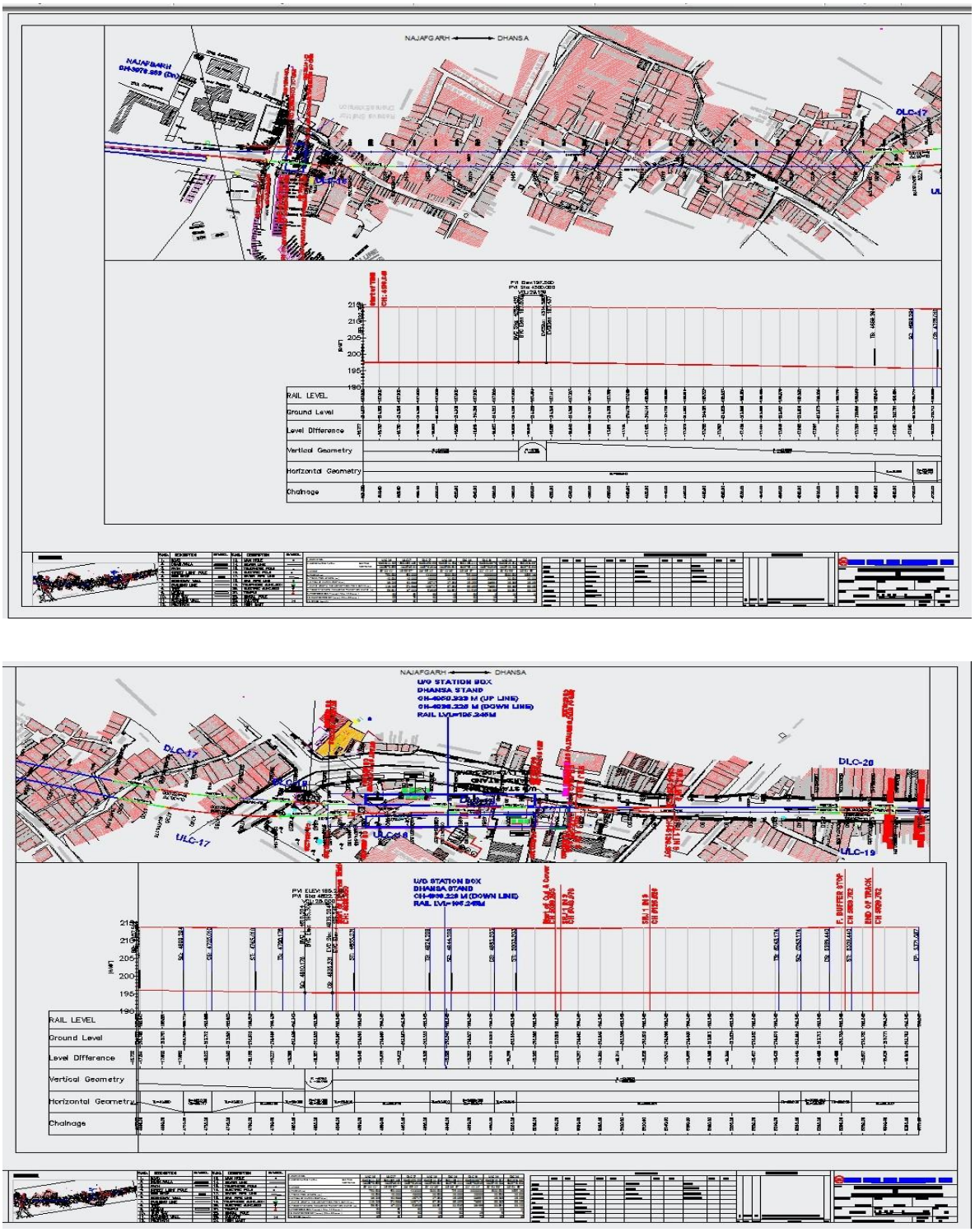


Figure 2.1 General Alignment of Proposed Corridor

2.4 TRAFFIC PROJECTIONS

Since the proposed extension is for only 1.2 km length from Njafgarh to Dhansa Bus stand which falls within the catchment area of Traffic forecast for Metro extension upto Najafgarh. The same projections have been considered for this extension also. However due to preset extension in the network of Delhi Metro the lead has been increased from 10.22 km to 16.80 Km.

The projected ridership figures as per traffic study considered for FIRR as for various years is indicated in Table 2.1 below:

Table 2.1 Year wise Ridership

S.No.	Year	Traffic
1	2020-21	61000
2	2030-31	78000

2.5 SYSTEM REQUIREMENT

Since the proposed corridor is the extension of underconstruction section, the same system design would be applicable on this corridor as well.

2.6 ROLLING STOCK REQUIREMENT

No additional rolling stock is required for this section. Therefor, provision has not been made for additional rolling stock for the proposed extension.

2.7 CONSTRUCTION METHODOLOGY

The Dwarka- Najafgarh corridor is under costruction. At Najafgarh the corridor is Udergrround and will continue to be underground for the entir extension section upto Dhansa Bus stand.

Construction is proposed to be commenced in December 2017 and is ikely to be completed in 36 months.

2.8 MAINTENANCE DEPOT

Depot for this corridor is not proposed as the Depot at Najafgarh would also serve this portion of the corridor as well.

CHAPTER 3
ENVIRONMENTAL BASELINE DATA

3.1 ENVIRONMENTAL SCOPING

Baseline environmental status in and around the proposed project depicts the existing environmental conditions of the location. Baseline data was collected for various/environmental attributes so as to compute the impacts that are likely to arise due to proposed project.

The scope of the present study includes detailed characterization of following environmental components, which are most likely to be influenced by the proposed project:

- Land Environment
- Water Quality (Surface + Ground water)
- Meteorological conditions
- Ambient Air Quality
- Noise Levels
- Biodiversity
- Socio Economic studies.

The information presented in this chapter has been acquired from various sources. Data on land environment has been collected and compiled from various reports and field surveys. The data on water, air, noise quality, and biodiversity were collected through field studies, sampling in October 2017. Climatological data was collected from India meteorological Department. Efforts have been made to compile the available data from literature, books, maps 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**.

Table 3.1 Environmental Attributes and Frequency of Monitoring

S. No	Attribute	Parameter	No. of Samples	Source
Land Environment				
1	Geology	Geological Status	---	Literature review
2	Seismology	Seismic Hazard	---	Literature review
Water Environment				
3	Ground Water	Physical, Chemical and Biological parameters	1	Sampling/ Monitoring locations

S. No	Attribute	Parameter	No. of Samples	Source
Air, Noise And Meteorology				
4	Ambient Air Quality	PM_{10}, $PM_{2.5}$, $SO_{2,}$ NO_x, CO	1	Sampling/ Monitoring locations
5	Noise	Noise levels in dB (A) Leq, Lmax, Lmin, L_{10}, L_{50}, L_{90}	1	Sampling/ Monitoring locations
6	Soil	Physico-Chemical parameters	1	Sampling Locations
Socio-Economic				
7	Socio-economic aspects	Socio-economic profile	Once	Field Studies, Literature review.
Ecology				
8	Trees	Number	Once	Field Studies

Sampling locations of Water Quality, Noise Level, and Ambient Air Qaulity are depicted in **Fig. 3.1**.

Table 3.2 Sampling / Monitoring Locations:

S. No	Station Name	Samples	Location
1	Ambient Air Quality	1	Dhansa Bus Stand
2	Noise Levels	1	Dhansa Bus Stand
3	Ground Water Quality	1	Dhansa Bus Stand
4	Soil Quality	1	Dhansa Bus Stand

Fig. 3.1 Air Quality, Noise level and Water Sampling/Monitoring Sites

3.2 LAND ENVIRONMENT

The Project area is situated in Delhi. The elevation of the project area is ranging between 214 m to 219 m. The parameters involved in land environment are physiography, geology and soils, and seismicity. These are discussed in the following paragraphs.

3.2.1 GEOLOGY AND SOIL

The proposed metro extension corridor is located in South-west Delhi District. Geomorphologically, Major part of the district is under Yamuna Alluvial Plain and small part of the district has Quartzites on the eastern border of the district. Major soil types of the district are sand, clay & kankar.

The area is characterized by unconsolidated Quaternary alluvial deposits belonging to Middle to Late Pleistocene Age. The area comprises of silt and clay mixed with kankar in varying proportions. Only 18 sq km area is covered by denudational hills especially in the eastern part of the district.

3.2.2 Seismicity

The country has been classified into different zones indicating the intensity of damage or frequency of earthquake occurrences. Delhi falls in zone IV according

to IS 1893: 2002 which means an earthquake upto magnitude 6.5 on Richer scale may be expected (Figure 3.2).

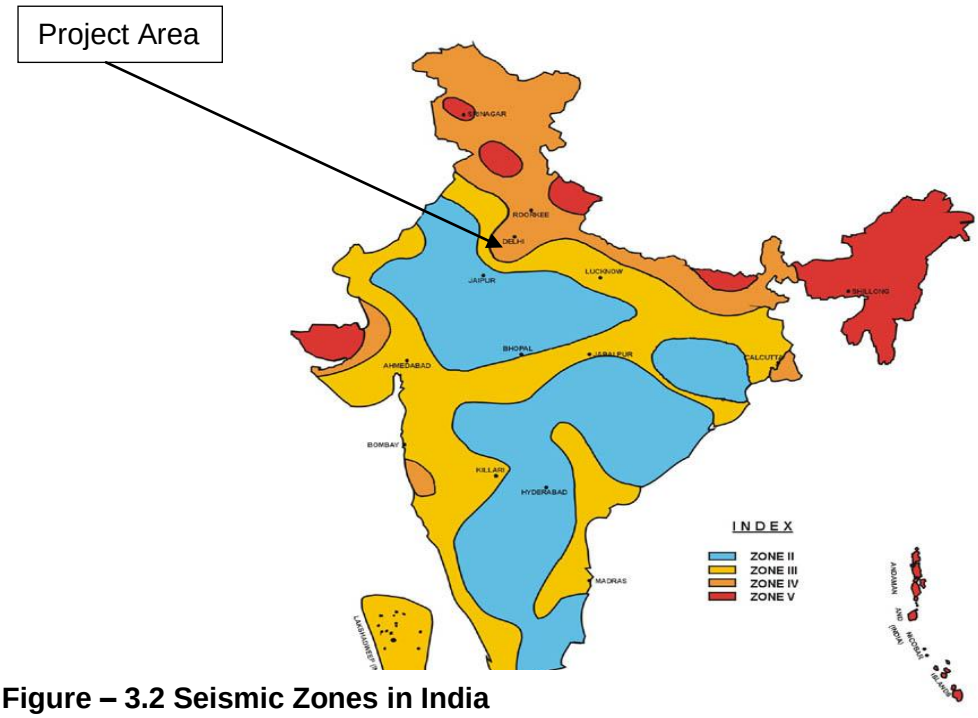


Figure – 3.2 Seismic Zones in India

3.2.3 Soil Quality

In order to ascertain the quality and nature of soil within the vicinity of the project site, soil sample was collected. The sample was collected at about 60 cm depth on 12th October 2017. The sample tested for physical and chemical properties. Soil Sampling site has been shown in **Fig. 3.1**. The results of soil analysis are presented in **Table 3.3.** As per the test results it is observed that soil is tending to become alkaline. Soil is high in nitrogen and the carbon contents at most of the places. However phosphors and potassium content is low. Calcium and magnesium content is adequate at most of the places. At all places the soil texture is of sandy silt.

