

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL,

SOUTHERN ZONE, CHENNAI

O.A. NO. 236 of 2024 (SZ)

BETWEEN:

Suo moto proceedings initiated
Based on news item titled "Over
2000 citizens oppose felling of
33000 trees for Bengaluru Suburban
Railway Project Report" appearing
in the Hindustan Times
dated 11.06.2024

PETITIONER

AND:

Bruhat Bengaluru Mahanagara Palike
And others

RESPONDENTS

INDEX OF VOLUME 2

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| Volume 2 | | |
| 1. | Annexure R-1: Copy of the Environment Impact Assessment Report | 270-519 |

CHENNAI

DATE: 25/10/24



ADVOCATE FOR RESPONDENT NO.2

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Table 5.27. Comparison of Average Monthly Relative Humidity of the Project Districts

| Month | Average Relative Humidity (%) | |
|-------|-------------------------------|-----------------|
| | Bengaluru Urban | Bengaluru Rural |
| Jan | 59.90 | 62.22 |
| Feb | 50.15 | 53.99 |
| Mar | 44.60 | 48.47 |
| Apr | 50.27 | 55.21 |
| May | 57.15 | 62.60 |
| Jun | 63.57 | 69.83 |
| Jul | 72.06 | 75.99 |
| Aug | 75.40 | 78.72 |
| Sep | 73.12 | 75.15 |
| Oct | 71.98 | 75.06 |
| Nov | 70.40 | 72.19 |
| Dec | 68.63 | 69.92 |

Source: Data Collected from IMD, Pune.

5.7.2.4. Wind Speed

Wind speed and wind direction have a significant role on the dispersion of atmospheric pollutants and therefore, the air quality of the area. Ground level concentrations for the pollutants are inversely proportional to the wind speed in the down wind direction, while in upwind direction no effect will be observed and in cross wind direction partial effect due to the emission sources is observed.

Table 5.28. Comparison of Average Monthly Wind Speed of the Project Districts

| Month | Average Wind Speed (Kmph) | |
|-------|---------------------------|-----------------|
| | Bengaluru Urban | Bengaluru Rural |
| Jan | 11.5 | 8.0 |
| Feb | 11.3 | 7.4 |
| Mar | 12.9 | 7.7 |
| Apr | 14.2 | 8.3 |
| May | 17.5 | 10.2 |
| Jun | 25.9 | 15.1 |
| Jul | 24.2 | 14.7 |
| Aug | 23.2 | 13.0 |
| Sep | 16.0 | 9.1 |
| Oct | 11.7 | 6.9 |
| Nov | 12.0 | 7.3 |
| Dec | 13.1 | 8.3 |