Table 3.3 Soil Test Results

S. No.	PARAMETERS	Dhansa Bus Stand
1.	pH	8.34
2.	Organic Matter (%)	0.68
3.	Nitrogen (kg/Hectare)	137.6
4.	Phosphorus (kg/Hectare)	<1.0
5.	Sodium (mg/100gm)	11.9
6.	Calcium (ppm)	2410
7.	Potassium (kg/Hectare)	98
8.	Magnesium (ppm)	250
9	Electrical Conductivity	723
10	Texture (%)	
	Sand	82.46
	Slit	15.40
	Clay	2.14

Source: Field study

3.3 WATER ENVIRONMENT

Water environment consists of water resources and its quality. Its study is important from the point of view of assessing 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 proposed project, ground water is proposed to be used during operations to meet out domestic water requirements of the project in case water is not made available by SW Delhi Municipal Corporation. Hence its quality has been tested to evaluate its suitability for the intended purpose. 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 this 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 m 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.

Rainwater: Delhi receives a normal rainfall of 714 in 27 rainy days. The utilized rainwater runoff is 193 Mm^3 per year. Apart from these the Bhakra storage and the Upper Ganga Canal also provide water.

3.3.2 Hydrogeology and Ground Water

Hydrogeological map of the district is shown in Figure 3.3. Thick pile of alluvium overlies the basement rock and consists of alternate layers of silt, clay, sand and kankar. Nearly fine to medium sand and silt grade sediments occur frequently up to the depth of 50 m along with buff coloured clayey bed admixed with coarse kankars. On the other hand, after the depth of 50 m, thickness of silty -clay and clay (Light yellow) beds with kankars increases with depth. The semi-plastic and plastic clay beds are also common at deeper depth i.e. 80 to 250 m bgl. The granular zone at deeper depth is not as frequent as in the shallower depth. The bed rock has been encountered at many places i.e. in Dhansa (297m), Pindwalakala (300m), Toghan pur(298m) and Jhuljhli(251m).

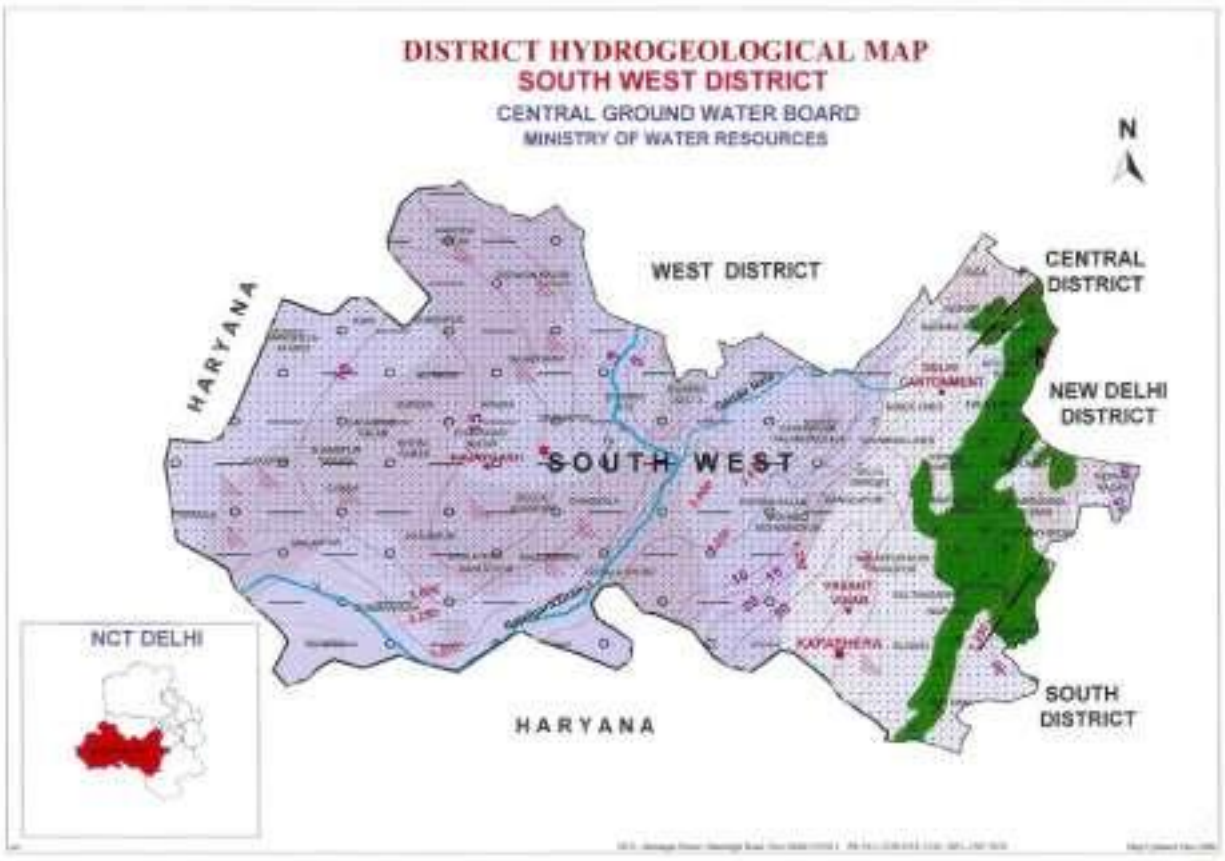


Figure 3.3 Hydrogeological Map of South-west Delhi District

SOUTHWEST DISTRICT

LEGEND

	Wells feasible	Rigs suitable	Depth of Well (m)	Discharge (lpm)	Suitable Artificial Recharge Structures **
Soft Rock Aquifer	Tube Wells	Reverse / Direct Rotary	30-90 *	120-400	Shaft/Trench with recharge well, Recharge Pit with/without bore
Hard Rock Aquifer	Tube Wells	DTH/ Rotary cum DTH	60-120*	90-180	Shaft/Trench with recharge well, Recharge Pit with/without bore, Check Dams/Bunds
Depth to Water level in m. (Pre-monsoon decadal mean, 2003-2012) 5		Electrical Conductivity (Micro mhos/cm at 25° C) 3000		Major river / Drain	Faults/Lineaments
Fluoride > Permissible limit (1.5 ppm)		Nitrate > Permissible limit (100 ppm)		Iron > Permissible limit (1.0 ppm) / * Fe	
State boundary		District boundary		Tehsil boundary	
Tehsil head quarter / District head quarter		Over exploited block		Area feasible for Artificial Recharge structures	

* Depth of the well is restricted to the availability of fresh water. ** Feasible in areas where depth to water level is more than 8 m below ground level. In soft rock formation recharge well may be constructed where water level is more than 15 m. bgl (meter below ground level).

OTHER INFORMATION

Name of State	Delhi
Name of District	Southwest
Geographical Area	420 Sq.Km.
Major Geological Formation	Alluvium - Older Alluvium Hard Rock - Quartzite
Major Drainage System	Yamuna
Population (as on 2011)	22.92 lakhs
No of Tehsils	3, Najafgarh, Delhi Cantt. and Vasant Vihar
Replenishable Ground Water Resources (MCM)/ Draft (MCM)/ Stage of Ground Water Development (%)	Delhi Cantt.- 8.92/18.08/225 Najafgarh- 70.12/82.97/125 Vasant Vihar- 18.48/24.64/148
Average Annual Rainfall	Palam - 794 mm
Range of Mean Daily Temperature	18-32°C
Tehsil Showing Intensive Ground Water Development	All the three tehsils

Depth to water level:

Depth to water level of the district shows large variation. Shallow water level is observed in the south western part of the district while deeper water levels are observed in the eastern part of the district. The depth to water level during pre monsoon period in the district ranges from 2.40 to 53.17 m bgl and during post monsoon period, it varies from 0.69 to 54.02 m bgl.

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 are related 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. Water sampling Site has been shown in **Fig. 3.1.** Groundwater sample taken on 12th October and its quality is not good for drinking. Total dissolved solids are a little higher than the desirable limits but within permissible limits. All other parameters are well within the desirable limits except fluoride levels.

Table 3.4 Ground Water Quality at Project Site

Location / **Parameter**	**Dhansa Bus Stand**	***Standard***
Colour, Hazen	Colourless	5 (15) Max
Odour	Unobjectionable	Unobjectionable
Taste	Agreeable	Agreeable
Turbidity, NTU	4.3	1 (5) Max
pH	8.19	6.5-8.5 Max
Total Hardness as Caco3, Mg/l	789	200 (600) Max
Chloride as Cl, Mg/l	241	250 (1000) Max
Total Iron as Fe, Mg/l	2.08	0.3 Max
Total Dissolved Solids, Mg/l	1613	500 (2000) Max
Sulphates as So4, Mg/l	279	200 (400) Max
Nitrates as No3, Mg/l	46.4	45 Max
Fluorides as F, Mg/l	2.69	1.0 (1.5) Max
Lead as Pb, Mg/l	BDL	0.01 Max
Copper as Cu,Mg/l	BDL	0.05 (1.5) Max
Manganese as Mn,Mg/l	BDL	0.1 (0.3) Max

Phenolic Compound as C6H5OH,Mg/l	BDL	0.001 (0.002) Max
Mercury as Hg,Mg/l	BDL	0.001 Max
Cadmium as Cd,Mg/l	BDL	0.01 Max
Selenium as Se, Mg/l	BDL	0.01 Max
Arsenic as As,Mg/l	BDL	0.05 Max
Cyanide as Cn,Mg/l	BDL	0.05 Max
Zinc as Zn, Mg/l	1.82	5 (15) Max
Detergent as MBAS, Mg/l	BDL	0.2 (1.0) Max
Chromium as Cr+6 ,Mg/l	BDL	0.05 Max
Total Alkalinity as Caco3,Mg/l	287.3	200 (600) Max
Aluminum as Al,Mg/l	BDL	0.03(2) Max
Boron as B, Mg/l	BDL	0.5(1) Max
Bacteriological Analysis		
Coliform,MPN/100Ml	Nil	10 Max
E-Coli/Ml	Negative	Negative

3.4 METEOROLOGY

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). The recorded meteorological data for the area have been summarised in Table 3.5 through 3.10. The mean annual rainfall of project area was 714 mm between the years 1980-90. Over 75% of the rainfall is received during rainy season (Ref Table 3.4).

Delhi has a monsoon climate with an average yearly rainfall of 714 mm. The air relative humidity at Delhi varies almost throughout the year but seldom drops below 30%. Records of monthly rainfall, mean maximum and mean minimum relative humidity of Delhi obtained from Indian Meteorological Department, from 2005 to 2009 are given in **Table 3.5 to Table 3.7**.