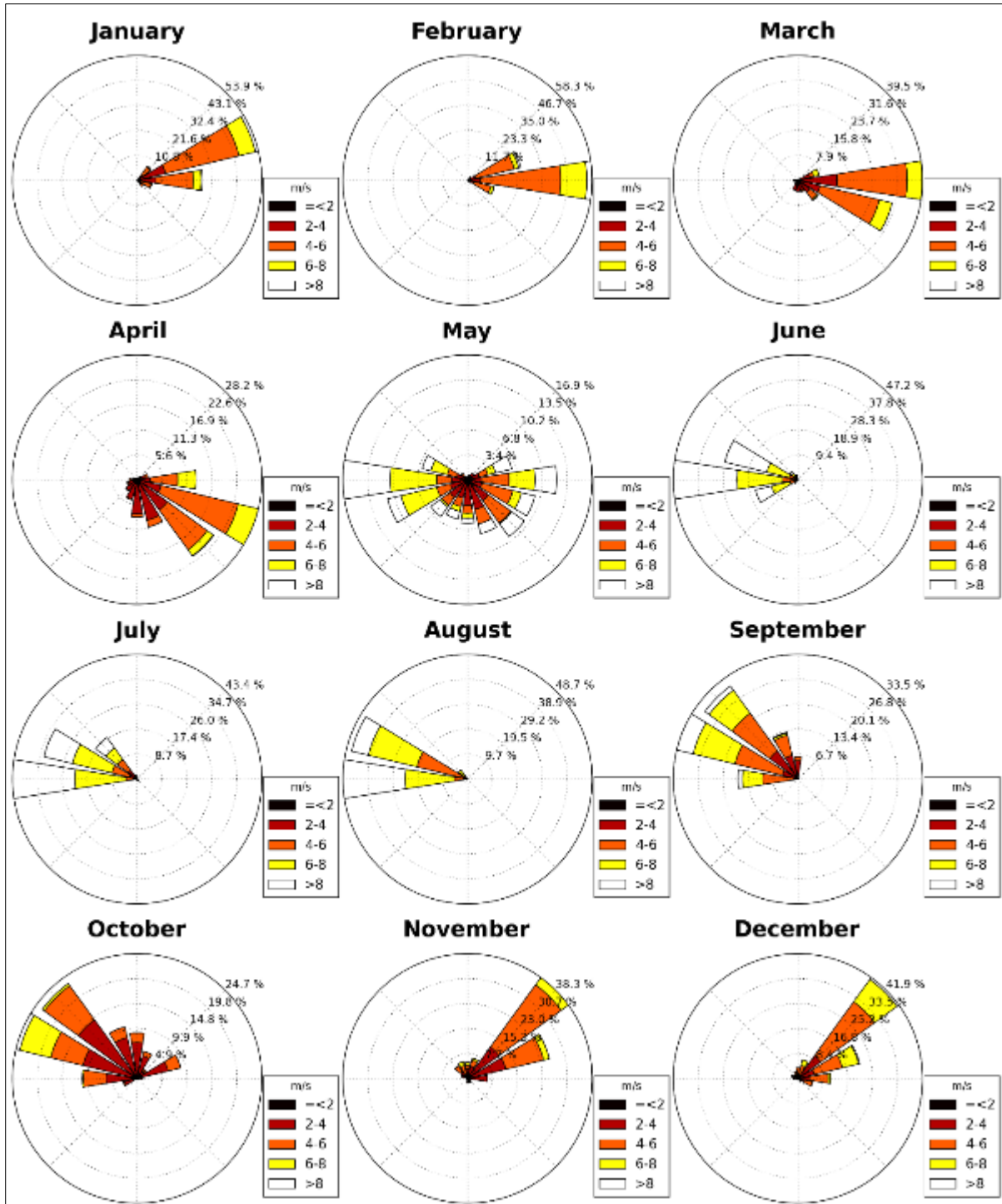
Source: Data Collected from IMD, Pune.

In Bengaluru Urban district, during October to March, wind blows generally from North Easterly and Easterly directions. South westerly and westerly winds predominate from May to September. The wind speed is least in October to February, while it is higher from July to September.

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Winds are generally light to moderate with some strengthening in monsoon season in Bengaluru Rural district. The region is influenced by winds from south-west and north-west during the period from May to September and from north-east and south-east during the period from October to April.

Comparatively, the Bengaluru Urban experience high wind speed than Bengaluru Rural district, which helps in higher dispersion of pollution in the project region. Wind Rose diagram of Bengaluru for the year 2016 is presented in **Figure 5.20**.



Source: <https://urbanemissions.info/india-apna/bengaluru-india/>

Figure 5.20. Wind Rose Diagram of Bengaluru Urban District for the Year 2016

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5.8. Noise & Vibration Environment

5.8.1. Ambient Noise Level Monitoring

Noise in general is unwanted / undesired sound, which is composed of many frequency components of varying loudness distributed over the audible frequency range. Various noise scales have been introduced to describe, in a single number, the response of an average human to a complex sound made up of various frequencies at different loudness levels. The most common and universally accepted scale is the A weighted scale which is measured as dB (A). This is more suitable for the audible range of sound, 20 to 20,000 Hz. The scale has been designed to weigh various components of noise according to the response of a human ear. The impact of noise sources on surrounding community depends on:

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

The environmental impact of noise can have several effects varying from Noise Induced Hearing Loss (NIHL) to annoyance depending on loudness of noise. The assessment of noise is carried out considering various factors like potential damage to hearing, physiological responses, annoyance and general community responses.

It is possible to describe important features of noise for noise levels measured over 24 hours using statistical methods. These features of noise are the parameters used for describing the noise levels at a particular location. Standards for permissible noise levels at various zones are set based on these parameters. The notations used for various noise level parameters are described below.

- Leq - Equivalent sound pressure level - the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
- Lday - The equivalent noise level from 6:00 hours to 22.00 hours.
- Lnight - The equivalent noise level from 22:00 hours to 6.00 hours.

In order to assess the baseline noise level along the project corridors, ambient noise monitoring network was designed considering the land use and presence of sensitive receptors along the project corridors. Noise monitoring locations were selected as per CPCB guidelines and Guidelines on Noise & Vibration study for Metro Rail Transit system by RDSO. An NABL accredited laboratory i.e., Enviro Solutions & Labs, Coimbatore was engaged to carry out monitoring of ambient Noise level in the project region. Monitored results were compared with CPCB standards.

The objective of assessing baseline noise levels can be later used to assess the impact of the total noise generated by the proposed project activities. Noise level monitoring was carried out continuously for 24 hours with one hour interval at each location during the study period. Hourly Leq values were computed by the noise integrating sound level meter and statistical analysis was done for measured

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noise levels at the pre-selected locations in the study area. Corridor wise Ambient Noise level monitoring locations are presented in **Table 5.29**. Photographs of the ambient noise level monitoring locations are presented in **Annexure 5.4**.

Table 5.29. Details of Ambient Noise Level Monitoring Locations along the BSRP Corridors

| Location Code | Name of the Location | Co-ordinates | Classification of Location as per Standards |
|--|--|--------------------------------|--|
| Corridor – 1: KSR Bengaluru City to Devanahalli | | | |
| NQ1 | KSR Bengaluru Rly. Qtr. Electrical office | 12°58'44.07"N 77°34'3.29"E | Residential building left side of the corridor which was 15m from the railway track |
| NQ2 | Residential Building Srirampura PRS | 12°59'19.31"N 77°34'11.87"E | Residential building left side of the corridor which was 20m from the railway track |
| NQ3 | Residential Building at Srirampura | 12°59'36.8"N 77°34'05.7"E | Residential building left side of the corridor which was 20m from the railway track |
| NQ4 | Malleswaram RS Station building | 13° 0'1.52"N 77°33'48.90"E | Commercial area which was located at railway station 10 m distance from the track |
| NQ5 | Ayyappa swamy temple, Malleswaram | 12°59'44.95"N 77°33'59.48"E | A silent zone which was located at 33m distance from the left side of the track |
| NQ6 | Manipal Hospital, Yeshwanthpur | 13° 0'52.08"N 77°33'22.75"E | A silent zone which was located at 38m distance from the right side of the track |
| NQ7 | Nitte Meenakshi Institute of Technology, Yelahanka | 13° 7'39.64"N 77°35'9.61"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ8 | Cluny convent high school, Malleswaram | 13° 0'15.48"N 77°33'42.06"E | A silent zone which was located at 25m distance from the right side of the track |
| NQ9 | Yeswanthapur RS | 13° 1'22.77"N 77°33'4.41"E | Commercial area which was located at railway station 10 m distance from the track |
| NQ10 | Residential Building near Mathikere | 13° 2'18.26"N 77°33'27.34"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ11 | Lottegollahalli RS | 13° 2'37.06"N 77°33'47.25"E | A commercial area railway station |
| NQ12 | Bishop Sargent Secondary school, Devinagar | 13° 3'2.69"N 77°34'2.17"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ13 | Residential Building of the Tatanagar | 13° 3'21.86"N 77°34'13.14"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ14 | Residential Building at Meenakunte | 13°10'49.91"N 77°38'30.82"E | Residential building left side of the corridor which was 13m from the railway track |