The mean monthly maximum temperatures are highest in April-May-June (38^{O}C). Mean minimum temperature is lowest during January (7^{O}C). Records of mean maximum and mean minimum temperatures are given in **Table 3.8** and **Table 3.9** respectively.

Winds are generally light to moderate (0.9 to 4.9 m/sec) but increases in April-May-June. Wind direction is mostly from North, North East; and North West. The sky is moderately cloudy in July-August and is generally cloud free from February till May.

TABLE 3.5

MONTHLY RAINFALL (In mm)

Month	Rainfall in mm	
	2009	**2010**
January	4	4.5
February	5.5	18.8
March	8.4	0
April	4.5	0.2
May	31.4	2.3
June	16.6	4.2
July	119	173.1
August	156.3	464.4
September	192.9	359.7
October	2	8.9
November	17.5	16.2
December	1.9	3.7
Annual Total	560	1056

TABLE 3.6

MEAN MAXIMUM RELATIVE HUMIDITY (In %)

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2005	89	85	83	51	53	61	86	78	87	85	82	88
2006	88	87	84	55	70	73	85	85	89	85	95	94
2007	94	92	82	60	69	73	86	88	90	84	95	90
2008	94	92	82	62	73	90	93	89	88	86	87	88
2009	90	85	71	52	59	56	75	90	85	89	97	97

TABLE 3.7

MEAN MINIMUM RELATIVE HUMIDITY (In %)

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2005	47	40	39	16	19	33	65	52	57	32	27	32
2006	37	27	30	19	32	38	59	57	49	36	35	40
2007	36	46	36	21	29	44	56	60	52	26	34	35
2008	41	36	26	23	34	56	59	64	55	39	36	46
2009	44	35	29	20	26	29	52	62	51	29	34	33

TABLE 3.8

MEAN MAXIMUM TEMPERATURE (In degree centigrade)

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2005	20.1	23.2	30.4	36.3	39.5	40.3	34.2	35.7	33.9	33.2	29	22.7
2006	22.4	29.7	29.6	37.5	39.8	38.2	34.9	35.4	34.5	33.6	28.9	23.3
2007	21.5	24.2	28.3	38.2	38.9	38.1	35.9	34.8	34.5	33.4	29	22.9
2008	20.9	23.5	33.4	36.2	37	35	35.3	33.7	33.9	34.2	29	24.5
2009	21.7	26.1	31.5	36.9	40.1	40.9	35.8	35.4	34.1	33	27.2	23.6

TABLE 3.9

MEAN MINIMUM TEMPERATURE (In degree centigrade)

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2005	7.7	10.8	17.1	20.4	24.8	28.2	27.1	27.3	25.1	18.8	12.2	6
2006	7.1	13.5	15.3	20.1	24.5	24.3	27.1	26.8	24.7	20.5	13.9	9.2
2007	6.7	11.8	15.3	23	25.8	28.4	27.6	27.1	25.2	17.5	12.6	8
2008	6.5	8.3	17.1	21.2	24.5	26.7	27.1	26.4	24.5	20.9	12.9	10.2
2009	8.9	11.3	16.1	22.2	26	28.2	28	27.2	25.1	19.2	13.5	8.7

Source: India Meteorological Department, Govt. of India.

3.5 AIR ENVIRONMENT

The atmospheric concentrations of air pollutants were monitored at Dhansa Bus stand between 12 to14 October 2017. Location of air monitoring station is shown in Figure 3.1. Air Monitoring was carried out for PM_{10}, $PM_{2.5}$, NOx, SO_2 and CO. Results of the air quality monitoring are presented in Table 3.10.

Table 3.10 Ambient Air Quality Results (µg/m3)

S.No	Location	Date	PM_{10}	$PM_{2.5}$	SO_2	NOx	CO
	Regulatory Standards		**100**	**60.0**	**80**	**80**	**2000**
1	Dhansa Bus stand	12 to14 October	322	187	19.4	139	1900
			351	192	21.6	149	2400

RSPM= Respirable Suspended Particulate Matter.

The results show that the concentration of RSPM ($PM_{2.5}$ and PM_{10}), NOx and CO are higher whereas SO_2 levels are within permissible limits.

3.6 NOISE ENVIRONMENT

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

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

Noise level survey was conducted along the alignment with an objective to establish the baseline noise levels and assess the impacts of total noise expected due to the proposed metro. Noise levels were measured at 1 location at Dhansa Bus stand on 12-13 October 2017 for 24 hours. The locations of Noise level monitoring have been shown in **Fig. 3.1**. The noise levels so obtained are summarized in **Table 3.11.**

Table 3.11 Noise Levels in dB(A)

S.No	Location	Date		Lmax	Lmin	Leq	L_{10}	L_{50}	L_{90}
1	Dhannsa Bus Stand (Roadside-Commercial)	12-13 October	Day	85.1	62.1	73.2	79.5	73.7	60.1
			Night	72.6	45.3	58.6	67.6	53.5	51.6

Allowable Noise Levels dB (A):

Category of Area/Zone	Day Time	Night Time	
Industrial Area	75	70	EPA-1986, Noise pollution (Regulation Control), Rule-2000, PCLS/02/1992, IVth Edition .
Commercial Area	65	55	
Residential Area	55	45	
Silence Area	50	40	

Day Time (6.00 AM-10.00 PM); Night Time (10.00 PM-6.00AM)

The observed noise level is higher than the permissible limits at all locations which may be due to heavy traffic movement and other activities on the roads.

3.7 TREES

Tree survey has been carried out along the proposed alignment. Tree with Girth at Breast Height (GBH) 30 cm have been counted. The alignment does not pass through any forest area. A total of 189 trees are located along the alignment and station area. No endangered species of trees have been noticed during field survey. Trees have been found of indigenous and common species like Pipal, Neem, Kikar, Babool, Tadi etc.

3.8 SOCIO- ECONOMIC CONDITIONS

Delhi was a small town in 1901 with a population 0.4 million. Delhi's population started increasing after it became the capital of British India in 1911. During the Partition of the country, a large number of people migrated from Pakistan and settled in Delhi. Migration into the city continued even after Partition. The 2001 Census recorded 138.51 lakh population of Delhi with 3.85% annual growth rate and 47.02% decennial growth rate during 1991-2001. With the rapid pace of urbanization the rural area of Delhi is shrinking. The number of rural villages has decreased from 314 in 1921 to 165 in 2001 census. The percentage of rural population of Delhi has also declined from 47.24% in 1901 to 6.99% in 2001.

As the country's capital, with vibrant trade and commerce and excellent employment opportunities, Delhi has attracted people from all over the country and its population today reflects the characteristics of almost every region. Delhi truly reflects the wealth and diversity of India wherein diverse religions, languages, customs and cultures co-exist in splendid plural harmony. Religious, cultural and social functions of different socio-cultural groups have transformed Delhi into a city of festivals.

Delhi is among the top three States/Union Territories in terms of per capita income. More than 80% of the state income is from the tertiary sector. The Net State Domestic Product (NSDP) of Delhi was about US$ 32.8 billion in 2007-08. The average NSDP growth rate between 1999-2000 and 2007-08 was about 14.7 per cent. Delhi's economy is dependent on commerce and trade more than on manufacturing and agriculture. In 1996, the Supreme Court of India ordered over 90,000 industrial units to relocate outside the state in order to control increasing levels of pollution. Consequently, the state has small scale industries which are mostly non-polluting.

Delhi's economy is primarily dominated by knowledge based service industry such as information technology, consulting etc. In 2007-08, at US$ 28.3 billion, the tertiary sector contributed 79 per cent to the GSDP of Delhi at current prices followed by secondary sector which contributed US$ 7.2 billion (20.3 per cent). The per capita GSDP of Delhi increased almost 2.4 times from US$ 901 in1999-2000 to US$ 2,136 in 2007-08. Per capita GSDP recorded CAGR of 11.4 per cent between 1999-2000 and 2007-08.

3.9 SOCIO-ECONOMIC SURVEY

A socio-economic survey was undertaken for the proposed corridor to assess the socio-economic conditions of project-affected families/people and to examine the

impacts of the proposed metro alignment on their conditions. There can be two types of impacts on the PAPs. One is the displacement of residential house and another is displacement of commercial establishments.

It has been found during socio-economic survey that no residential structure is affected by the metro extension between Najafgarh and Dhansa Bus stand. Land is mainly required for construction of station and allied services. Total land is Govt land- 9284 sqm permanently and 2352 sqm temporary. Land mainly belongs to SDMC, Fire Deptt., and DDA.

3.10 ARCHAEOLOGICAL SITES

The proposed metro alignment in Delhi city is not passing through or near any historical or archaeological monument or heritage site.

CHAPTER 4

ENVIRONMENTAL IMPACTS ASSESSMENT

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.

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.

4.3 IMPACTS DUE TO PROJECT LOCATION

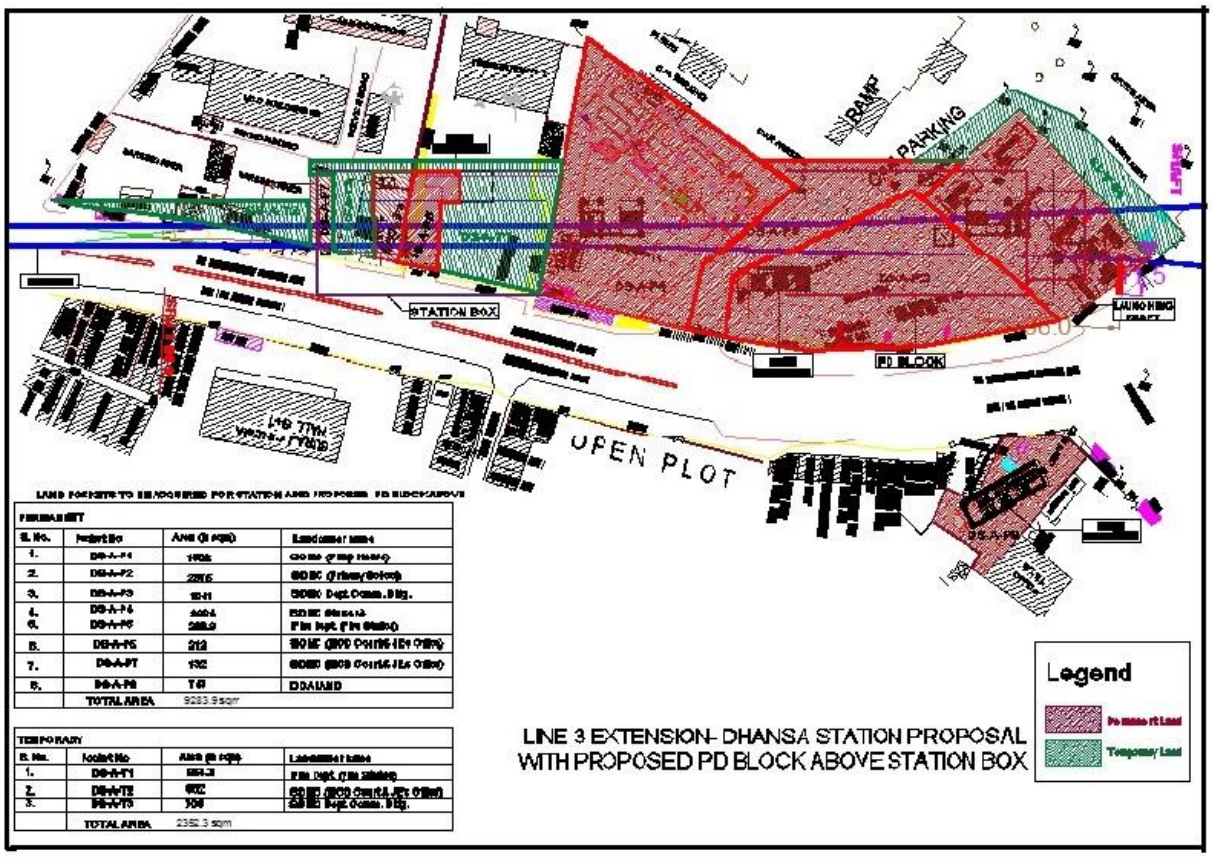
During this phase, those impacts, which are likely to take place due to the layout of the project, have been assessed. These impacts are:

- Project Affected People (PAPs)
- Change of Land use;
- Loss of trees/forest;
- Utility/Drainage Problems,
- Socio-economic impacts;
- Impact on Historical and Cultural Monuments.