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| Location Code | Name of the Location | Co-ordinates | Classification of Location as per Standards |
|--|--|--------------------------------|--|
| NQ15 | Kodigehalli RS | 13° 3'47.70"N 77°34'35.37"E | A commercial area railway station |
| NQ16 | Residential Building near irish house | 13° 5'18.57"N 77°35'41.57"E | Residential building left side of the corridor which was 13m from the railway track |
| NQ17 | Yelahanka Gnanabarathi School | 13° 6'45.31"N 77°35'20.49"E | Educational institution building right side of the corridor which was 80m to the railway track |
| NQ18 | Near Airport Terminal PRS | 13°11'55.45"N 77°39'32.91"E | A busy traffic area with lot of vehicle movements towards airport |
| NQ19 | Devanahalli RS | 13°14'50.89"N 77°42'19.15"E | A commercial area railway station |
| NQ20 | Nirmithi Kendra near prop. Akkupete Depot | 13°14'56.80"N 77°41'10.05"E | A rural settlement with limited movement of vehicle |
| Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara | | | |
| NQ1 | Govt. School, Benniganahalli | 12°59'41.56"N 77°39'49.15"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ2 | Mother Mary English School, Chikka Banaswadi | 13° 0'18.95"N 77°38'55.08"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ3 | Eunice English school , Lingarajapuram | 13° 0'33.34"N 77°37'15.20"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ4 | Residential Building Kadugondanahalli | 13° 1'26.98"N 77°37'18.77"E | Residential building left side of the corridor which was 13m from the railway track |
| NQ5 | Residential Building, Kadugondanahalli | 13° 2'27.05"N 77°36'14.24"E | Residential building left side of the corridor which was 13m from the railway track |
| NQ6 | Public Library, MK Nagar | 13° 2'43.72"N 77°34'50.65"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ7 | Lottgollanahalli RS | 13° 2'37.06"N 77°33'47.25"E | A commercial area railway station |
| NQ8 | P.R Public School, Mohan Kumar Nagar | 13° 1'53.30"N 77°33'9.50"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ9 | Sheela Engineerings, Kammagondanahalli | 13° 3'30.89"N 77°31'55.69"E | Industrial area which was adjacent to corridor |
| NQ10 | Residential Building, Kammagondanahalli | 13° 4'23.15"N 77°30'28.74"E | Residential building left side of the corridor which was 13m from the railway track |
| NQ11 | National Public School, Shettyhalli | 13.071269 N, 77.509686 E | A silent zone which was located at 5m distance from the right side of the track |
| NQ12 | Residential House, Chikkabanavara | 13° 4'38.20"N 77°30'15.17"E | Residential building left side of the corridor which was 13m from the railway track |

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| Location Code | Name of the Location | Co-ordinates | Classification of Location as per Standards |
|---|--|--------------------------------|--|
| Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment) | | | |
| NQ1 | Kengeri RS | 12°55'0.73"N 77°29'0.56"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ2 | Bengaluru Institute of Management Studies, Kengeri | 12°55'33.57"N 77°29'57.41"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ3 | Residential near Nayandanahalli RS | 12°56'31.89"N 77°31'18.93"E | Residential area |
| NQ4 | SreeChakra Industrial Unit Nayandanahalli | 12°56'45.27"N 77°31'34.40"E | Industrial area adjacent to railway track |
| NQ5 | Shiva & Ganesh temple Krishnadevaraya Halt | 12°57'31.56"N 77°32'22.84"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ6 | Subramanya Swamy Temple, Krishnadevaraya | 12°58'3.76"N 77°33'4.72"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ7 | Holy Gopsee Prayer House | 12°58'6.18"N 77°33'36.52"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ8 | Karnataka Welfare Association for the Blind School, Sheshadripuram | 12°59'4.80"N 77°34'29.84"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ9 | Residential near Nehru Circle Sheshadripuram | 12°59'17.16"N 77°34'42.44"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ10 | Mount Carmel College Palace Road, Jeevanahalli | 12°59'45.67"N 77°35'0.56"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ11 | Residential near Cantonment RS | 12°59'30.04"N 77°36'8.90"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ12 | Anugraha AG church Jeevanahalli | 13° 0'0.47"N 77°40'9.37"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ13 | City Hospital, Pulikeshi Nagar | 13° 0'5.80"N 77°36'45.52"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ14 | Central Library, Jeevanahalli | 12°59'41.72"N 77°37'40.79"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ15 | Govt. PU College, Hoodi | 12°59'44.33"N 77°43'5.75"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ16 | Residential at Sadarmangala | 12°59'53.04"N 77°44'16.93"E | Residential building left side of the corridor which was adjacent to the railway track |