4.3.1 Project Affected People (PAPs)

There will be no acquisition of private land and property in this project hence there are NO PAPs as a result of the project activity. **Change of Land Use**

The required land (permanent& temporary) for the construction of the proposed alignment is both government land which shall be allotted by Delhi Authorities. Private land, if any required in future, will be acquired as per the provisions of The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act 2013 (Act 30 of 2013). Details of Land requirement for all the three corridors have been summarized in **Table 4.1**.



The details of land required (permenant and temporary) and change in land use are presented in **Table 4.1.**

Table 4.1 Land to be Acquired at Dhansa Bus Stand (Area in Sqm)

S.No.	Pocket No.	Area (in Sqm)	Land Owner Name
Permanent			
1	DS-A-P1	1502	SDMC (Pump House)
2	DS-A-P2	2375	SDMC (Primary School)
3	DS-A-P3	1041	SDMC(D. C. Bldg.)
4	DS-A-P4	2994	SDMC (Nursery)
5	DS-A-P5	280.9	Fire Department
6	DS-A-P6	212	SDMC (MCD Court & JE Office)
7	DS-A-P7	132	SDMC (MCD Court & JE Office)
8	DS-A-P8	747	DDA
	Total Area	**9283.9**	
Temporary			
1	DS-A-T1	964.3	Fire Department
2	DS-A-T2	682	SDMC (MCD Court & JE Office)
3	DS-A-T3	706	SDMC Dept. Comm. Bldg
	Total Area	**2352.3**	
Gross Area Requirement		**11636.2**	**Government Land**

The required land (permenant & temporary) for the construction of the proposed alignment is government land which shall be transferred by the concerned departments after formalities.

4.3.2 Loss of Forests/ Trees

The proposed metro lines are in urban/ city area and will not pass through any forests. Hence no loss to forest is anticipated due to the project. However, trees do exist in patches in the corridor selected for the project. There are about 189 trees which are likely to be felled during construction. Trees are assets in purification 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	:	189
ii)	Decrease in CO_2 absorption @ 21.8		
	Kg/ year tree for 8 years	:	32962 kg
iii)	Oxygen production @ 49 kg/ year tree		
	For 8 years	:	74088 kg

The average consumption of oxygen for a person is about 182 kg/ year. It means these trees will meet the requirement of about 407 people round the year. Trees help carbon sequestration acting as a carbon sink. By removing the carbon and storing it as cellulose, trees release oxygen back into the air.

4.3.4 Utility/ Drainage Problems

Metro lines are mostly planned to run through the urban area. The alignment/ statio block may cross many properties, drains/ nalas, large number of sub-surface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, roads, 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.

4.3.5 Socio-Economic Impact on PAPs

There is no PAP since the area to be acquired has been carved out leaving all the properties both Permannent as well as temporary.

4.3.6 Impact on Archaeological Sites

There is no historical monument having any archeological value in the close vicinity of the proposed alignment. Thus, on this aspect there would be no impact.

4.3.7 Impact on Sensitive Receptors

There are a few sensitive receptors at station area like MCD school and and religious places in the vicinity. Care shall be taken to keep them safe during construction.

4.4 IMPACTS DUE TO PROJECT DESIGN

Considered impacts, due to project designs are:

- Lighting,
- Risk due to Earthquake.

4.4.1 Lighting

The platforms, concourse, staircase and escalator areas for the elevated stations will have adequate and uniform LED lighting to provide pleasant and cheerful environment. It is proposed to adopt the norms prevailing in Metro for illumination. It is pertinent to note that care has been taken at design stage itself to avoid too much illuminating the stations. Maximum illumination level proposed is 200Lux which provides normal lighting.

4.4.2 Risk Due to Earthquake

The project area lies in Zone IV of Bureau of Indian Standards (BIS) Seismic Zoning Map (**Fig. 3.2**). Seismic factor proposed by India Meteorological Department (IMD) for the purpose of design of Civil Engineering structures shall be incorporated suitably while designing the structures.

4.5 IMPACTS DUE TO PROJECT CONSTRUCTION

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

- Top Soil erosion, pollution and health risk at construction site,
- Traffic diversion and risk to existing building,
- Excavated soil disposal problems,
- Dust Generation,
- Increased water demand,
- Impact due to Supply of Construction Material,
- Disposal of Construction and Demolition Waste,
- Impacts due to batching plant and casting yard,
- Noise Pollution,

4.5.1 Soil Erosion, Pollution and Health Risk at Construction Site

Every care will be taken to avoid damage to the top soil. It shall be preserved and utilized. 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.

Health risks include disease hazards due to lack of sanitation facilities in labour camps (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 immigrant workers 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.

4.5.2 Traffic Diversions and Risk to Existing Buildings

During construction period, complete/ partial traffic diversions on road will be required where cut and cover would be used as the construction activities are underground using TBM. Traffic would get affected on the roads. Rather than completely blocking the roads it will be advisable to make the narrowportion of roads as one way to allow for operation of traffic together with construction activities. Advance traffic updates/ information on communication systems will be an advantage to users of affected roads. The rail corridor does not pose any serious risk to existing buildings since there is safe distance between buildings and proposed corridor except at a few places where shops are affected due to the turning of alignment. Moreover, at many places facilities for station would affect open spaces and a few buildings which may be avoided by suitably adjusting the station layouts. Special care shall be taken for safety of the structures during construction.

4.5.3 Problems of Excavated Soil and Bentonite Disposal

The proposed alignment is underground and thus TBM would be used. At station area there may be cut and cover methodology. The soil would be used for refilling at station site. The residual soil would be disposed off at designated locations as per Delhi Authority directions.

4.5.4 Air Pollution and Dust Generation

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. Simultaneously there would be fugitive gas emissions due to vehicular and machinery exhausts during their working during construction. However, this activity will be only short-term. Protective measures shall be undertaken during construction phase. Movement of trucks and other heavy equipment at construction site would generate dust during construction phase.

4.5.5 Water Pollution

Source of Water contamination will be from the washings and the surplus water from curing the structures which shall be diverted and passed through desilting chambers before letting it go outside the working site. Muck shall not be allowed to confluence with any water course. Controlled water should be used for curing.

4.5.6 Increased Water Demand

The water demand will increase during construction phase for meeting out drinking and domestic water requirement of workers. Sufficient water for construction purpose would be made available by DJB as it is responsible for water supply in Delhi. Water requirement for construction of Metro will be met through the public supply. It is suggested to use treated STP water for the purpose of Construction. Proper care shall be taken while drawing water from public facilities to avoid any negative impact on the residents living in the vicinity of the project whose water demand is, in any case, met by SDMC supplied water.

4.5.7 Impact due to Supply of Construction Material

Metro construction is a material intensive activity. Huge quantity of different construction materials will be required for construction of metro corridor. These shall be sourced from the nearest source. Quarry operations are independently regulated activities and outside the purview of the project proponent. It is nonetheless, appropriate to consider 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. Although quarry operation is out of purview of the metro construction but, the construction material shall be sourced only from legalized and approved quarries.

4.5.8 Generation of Construction and Demolition Waste and Earthwork

Construction and demolition (C&D) debris is defined as that part of the solid waste stream that results from land clearing and excavation, and the construction, demolition, remodeling and repair of structures, roads and utilities. C&D waste includes concrete, stones and dirt generated during excavation (sometimes collectively referred to as "fill material" or rubble). C& D Waste may be generated from Pile caps, residual cement bags, residual steel scrap, excess construction material stacked at site etc. It is a waste stream that is separate and distinct from residential and commercial waste, commonly called municipal solid waste (MSW). About 10-15% of the construction material such as waste material from contractor camps is left behind by the contractor as construction waste/ spoils. Dumping of construction waste/spoil in haphazard manner may cause surface and ground water pollution near the construction sites. The C& D waste would be handled and disposed-off to C&D waste processing facility of IL & FS at Burari.

The excavation will be to the tune of 340336 cum for construction of twin tunnel by shield TBM, Cut & Cover tunnel box and one underground station namely Dhansa Stand including Architectural Finishing, Water Supply, Sanitary

Installation & Drainage Works from chainage 4121.350 to 5340.00 for extension of Dwarka Najafgarh Metro Corridor of Phase-III of Delhi MRTS. The details have been given in following table:

Excavation Quantity For CC126 Project			
S.No	Items Description	Unit	Excavation
1	Dhansa Stand Station	Cum	154261
2	Box Pushing	Cum	9276
3	Ancillary building	Cum	6001
4	C/C TUNNEL	Cum	108486
5	Retrieval Shaft	Cum	7291
6	Tunnel	Cum	50021
7	Mis (Foundation, Muckbin,etc)	Cum	5000
	Total	Cum	340336

4.5.9 Impacts due to Casting Yard and Batching Plant

There would not be separate Casting Yard and Batching Plant for this extension as this is the extension of Dwarka – Najafgarh line of Delhi Metro. But, during construction phase, there would be establishment and operation of Batching Plant and Casting Yard which would be located in an area designated and allotted by DMRC/ DDA away from habitation. There would be requirement to get NOC (Consent to establish) and Consent to operate under water and air Acts from Delhi Pollution Control Committee at the time of establishing the facilities. Simultaneously, there would be requirement to get the authorization for storage and handling of hazardous chemicals to store and handle used oils and other such materials. All the Application forms are available from the office of DPCC at Delhi. There would be significant movement of men, material and machinery in batching plant and casting yard. It is expected that both batching and casting yard would be located at same complex. Huge quantity of Cement, aggregates and other construction materials would be used in batching plant and casting yard. There would be generation of dust, noise, flue gases and other contaminants from the working of heavy machinery for handling and transporting the construction materials. The mitigation measures have been elaborated in EMP.

4.5.10 Noise Pollution

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.