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| Location Code | Name of the Location | Co-ordinates | Classification of Location as per Standards |
|---|--|--------------------------------|--|
| Corridor – 4: Heelalige to Rajanukunte | | | |
| NQ1 | Bengaluru College of Engineering, Heelalige | 12°48'48.32"N 77°42'38.42"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ2 | Norwich High School, Electronic City Phase II | 12°49'29.97"N 77°42'43.75"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ3 | Carmelram Campus, Chikkabellandur | 12°54'33.42"N 77°42'21.62"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ4 | iSmile Dental Care, Sapthagiri Layout, Marthalli | 12°56'53.27"N 77°42'21.77"E | A Commercial place adjacent to track |
| NQ5 | Lions Airport City Hospital, Munnekollal | 12°57'18.31"N 77°42'18.45"E | A Commercial place adjacent to track |
| NQ6 | Kies mansion School, Chinnappanahalli | 12°57'44.03"N 77°42'12.93"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ7 | Geethanjali Vidyalaya, Mahadevapura | 12°58'51.16"N 77°41'8.76"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ8 | Ayappaswamy Temple Kaggadasapura | 12°59'0.76"N 77°40'49.76"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ9 | Sai Speciality Hospital, Benniganahalli | 12°59'58.55"N 77°39'46.14"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ10 | Ebinazer School at Horamavu | 13° 1'20.83"N 77°39'40.25"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ11 | Grace Methodist Church, Shanthinagar | 13° 2'22.66"N 77°38'52.74"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ12 | Ayappaswamy Temple Kaggadasapura | 13° 4'49.08"N 77°36'31.25"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ13 | Govt. PU College, Yelahanka | 13° 5'50.08"N 77°35'41.26"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ14 | Residential Building at Vasudevapura | 13° 7'3.87"N 77°35'2.25"E | A silent zone which was located at 5m distance from the right side of the track |
| NQ15 | Industry, Rajanukunte | 13°10'44.89"N 77°33'55.82"E | Industrial Area adjacent to railway track |
| NQ16 | Residential near RGA Tech Park | 12°54'9.23"N 77°42'21.75"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ17 | Residential near Belandur Pro RS | 12°56'9.14"N 77°42'24.21"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ18 | Residential near Doddanakundi | 12°58'16.62"N 77°42'5.46"E | Residential building left side of the corridor which was adjacent to the railway track |

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| Location Code | Name of the Location | Co-ordinates | Classification of Location as per Standards |
|---------------|--------------------------------------|--------------------------------|--|
| NQ19 | Residential near Pai layout | 12°59'21.29"N 77°40'13.96"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ20 | Residential near Arkavathi Layout | 13° 1'55.72"N 77°39'12.16"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ21 | Residential near Arkavathi Layout | 13° 3'43.53"N 77°37'44.16"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ22 | Residential near Nagenahalli Village | 13° 7'53.50"N 77°34'33.13"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ23 | Residential near Sai Layout | 13° 8'50.13"N 77°34'13.58"E | Residential building left side of the corridor which was adjacent to the railway track |
| NQ24 | Residential near Rajanukunte RS | 13°10'17.67"N 77°33'55.67"E | Residential building left side of the corridor which was adjacent to the railway track |

The Leq day and Leq night and Leq Max and Leq Min calculated for various locations in the project area are presented in **Table 5.30**. The values are compared with the standards prescribed by CPCB for various zones.

Table 5.30. Corridor wise Ambient Noise Level Monitoring Results

| Location Code | Name of the Location | Noise Level Results (Leq) | | | | Standards* | |
|--|--|---------------------------|-------------|-------------|---------------|-------------|---------------|
| | | Max [dB(A)] | Min [dB(A)] | Day [dB(A)] | Night [dB(A)] | Day [dB(A)] | Night [dB(A)] |
| Corridor – 1: KSR Bengaluru City to Devanahalli | | | | | | | |
| NQ1 | KSR Bengaluru RQ | 92.3 | 41.8 | 57.1 | 45.3 | 55 | 45 |
| NQ2 | Srirampura PRS | 87.3 | 37.4 | 56.1 | 43.9 | 55 | 45 |
| NQ3 | Residential Building at Srirampura | 88.1 | 38.8 | 54.8 | 41.3 | 55 | 45 |
| NQ4 | Malleshwaram RS | 90.2 | 36.9 | 53.5 | 43.8 | 65 | 55 |
| NQ5 | Ayyappa swamy temple | 88.6 | 37.5 | 52.8 | 41.6 | 55 | 45 |
| NQ6 | Manipal Hospital | 87.9 | 36.1 | 55.7 | 42.8 | 55 | 45 |
| NQ7 | Nitte Meenakshi Institute of Technology | 87.5 | 33.2 | 51.6 | 38.5 | 50 | 40 |
| NQ8 | Cluny convent high school | 88.3 | 35 | 52.1 | 40.6 | 50 | 40 |
| NQ9 | Yeswanthapur RS | 91.7 | 42.1 | 60.8 | 48.2 | 65 | 55 |
| NQ10 | Residential Building near Mathikere | 88.5 | 36.8 | 53.5 | 41.8 | 55 | 45 |
| NQ11 | Lottegollahalli RS | 89.8 | 35.1 | 53.2 | 42.9 | 65 | 55 |
| NQ12 | Bishop Sargent Secondary school, Devinagar | 87.6 | 34.3 | 52.8 | 41.7 | 50 | 40 |