4.5.11 Vibrations

There may be vibration during tuneling operations due to working of heavy construction machinery and the movement of heavy transport vehicles, loading and unloading of materials etc. This would be a short-term activity and effort will

be made to avoid operations during night between 11.00 pm to 5.00 am in the vicinity of residential areas.

4.5.12 Loss of Historical and Cultural Monuments

No historical/ cultural monuments will be lost because of the proposed development.

4.6 IMPACTS DUE TO PROJECT OPERATION

Along with many positive impacts, 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,
- Station refuse disposal and sanitation,
- Pedestrianization and visual issues

4.6.1 Noise Pollution

During the operation phase the main source of noise will be from running of metro trains. Noise radiated from train operations and track structures generally constitute the major noise sources. The noise level reduces with distance logarithmically.

4.6.2 Water Supply and Sanitation at Station

Public facilities such as sanitation and wash rooms are very much needed at the stations. The water requirement for stations would be for drinking, toilets, cleaning and also for other purpose like AC. Raw water should be treated and brought to national drinking water standards, before used for consumption. In addition, water will be required for contractor's camps during construction. The water requirement for the stations will be met through the public water supply system or purpose built tubewells after taking necessary approvals from CGWA/DJB. However, as an environmental conservation measure, rainwater harvesting structure will also be constructed near station.

Thus, there would be total water requirement of 100 KLD in 1 station.

4.6.3 Station Refuse

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

- Garbage,
- Rubbish, and
- Floor Sweepings.

As per the available data from Delhi Metro Phase I and II and other operational metros, the solid waste generation is about 0.6 – 1.0 cum/day at underground

station. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of the project authorities. The storage containers for this purpose need to be designed. However, it is suggested that the capacity of these containers should not exceed 50 litres and these should be equipped with side handles to facilitate handling. To avoid odour and the accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals.

4.6.4 Visual Impacts

The introduction of MRTS implies a change in streets through which it will operate. 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 optimised at this stage itself.

4.6.5 Vibrations

The effects of ground-borne vibration include perceptible movement of the building floors, rattling of windows, shaking of items on shelves or hanging on walls, and rumbling sounds. In extreme cases, such vibration can damage buildings and other structures. In addition, the sound reradiated from vibrating room surfaces, referred to as ground-borne noise, may be audible in the form of a low-frequency rumbling sound. The train wheels rolling on the rails create vibration energy transmitted through the track support system into the track bed or track structure. The amount of energy that is transmitted into the track structure depends strongly on factors such as how smooth the wheels and rails are and the resonance frequencies of the vehicle suspension system and the track support system. The vibration of the track or guide way 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 maximum vibration amplitudes of floors and walls of a building often occur at the resonance frequencies of those building elements.

4.7 POSITIVE ENVIRONMENTAL IMPACTS OF THE PROJECT

Based on project particulars and existing environmental conditions, potential impacts that are likely to result from the proposed Delhi metro corridors development have been identified and wherever possible these have been quantified. This section deals with the positive impacts of the project. The introduction of the corridor will also yield benefits from non-tangible parameters such as savings 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;
- Enhancement of Economy;
- Mobility, Safety and reduced accidents;
- Traffic Congestion Reduction;
- Reduced Fuel Consumption;
- Reduced Air Pollution;
- Reduction in Number of Buses/ Auto rickshaws, and

4.8.1 Employment Opportunities

The project is likely to be completed in a period of about 2-3 years. During this period manpower will be needed to take part in various activities. About 500 persons are likely to work during peak period of activity. In operation phase of the project about 40 persons will be employed for operation and maintenance of the proposed system in shifts. Thus, the project would provide substantial direct employment. Besides, more people would be indirectly employed in allied activities and trades.

4.8.2 Enhancement of Economy

The proposed transport facility of DMRC will facilitate sub-urban population to move quickly. With the development of metro corridors in Delhi, it is likely that more people will be involved in trade, commerce and allied services. DMRC will, however, make it convenient for more people to move in the present suburban areas. This will reduce population pressure on transport facilities in the urban area.

4.8.3 Mobility Safety and Reduced Accidents

The metro network increases the mobility of people at faster rate. The proposed corridor will provide more people connectivity to other parts of the city. Metro journey is safe and result in reduced accidents on roads.

4.8.4 Traffic Congestion Reduction

Since the proposed extension is for only 1.2 km length from Najafgarh to Dhansa Bus stand which falls within the catchment area of Traffic forecast for Metro extension upto Najafgarh. The same projections have been considered for this extension also. However due to preset extension in the network of Delhi Metro the lead has been increased from 10.22 km to 16.80 Km. The projected ridership figures as per traffic study considered for FIRR as for various years is indicated below:

S.No.	Year	Traffic
1	2020-21	61000
2	2030-31	78000

It is assumed that passenger numbers can be converted to PCE @ 4 passeners per Petrol Car Equivalent (PCE) unit. Thus there would be traffic of 15250 PCE in 2021 ad 19500 PCE in 2031. The Asian Development Bank's "Transport Emissions Model" for the National Environment Commission has been used to predict/calculate the fuel consumption as well as the emissions of the harmful pollutants into the environment. This will lead to substantial reduction in traffic congestion on roads.

4.8.5 Reduced Fuel Consumption

On implementation of the project, it is estimated that both petrol and diesel consumption will get reduced. The saving will be due to two factors namely Reduction in vehicles and decongestion on roads. On the basis of assumptions as give in following table there will be significant saving of Petrol and Diesel consumption in litres as per **Table 4.2**.

Table 4.2 Saving of Petrol and Diesel due to Metro

Year	PCE	Trip Length	Petrol Saving Litres	Diesel Saving Litres
2021	15250	16.80	15791	3332
2031	19500	16.80	20192	4261

4.8.6 Reduced Air Pollution

Based on available data and assumptions, an attempt has been made to model the air quality scenario for future using Asian Development Bank's "Transport Emissions Model". On the basis of above referred assumptions, daily reduction in pollutants would be as given in **Table 4.3** below:

Table 4.3 Reduction in Emmission of Greenhouse Gasses due to Modal Shift to MetroAll Values are in Kg.

S. No.	Parameter	Najafgarh to Dhansa Road	
1	Year	2021	2031
2	PCE No.	15250	19500
3	Distance km	16.80	16.80
4	CO	1012.7	1294.9
5	CO_2	44512.7	56917.9
6	NOx	176.1	225.1
7	VOC	156.8	200.4
8	Particulates	2.7	3.4
9	SO_2	5.5	7.0

4.8.7 Carbon Credits

Due to savings in fuel and reduction in airpollution etc. carbon credit would be generated during operation of the metro rail similar to the experience with Delhi Metro Rail Corporation Ltd. However, at this stage calculation of carbon credits is not feasible which would be worked out after the system become operational.

4.8.8 Improvement of Quality of Life

Development of Metro rail in the city would lead to overall improvement of quality of life of local populace by virtue of availability of better transport facility at competitive rates, better road safety, reduced pollution, improved general health etc.

4.9.1 CHECKLIST OF IMPACTS

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

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

Each of the methods is subjective in nature and none of these is applicable in every case. Of the 7 methods listed above, checklist has been used and presented. Checklist is a list of environmental parameters or impact indicators which encourages the environmentalist to consider and identify the potential impacts. A typical checklist identifying anticipated environmental impacts is shown in **Table 4.4**.

Table 4.4 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.	Socio-economic Impacts	*		

S. No.	Parameter	Negative Impact	No Impact	Positive Impact
v.	Loss of Trees	*		
vi.	Drainage & Utilities Problems	*		
B.	**Impact due to Project Design**			
i.	Platforms - Inlets and Outlets		*	
ii.	Ventilation and Lighting		*	
iii.	Station Refuse	*		
iv.	Risk due to Earthquakes		*	
C.	**Impact due to Project Construction**			
i.	Top Soil Erosion, Pollution and Health risk	*		
ii.	Traffic Diversions	*		
iii.	Risk to Existing Buildings	*		
iv.	Problems of Soil Disposal and Seepage Risk	*		
v.	Dust Generation	*		
vi.	Increased Water Demand	*		
vii.	Supply of Construction Material	*		
viii.	Construction and Demolition Waste	*		
ix.	Batching Plant and Casting Yard	*		
x.	Noise	*		
D.	**Impact due to Project Operation**			
i.	Oil Pollution	*		
ii.	Noise		*	
iii.	Water supply and sanitation	*		
iv.	Vibrations	*		
v.	Pedestrian Issues		*	
vi.	Visual Impacts		*	
vii.	Station Illumination		*	
viii.	Employment Opportunities			*
ix.	Enhancement of Economy			*
x.	Mobility			*

S. No.	Parameter	Negative Impact	No Impact	Positive Impact
xi.	Safety			*
xii.	Traffic Congestion Reduction			*
xiii.	Less fuel Consumption			*
xiv.	Less Air Pollution			*
xv.	Carbon dioxide Reduction			*
xvi.	Reduction in Buses			*
xvii.	Reduction in Infrastructure			*

CHAPTER 5

ANALYSIS OF ALTERNATIVES AND PUBLIC CONSULTATION AND INFORMATION DISCLOSURE

5.1 ANALYSIS OF ALTERNATIVES

Historically, the alternative probable corridors were discussed with representatives of local authorities and finally a network was selected as Master Plan for Delhi Metro. The most important criteria in finalizing the Master plan were:

- To serve areas of population and employment concentration not served hereto.
- To ensure regional linkages and connectivity to rail system proposed in adjoining regions.
- Maximum inter-modal integration with existing and committed suburban rail network.
- Easy connectivity to depot sites.
- Feasibility of the minimum values for system parameters in terms of vertical curves, horizontal curves and gradients.

Various alternatives were explored by the DMRC before arriving at the preferred mode of transport and technical design. The project is unique in the sense that alternative alignments were not evaluated as it was the principal objective of the Comprehensive Mobility Plan to connect various parts of suburbs.

Need to Increase Public Transport Share

The proposed corridor is part of Comprehensive Mobility Plan (CMP), which included strategies on motorized and non-motorized modes to enhance mobility and economic development. The metro was conceived in recognition to the heavy reliance of the population to private buses as public transport that is inadequate and routes are unregulated causing confusion and congestion.

5.2 PUBLIC CONSULTATION AND DISCLOSURE

Public consultation and participation is a continuous two way process, involving, promoting of public understanding of the processes and mechanisms through which developmental problems and needs are investigated and solved. The public consultation, as an integral part of environmental and social assessment process throughout the project preparation stage not only minimizes the risks and unwanted political propaganda against the project but also abridges the gap between the community and the project formulators, which leads to timely completion of the project and making the project people friendly.

Public consultations with the people of different sections of the society along the project alignment, shopkeepers, and influential persons of the project area will be

made. Attention shall be given to potential vulnerable people like, squatters, encroachers, schedule caste, and other backward section (OBC) of society shall be consulted to make them aware and identify adverse impacts of the project.

A. Consultation with Stakeholders

As required for Category A projects, preliminary consultations were conducted at the early stage of EIA preparation, mostly involving local communities. Successive consultations shall be conducted by the DMRC after the finalization of this report that includes representatives of local communities and entities tasked with the regulation of the road development and environmental protection.

Discussions with Primary Stakeholders

Discussions with Primary Stakeholders

B. Compliance with Regulatory and Funding Agency Requirement

As per Indian Environmental Regulations, public hearing is not required, as railway projects do not attract EIA Notification 2006, amended 2009. Meaningful consultations will be undertaken. All the five principles of information dissemination, information solicitation, integration, co-ordination and engagement into dialogue will be incorporated in the consultation process.

C. Disclosure of the EIA and Monitoring Reports

In compliance to the Safeguard and Disclosure policies of Funding Agencies, this report will be disclosed in the websites of DMRC. Further, semi-annual monitoring reports will be prepared by the DMRC.

CHAPTER 6

ENVIRONMENTAL MANAGEMENT PLAN

6.1 MANAGEMENT PLANS

The proposed section of Delhi Metro Project will provide some employment opportunity, quick mobility service and safety, traffic congestion reduction, less fuel consumption and reduction in 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.

6.2 MITIGATION MEASURES

The main aim of mitigation measures is to protect and enhance the existing environment of the project. Mitigation measures have to be adopted during construction at all the construction sites including Batching Plant and Casting Yards on all the aspects. The mitigation measures to be adopted have been described under following heads:

- Compensatory Afforestation,
- Construction Material Management,
- Labour Camp,
- Energy Management
- Hazardous Waste Management
- Environmental Sanitation,
- Utility Plan,
- Air Pollution Control Measures,
- Noise Control Measures,
- Vibration Control Measures,
- Traffic Diversion/Management,
- Soil Erosion Control,
- Water Supply, Sanitation and Solid Waste management,
- Rain water harvesting
- Training and Extension

6.2.1 Compensatory Afforestation

The objective of the afforestation program should be to develop natural areas in which ecological functions could be maintained on a sustainable basis. According to the results of the present study, it is found that about 189 trees are likely to be lost due to the project. Inn Delhi ten saplings are to be planted for felling a single tree. Hence 1890 trees need to be planted. Plantation program will be finalized in consultation with DMRC and project proponent would provide the funds for compensatory afforestation as per government policy.

6.2.2 Construction Material Management – Storage and Procurement

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

The duties of the contractor will include monitoring all aspects of construction activities, commencing with the storing, loading of construction materials and equipment in order to maintain the quality. During the construction period, the construction material storage site is to be regularly inspected for the presence of uncontrolled construction waste. Close liaison with the DMRC Officer and the head of the construction crew will be required to address any environmental issues and to set up procedures for mitigating impacts. The scheduling of material procurement and transport shall be linked with construction schedule of the project. The Contractor shall be responsible for management of such construction material during entire construction period of the project. Sufficient quantity of materials should be available before starting 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. Care shall be taken to avoid spillage of material during construction. Procurement of material would be from environment friendly source. The materials shall be procured from nearest available source and shall be transported in covered trucks. All the material would be stored in a manner to avoid multiple handling for use in construction activities.

6.2.3 Labour Camp

The Contractor during the progress of work will provide, erect and maintain the 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 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 sites and camps shall be provided sanitary latrines and urinals. Mobile STP/ septic tanks 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. 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 labourers. Sheds shall be maintained in proper hygienic conditions.

First aid facilities: At every workplace, a readily available first-aid unit including an adequate supply of sterilized dressing materials and appliances shall be provided. Suitable transport shall 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 25 or more women are ordinarily employed, at least a hut shall be provided for use of children under the age of 6 years belonging to such women. Huts shall be provided with suitable and sufficient openings for light and ventilation. Size of crèches shall vary according to the number of women workers employed.

6.2.4 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 DMRC request. Measures to conserve energy include but not limited to the following:

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

The contractor shall design site offices 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 explored.

6.2.5 Hazardous Waste Management

The contractor shall identify the nature and quantity of hazardous waste generated as a result of his activities and shall file a 'Request for Authorization' with DelhiPollution Control Committee along with a map showing the location of storage area. 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 contractor shall approach only Authorized Recyclers for disposal of Hazardous Waste, under intimation to the DMRC.

6.2.6 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 at all times at Work Site, Construction Depot, Batching Plant, Labour Camp, Stores, Offices and toilets/urinals. The contractor shall employ a special group of environmental sanitation personnel to carry out following activities:

- Full height fence, barriers, barricades etc. shall be erected around the working 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, DMRC 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 are removed/disposed off from the working areas to officially designated dumpsites. Trucks carrying sand, earth and any pulverized materials etc. in order to avoid dust or odour impact shall be covered while moving.
- No parking of trucks/trolleys, cranes and trailers etc. shall be allowed on roads, which may obstruct the traffic movement.
- Roads shall be kept clear and materials like: pipes, steel, sand boulders, concrete, chips and brick etc. shall not be allowed on the roads to obstruct free movement of road traffic.
- Water logging on roads shall not be allowed.
- Proper and safe stacking of material are of paramount importance at yards, stores and such locations where material would be unloaded for future use. The storage area shall be well laid out with easy access and material stored / stacked in an orderly and safe manner.
- Flammable chemicals / compressed gas cylinders shall be safely stored.
- Unused/surplus cables, steel items and steel scrap lying scattered at different places within the working areas shall be removed to identified locations.
- All wooden scrap, empty wooden cable drums and other combustible packing materials, shall be removed from work place to identified location(s).
- Empty cement bags and other packaging material shall be properly stacked and removed.

6.2.7 Utility Plan

A 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. exists 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. 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 alignment, 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.

6.2.8 Air Pollution Control Measures

During the construction period, the impact on air quality will be mainly due to increase in dust and PM_{10} along haul roads and emission from vehicles and construction machinery. Though the estimation of air quality during construction shows some impact on ambient air quality, nevertheless certain mitigation measures which shall be adopted to reduce the air pollution are presented below:

- The Contractor shall take all necessary precautions to minimise fugitive dust emissions from operations involving excavation, grading, and clearing of land and disposal of waste. He shall not allow emissions of fugitive dust from any transport, 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.
- The Contractor shall use construction equipment to minimize or control of air pollution. He shall maintain evidence of such design and equipment and make these available for inspection by Employer.
- Contractor's transport vehicles and other equipment shall conform to emission standards fixed by Statutory Agencies of Government of India or the State Government from time to time. The Contractor shall carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.
- The Contractor shall 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-utilized 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 especially where the work is near sensitive receptors.
- The Contractor shall provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from work sites such as construction depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt.

6.2.9 Construction and Demolition Waste

Waste prevention, reuse and recycling can not only save money, but also generate broad environmental benefits, including the conservation of natural resources. Reuse and waste prevention reduce the air and water pollution associated with materials manufacturing and transportation. This saves energy and reduces attendant greenhouse gas production. The recycling of many materials require less energy than production from virgin stock, and can also reduce transportation requirements and associated impacts.

Opportunities for reducing C&D waste focus on three approaches, typically expressed as **Reduce-Reuse-Recycle**.

The source of C & D waste is excess RMC and demolition material. An effort shall be made to recover embedded energy and to recycle the maximum quantity of C & D Waste to manufacture tiles, curb stones, paver block etc. The contractor shall store C&D waste separately at the site and sent to recycling facility periodically. There shall be no disposal of any waste along storm water drains, canals and/ or any other water body or depression. Rather C & D waste shall be collected and sent to any authorized waste recycling facility.

There will be generation of 340336 cum of earthwork for construction of Shafts, Station and other works by cut and cover in the project out of which 66 920 cum earthwork will be backfilled as detailed below.

Excavation Quantity For CC126 Project			
S.No	Items Description	Unit	Excavation
1	Dhansa Stand Station	Cum	154261
2	Box Pushing	Cum	9276
3	Ancillary building	Cum	6001
4	C/C TUNNEL	Cum	108486
5	Retrieval Shaft	Cum	7291
6	Tunnel	Cum	50021
7	Mis (Foundation, Muckbin,etc)	Cum	5000
	Total	Cum	340336
Backfilling Quantity For CC126 Project			
S.No	Items Description	Unit	Excavation
1	Cut & cover	Cum	50400
2	Ancillary building	Cum	3600
3	Retrieval	Cum	7920
4	Box pushing	Cum	5000
	Total	Cum	66920

The residual earthwork would be disposed off at the designated low lying place as provided by local authoritieslike MCD/DDA.

6.2.10 Noise Control Measures

There will be an increase in noise level in nearby ambient air due to construction and operation of the Metro corridors near station area. During construction, the exposure of workers to high noise levels especially near the machinery need to be minimized. This could be achieved by:

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

Special acoustic enclosures should be provided for individual noise generating equipment, wherever possible. Workers in 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.

6.2.11 Vibration Control

Mitigation can minimize the adverse effects of project ground-borne vibration on sensitive land uses. Vibrations arise due to rail - wheel interaction during operations. Vibrations could be reduced by improving track geometry, providing elastic fastenings, minimizing surface irregularities of wheel and rail, and

separation of rail seat assembly from the concrete plinth with insertion of resilient and shock absorbing pad.

Adequate wheel and rail maintenance in controlling levels of ground-borne vibration is very important. Problems with rough wheels or rails can increase vibration levels by as much as 20 dB, negating the effects of even the most effective vibration control measures. It is rare that practical vibration control measures will provide more than 15- to 20-decibel attenuation. When ground-borne vibration problems are associated with existing rails and rolling stock, often the best control measure is to implement new or improved maintenance procedures. Grinding rough or corrugated rail and implementing wheel truing to restore the wheel surface and contour may reduce vibration more than completely replacing the existing track system with floating slabs.Assuming that the track and vehicles are in good condition, the options to further reduce ground-borne vibration fit into one of seven categories: (1) maintenance procedures, (2) location and design of special track work, (3) vehicle modifications, (4) changes in the track support system, (5) building modifications, (6) adjustments to the vibration transmission path, and (7) operational changes.

Maintenance

Effective maintenance programs are essential for keeping ground-borne vibration levels under control. When the wheel and rail surfaces are allowed to degrade, the vibration levels can increase by as much as 20 dB compared with a new or well-maintained system. Maintenance procedures that are particularly effective at avoiding increases in ground-borne vibration include the following:

- Rail grinding on a regular basis, particularly for rail that develops corrugations. Rail condition monitoring systems are available to optimize track conditions.
- Wheel truing to re-contour the wheel, provide a smooth running surface, and remove wheel flats. The most dramatic vibration reduction results from removing wheel flats. However, significant improvements also can be observed simply from smoothing the running surface. Wheel condition monitoring systems are available to optimize wheel conditions.
- Reconditioning vehicles, particularly when components such as suspension system, brakes, and wheels will be improved and slip-slide detectors will be installed.
- Installing wheel condition monitoring systems to identify those vehicles most in need of wheel truing.

Location and Design of Special Track Work

Most vibration impact from a new train system is caused by wheel impacts at the special track work for turnouts and crossovers. Careful review of crossover and turnout locations during the preliminary engineering stage is an important step in minimizing potential for vibration impact. When feasible, the most effective vibration control measure is to relocate the special track work to a less vibration-sensitive area. Another approach is to install movable point or spring frogs that eliminate the gaps that occur when standard railbound frogs are used. These

special frogs significantly reduce vibration levels near crossovers, and they are often specified because of their longer lifespan under repetitive high-speed conditions.

Vehicle Suspension

The ideal rail vehicle, with respect to minimizing ground-borne vibration, should have a low unsprung weight, a soft primary suspension, a minimum of metal-to-metal contact between moving parts of the truck, and smooth wheels that are perfectly round. A thorough dynamic analysis, including the expected track parameters, should be part of the specifications for the proposed high-speed trainset.

Special Track Support Systems

When the vibration assessment indicates that vibration levels will be excessive, it is usually the track support system that is modified to reduce the vibration levels. Floating slabs, resiliency supported ties; high-resilience fasteners, ballast mats, and tire-derived aggregate (shredded tires) all have been used to reduce the levels of ground-borne vibration. To be effective, these measures must be optimized for the frequency spectrum of the vibration.

While designing of the structures such as viaducts and pillars following points shall be taken into consideration:

- A heavy rail section of 60-kg/m, 90 UTS, supported at every 60-cm. has been proposed in order to prevent the development of surface irregularities on the rail.
- The rail used shall be the one which is continuously welded which shall lead to reduction of noise/ vibration especially on account of irregular track geometry and at curves.
- Elastic fastening system is proposed to be used which shall reduce the vibration generated from rail- wheel interaction.
- Monitoring requirements for vibrations at regular intervals throughout the construction period.
- Pre-construction structural integrity inspections of historic and sensitive structures in project activity.
- The ballast-less track is supported on two layers of rubber pads to reduce track noise and ground vibrations. The concept of a “low-noise” electric locomotive must be adopted at a very early stage of planning and must be followed up with detailed work throughout the project execution and operation. In addition, baffle walls as parapets will be constructed up to the rail level so as to reduce sound levels.
- In addition, we have proposed to provide skirting of coach shell covering the wheel which will screen any noise coming from the rail wheel interaction as of propagating beyond the viaduct. In sensitive areas, track can be suitably designed so as to avoid propagation of noise to adjacent structures.
- The lower vibration can be achieved by providing bolster less type bogies having secondary air spring.

All these measures would be part of project cost.

6.2.12 Traffic Diversion/ Management

During construction, traffic is 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 of the corridor. Any reduction of road space during Metro construction may result in constrained traffic flow at Dhansa Bus stand. 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 etc. Maintenance of diverted roads in good working condition to avoid slow down and congestion shall be a prerequisite during construction period.

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

- The requirement would be mainly along the central verge/ side of the road.
- As regards to the alignment cutting across a major traffic corridor, 'Box Girder Construction Technology' would be applied to prevent traffic hold-ups or diversions of any kind.

Only temporary diversion plans will be required during construction of the proposed 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.

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

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 as most of viaduct and station works are on the 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.

6.2.13 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 are as applicable for the items of clearing and grubbing, roadway and drainage excavation, embankment/sub-grade construction, bridges and/ or 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 project authority.

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

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 or 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 project authority.

The DMRC may limit the area of excavation, borrow and embankment operations in progress, commenDelhie 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 project authority, and these shall be carried out at the Contractor's own expense. Temporary erosion, sedimentation and pollution control work required, which is not attributed to the Contractor's negligence, carelessness or failure to install permanent controls, will be performed as ordered by the project authority.

6.2.14 Water Supply, Sanitation And Solid Waste Management

During Construction

The public health facilities, such as sanitation and toilets are much needed at the stations. Water should be treated to national drinking water standards before use. 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 mobile STP/ septic tanks should be adopted for sewage disposal. The water for domestic consumption shall be sourced from public water supply or alternatively designated borewells may be installed with due permission from statutory authority prior to installation of borewell.

For Construction activity, there is a restriction to utilize groundwater all over the nation as per order of National Green Tribunal (NGT). Thus, construction water shall be sourced from Delhi Municipal Corporation/ DJB which is responsible for supplying water in the area. Alternatively, contractor shall arrange tie up for surface water supply or tanker water supply for construction activity. Best option is to use treated STP water for construction activity.

Solid waste shall be stacked at designated place and when sufficient quantity accumulates it shall be disposed-off through covered trucks to land fill site designated and authorized by DMRC.

During Operations

Practically, public facilities at stations have to be operated by regular staff or may be designated to any NGO working in the area in the field of sanitation as per policy of DMRC.

Requirement of drinking water supply at an elevated station is about 100 KL/day. This shall be provided from SDMC.

Solid waste will be generated at station is about 0.6 – 1.0 m^3/Day. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of the project authority. The storage containers for this purpose need to be designed. However, it is suggested that the capacity of these containers should not exceed 50 litres and these should be equipped with side handles to facilitate handling. To avoid odour and the accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals.This should be collected and transported to local municipal bins for onward disposal to disposal site by municipality. During operation, as

mitigation measures rainwater harvesting will be carried out at stations and along the viaduct.

6.2.15 Rain Water Harvesting

To conserve and augment the storage of groundwater, it is suggested to construct rainwater harvesting structures of suitable capacity near stations. The stations shall be provided with the facility of rainwater harvesting and artificial recharge. The total length of the proposed alignment is about 1.21 km and there would be 1 station. The estimated cost of rain water harvesting for elevated corridor is about Rs. 5 lakhs for station area.

6.2.16 Tree Protection

There is requirement of felling 160 trees during construction of Metro corridors in Delhi. An attempt shall be made to minimize the tree felling. As remediation of tree felling it is suggested to plant 10 trees for each tree felled. Thus 160 trees would be planted. Moreover, DMRC would chalk out the plantation program in close coordination with Forest Authority. DMRC by making the payment for plantation work including after care for three years. An attempt would be made to minimize the felling of trees to the bare minimum while working and undertaking construction work. The left out trees shall be protected by providing metal or brick tree guard around the tree at a distance of one metre surrounding the tree. Scope of transplantation of trees would also be explored with discussion with the DFO. A provision of 3.2 Lakh has been made @ Rs. 2000/- per tree to be planted and maintained for a period of three years.

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 overhead rail. The potential causes are excessive load, cracks, failure and malfunctioning of sensing instruments, accident, etc. This 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 facility

- **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 fool 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 Manager 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 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, viaduct for a period of 2 hours.

6.4.1 Fire Protection

The building materials should be of appropriate fire resistance standard. The fire resistance period should be at least 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

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 Dioxide, 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, 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 25 cm.

E. 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 6.1,** which defines actions to be undertaken during the design stage, pre-construction, construction and operation stage of the project. The effectiveness of environmental considerations will, however, depend on appropriate inclusion of these in the work contracts.

The major concern during the construction stage is that the contractors, due to lack of enforcement, would not 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.

Additionally, project authority should prepare and establish Environmental and Health Policy and Procedures as per earlier Phases 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 DMRC and prepare a follow on timetable of actions.

TABLE 6.1 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 environmentally sensitive areas.	During Design	DPR and design consultant	DMRC
Cultural Heritage	Avoided by adjustment of alignment.	During Design	DPR and design consultant	DMRC
Flood	Bridges shall be well designed	During Design	DPR and design consultant	DMRC
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-IV.	DPR and detailed design stage	DPR and design consultant	DMRC
PRE –CONSTRUCTION STAGE				
Water requirement	The requirement of water for construction purpose etc shall be planned and shall be arranged from available and authorized sources in order to avoid digging of Tube wells.	Pre construction stage	Contractor	DMRC/ EMP implementing agency
Disposal of final treated effluent from treatment plant	Options for final disposal shall be studied and the suitable disposal route shall be decided carefully to minimize the impact on receiving bodies. As far as possible zero discharge rules may be adopted.	During design stage / and pre construction of treatment plant	Contractor	DMRC/ EMP implementing agency
Batching Plant and Casting	These facilities to be located away from habitation. Consent to Establish and	During Pre-construction	Contractor	DMRC/EMP implementing

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
Yard	Consent to Operate to be taken from DPCC and to comply with all stipulations.	Stage		agency
CONSTRUCTION PHASE				
Environmental Management and Monitoring	This will include institutional requirements, training, environmental management and monitoring	During and after construction	Contractor	DMRC/EMP implementing agency
Dust	Water should be sprayed during construction phase, wherever it is required to avoid dust. Vehicles delivering materials should be covered to reduce spills and dust blowing off the load. All construction materials prone to dust emission shall be covered with tarpaulin sheet.	During construction	Contractor	DMRC/EMP implementing agency
Air Pollution	Vehicles and machinery are to be regularly maintained so that emissions conform to National and State AAQ Standards. No vehicle without valid PUC certificate would be allowed at Construction Sites.	Beginning with and continuing throughout construction period	Contractor	DMRC/EMP implementing agency
Equipment Selection maintenance and operation	Construction plants and equipment will meet acceptable standards for emissions and will be maintained and operated in a manner that ensures that relevant air, noise, and discharge regulations are met.	During construction	Contractor	DMRC/EMP implementing agency
Earthwork	Total excavate would be 340336 cum out of which 66920 cum would be backfilled and balance 273416 cum shall be	During Construction	Contractor	DMRC/ EMP Implementig agecy

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
	disposed off at lowlying sites authorized by DDA/ MCD			
Noise	Noise standard at processing sites, will be strictly enforced as per GOI noise standards. 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. Machinery to be provided noise barriers (Stone walls and plantation) for silence zones including schools and hospitals.	Beginning and through construction	Contractor	DMRC/EMP implementing agency
Vibration	The vibration level limits at work sites adjacent to the alignment shall conform to the permitted values of peak velocity as given in Environmental Manual	Beginning and through construction	Contractor	DMRC/EMP implementing agency
WATER				
Contamination from Wastes	All justifiable measures will be taken to prevent the wastewater produced in construction from entering directly into any rivers, drainage and irrigation system	Throughout construction period	Contractor	DMRC/EMP implementing agency
Wastage of water	Measures shall be taken to avoid misuse of water. Construction agency shall be instructed accordingly to follow strict procedures while using the water for construction and drinking purpose.	Beginning with and continuing throughout construction	Contractor	DMRC/EMP implementing agency

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
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	DMRC/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 off 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	DMRC/ EMP implementing agency
SOIL				
Quarrying	Quarrying will be carried out at approved and licensed quarries only. All environmental mitigation measures shall be enforced at Quarry site also.	During construction	Contractor	DMRC/ 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. Ten trees will be planted against every tree felled as per norms.	During and after completion of construction activities	DMRC	DMRC

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
SOCIAL				
Loss of Access	Temporary access should be built at the interchange and other roads.	During construction	Contractor	DMRC/ Traffic department
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	DMRC/ 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.	During construction	Contractor	DMRC/ Traffic department
	• 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			
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	During construction At start-up Throughout construction	Contractor	DMRC/ EMP implementing agency

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
	away from vulnerable groups, if any			
Location of camps depots and storage areas	Location of camps depots and storage areas shall be as per the contract specifications.	Throughout construction	Contractor	DMRC/ EMP implementing agency
OPERATION PHASE				
Noise and Vibration	Suitable measures should be considered where warranted. The public shall be educated about the regulations of noise and vibration pollution and its implications.	After completion of construction	DMRC/EMP implementing agency	DMRC/ EMP implementing agency
WATER				
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	DMRC/EMP implementing agency	DMRC/ EMP implementing agency

CHAPTER 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. Historically, environmental monitoring has been integral part of works of DMRC towards better environmental management of air, noise, vibration, water quality etc both during construction and in operation. Generation of dust and noise are two main issues during any large construction activity. Degradation of water quality is another. The parameters are monitored in pre- construction, construction and operation phase and 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.

7.1 CONSTRUCTION PHASE

During construction stage environmental monitoring will be carried out for air quality, noise levels and water quality. Keeping a broad view of the sensitive receptors and also the past experience of Phase I and II of DMRC and Other Metros, an estimate of locations has been made and are summarized in **Table 7.1.** The number 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. Monitoring should be carried out by NABL certified laboratory. Water quality should be analyzed following the procedures given in standard methods. Parameters

for monitoring will be as per BIS: 10500. The monitoring points could be ground and surface water.

7.2.2 Air Quality

Air quality should be monitored at the locations of baseline monitoring. The parameter recommended is Particulate Matter (PM_{10}). The contractor will be responsible for carrying out air monitoring during the entire construction phase under the supervision of project authority.

7.2.3 Noise and Vibration

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

7.2.4 Workers Health and Safety

Monitoring of health risk issues that might arise throughout the project life time will be done. Epidemiological studies at construction sites and workers camp will be performed to monitor the potential spread of diseases. Regular inspection and medical checkups shall be carried out to workers health and safety monitoring. Any 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 and ecology are presented in **Table 7.1.**

TABLE 7.1

CONSTRUCTION STAGE MONITORING SCHEDULE

Item	Parameter	Frequency and Duration	Locations
Air	PM_{10}	2×24 hours Twice a month During entire civil construction stage or even later, if directed by DMRC	2 locations
Water	Groundwater quality (IS 10500:1991)	Once in 6months During entire civil construction stage or even later, if directed by DMRC	1 locations
Noise	Noise Level (Leq and Lmax)	24hours Once a week During entire civil construction stage or even later, if directed by DMRC	2 locations
Ecology	Felled and planted trees	Once a year till all trees that were to be planted by Delhi Government on behalf of project authority, are planted	All the trees felled and newly planted

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, water, waste water, solid waste and ecology during operation phase of the project. The parameters monitored during operation will be PM_{10} for air, heavy metals for solid waste, pH, TSS, BOD, COD, oil and grease for waste water. However, water quality parameters that will be monitored will be as per BIS 10500. The monitoring schedule is presented in **Table 7.2**. The monitoring programme shall be conducted by an external agency certified by NABL under the supervision of DMRC. Project proponent (DMRC) is responsible for successful environmental monitoring of the proposed project during operation phase.

TABLE 7.2
OPERATION STAGE MONITORING SCHEDULE

Item	Parameter	Frequency and Duration	Locations
Air	PM_{10}	2×24hours Once a month For 3years	1 location
Water	Groundwater quality (IS 10500:1991)	Once a year For 3years	1location

The results of Air quality, water quality, will be submitted to management quarterly during construction phase and half yearly during operation phase.

7.2 ESTABLISHMENT OF AN ENVIRONMENTAL DIVISION

DMRC already has the division for environmental Management. Therefore, additional set-up for environmental management is not required.

CHAPTER 8

COST ESTIMATES

8.1 SUMMARY OF COSTS

All costs involved in Environmental mitigation and management and monitoring has to be put on the account of Delhi Metro Project corridors**.** A summary of these is presented in **Table 8.1.**

Table 8.1 Environmental Costs Rs. lakh

S. No.	ITEM	COST Rs. lakh
1.	Rain Water Harvesting at station	5.00
2.	Air, Noise, vibration, Water, Waste Water, Solid waste, during construction and operation	5.00
3.	Ecological monitoring	5.00
4.	Tree Plantation 1890 trees @ Rs.2000/- per tree	37.80
	Total	**52.80**

The compensation for loss of land, fire control, information systems and contractor's obligations has been incorporated in project costs. The Environmental management plan should be implemented in phases so that optimum benefit could be achieved and should be synchronized with the construction schedules.

8.2 CONCLUSION

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

Annexure 1

DRINKING WATER QUALITY STANDARDS (IS 10500:1991)

S. No.	Substance or Characteristic	Requirement (Desirable Limit)	Undesirable Effect outside the Desirable limit	Permissible limit in the absence of alternate source
Essential Characteristics				
1	Colour, Hazen units, Max	5	Above 5, consumer acceptance decreases	25
2	Odour	Unobjectionable	-	-
3	Taste	Agreeable	-	-
4	Turbidity NTU, max	5	Above 5, consumer acceptance decreases	10
5	pH Value	6.5 to 8.5	Beyond this range the water will affect the mucous membrane and/or water supply system	No relaxation
6	Total Hardness (as $CaCO_3$) mg/l, Max	300	Encrustation in water supply structure and adverse effects on domestic use	600
7	Iron (as Fe) mg/l, max	0.3	Beyond this limit taste/appearance are affected, has adverse affect on domestic uses and water supply structures and promotes iron bacteria	1.0
8	Chloride (as Cl) mg/l, Max	250	Beyond this limit, test, corrosion and palatability are affected	1000
9	Residual free Chlorine, mg/l, Min	0.2	-	-
10	Fluoride (as F) mg/l, Max	1.0	Fluoride may be kept as low as possible. High fluoride may cause	1.5

S. No.	Substance or Characteristic	Requirement (Desirable Limit)	Undesirable Effect outside the Desirable limit	Permissible limit in the absence of alternate source
Essential Characteristics				
			florosis	
11	Dissolved solids mg/l, Max	500	Beyond this palatability decreases and may cause gastro intestinal irrigation	2000
12	Calcium (as Ca) mg/l, Max	75	Encrustation in water supply structure and adverse effects on domestic use	200
13	Magnesium (as Mg) mg/l, Max	30	Encrustation in water supply structure and adverse effects on domestic use	100
14	Copper (as Cu) mg/l, Max	0.05	Astringent taste, discoloration and corrosion of pipes fitting and utensils will be caused beyond this	1.5
15	Manganese (as Mn) mg/l, Max	0.1	Beyond this limit taste/appearance are affected, has adverse effect on domestic uses and water supply structures	0.3
16	Sulphate (as SO_4) mg/l, Max	200	Beyond this causes gastro intestinal irritation when magnesium or sodium are present	400
17	Nitrate (as NO_2) mg/l, Max	45	Beyond this methaemoglobinemia takes place	100
18	Phenolic compounds (as C_6H_5OH) mg/l, Max	0.001	Beyond this, it may cause objectionable	0.002

S. No.	Substance or Characteristic	Requirement (Desirable Limit)	Undesirable Effect outside the Desirable limit	Permissible limit in the absence of alternate source
Essential Characteristics				
			taste and odour	
19	Mercury (as Hg) mg/l, Max	0.001	Beyond this, the water become toxic	No relaxation
20	Cadmium (as Cd), mg/l, Max	0.01	Beyond this the water become toxic	No relaxation
21	Selenium (as Se), mg/l, Max	0.01	Beyond this the water become toxic	No relaxation
22	Arsenic (as As), mg/l, Max	0.05	Beyond this the water become toxic	No relaxation
23	Cyanide (as CN), mg/l, Max	0.05	Beyond this the water become toxic	No relaxation
24	Lead (as Pb), mg/l, Max	0.05	Beyond this the water become toxic	No relaxation
25	Zinc (as zn), mg/l, Max	5	Beyond this limit it can cause astringent taste and an opalescene in water	15
26	Anionic detergents (as MBAS), mg/l, Max	0.2	Beyond this limit it can cause a light froth in water	1.0
27	Chromium (as Cr^{+6}) mg/l, Max	0.05	May be carcinogenic above this limit	No relaxation
28	Plynuclear aromatic hydrocarbons (as PAH) g/l, Max	-	May be carcinogenic	-
29	Mineral oil mg/l Max	0.01	Beyond this undesirable and odour chlorination place	0.03
30	Pesticides mg/l Max	Absent	Toxic	0.001
31	Radioactive materials a) Alpha emitters Bq/l	-	-	0.1

S. No.	Substance or Characteristic	Requirement (Desirable Limit)	Undesirable Effect outside the Desirable limit	Permissible limit in the absence of alternate source
Essential Characteristics				
	max b) Beta emitters pci/l, Max	-	-	1
32	Alkalinity mg/l Max	200	Beyond this limit taste becomes unpleasant	600
33	Aluminium (as Al), mg/l Max	0.03	Cumulative effect is report to cause demntia	0.2
34	Boron, mg/l, mg/l Max	1	-	5

Annexure 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

S.No.	Parameter	Unit	Standards
22	Nickel (as Ni), Max.	mg/l	3.0
23	Cyanide (as CN), Max.	mg/l	0.2
24	Fluorides (as F), Max.	mg/l	2.0
25	Dissolved phosphates (as P), Max.	mg/l	5.0
26	Sulphides (as S), Max.	mg/l	2.0
27	Phenolic compounds (as C_6H_5OH), Max.	mg/l	1.0
28	Radioactive Materials α Emitters, μcurie/ml, Max. β Emitters, μcurie/ml, Max.	mg/l	 10^{-7} 10^{-6}
29	Bio-assay test	mg/l	90% survival of fish after 96 hours in 100% effluent
30	Manganese (as Mn)	mg/l	2.0
31	Iron (as Fe)	mg/l	3.0
32	Vanadium (as V)	mg/l	0.2
33	Nitrate Nitrogen	mg/l	10.0

Annexure 3

TOLERANCE LIMITS FOR INLAND SURFACE WATER QUALITY

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

Characteristic	Designated Use Class of Inland Waters				
	A	B	C	D	E
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 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), μgm^3	Annual	50	20
	24 Hours**	80	80
Nitrogen Dioxide as NO_2, μgm^3	Annual	40	30
	24 Hours**	80	80
Particulate Matter (size less than 10□m) or PM_{10} μgm^3	Annual	60	60
	24 Hours**	100	100
Particulate Matter (size less than 2.5□m) or PM2.5 μgm^3	Annual *	40	40
	24 Hours**	60	60
Ozone (O3) μgm^3	8 hours**	100	100
	24 Hours**	180	180
Lead (Pb) μgm^3	Annual *	0.50	0.50
	24 Hours**	1.0	1.0
Carbon Monoxide (CO) mg/m^3	8 Hours**	02	02
	1 Hour**	04	04
Ammonia (NH_3) μgm^3	Annual *	100	100
	24 Hours**	400	400
Benzene (C_6H_6) μgm^3	Annual *	05	05
Benzo (a) pyrene (BaP)particulate phase only nm^3	Annual *	01	01
Arsenic (AS) μgm^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 5

NATIONAL AMBIENT NOISE STANDARDS

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

Source: Central Pollution Control Board

* *Day Time is from 6.00 AM to 9.00 PM.*

** ***Silence Zone*** *is defined as an area up to 100m around premises of Hospitals, Educational Institutions and Courts. Use of vehicle horn, loudspeaker and bursting of crackers is banned in these zones*