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| Location Code | Name of the Location | Noise Level Results (Leq) | | | | Standards* | |
|---|---|---------------------------|-------------|-------------|---------------|-------------|---------------|
| | | Max [dB(A)] | Min [dB(A)] | Day [dB(A)] | Night [dB(A)] | Day [dB(A)] | Night [dB(A)] |
| NQ13 | Residential Building of the Tatanagar | 88.2 | 37.1 | 53.9 | 40.8 | 55 | 45 |
| NQ14 | Residential Building at Meenakunte Hosur | 87.9 | 34.6 | 52.5 | 41.1 | 55 | 45 |
| NQ15 | Kodigehalli RS | 88.8 | 35.9 | 53.1 | 41.9 | 65 | 55 |
| NQ16 | Apartment of the Irish house | 89.4 | 38.5 | 54.6 | 42.8 | 55 | 45 |
| NQ17 | Yelahanka Gnanabarathi School | 87.1 | 37.8 | 51.9 | 39.2 | 50 | 40 |
| NQ18 | Near Airport Terminal PRS | 88.5 | 38.5 | 53.6 | 42.7 | 65 | 55 |
| NQ19 | Devanahalli RS | 90.9 | 36.2 | 52.4 | 41.1 | 65 | 55 |
| NQ20 | Nirmithi Kendra near Pro. Akkupete Depot | 82.5 | 31.4 | 48.9 | 37.6 | 55 | 45 |
| Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara | | | | | | | |
| NQ1 | Govt. School, Benniganahalli | 87.5 | 37.6 | 54.3 | 43.6 | 50 | 40 |
| NQ2 | Mother Mary English School | 89.1 | 35.3 | 52.1 | 41.4 | 50 | 40 |
| NQ3 | Eunice English school, Lingarajapuram | 86.9 | 38.1 | 52.7 | 41.9 | 50 | 40 |
| NQ4 | Residential Building Kadugondanahalli | 89.4 | 39.7 | 56.7 | 44.6 | 55 | 45 |
| NQ5 | Residential Building, Kadugondanahalli | 88.1 | 38.5 | 54.2 | 43.5 | 55 | 45 |
| NQ6 | Public Library MK Nagar | 91.5 | 39.3 | 56.1 | 45.8 | 50 | 40 |
| NQ7 | Lottegollanahalli RS | 89.8 | 35.1 | 53.2 | 42.9 | 65 | 55 |
| NQ8 | P.R Public School, MK Nagar | 90.5 | 35.8 | 55.8 | 43.6 | 50 | 40 |
| NQ9 | Sheela Engineerings, Kammagondanahalli | 89.4 | 39.6 | 53.6 | 44.1 | 75 | 70 |
| NQ10 | Residential Building, Kammagondanahalli | 87.6 | 37.3 | 52.8 | 43.7 | 55 | 45 |
| NQ11 | National Public School, Shettyhalli | 87.1 | 33.2 | 51.4 | 40.8 | 50 | 40 |
| NQ12 | Residential House, Chikkabanavara | 93.8 | 40.1 | 60.6 | 47.6 | 55 | 45 |
| Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment) | | | | | | | |
| NQ1 | Kengeri RS | 91.3 | 39.2 | 53.8 | 42.9 | 65 | 55 |
| NQ2 | Bengaluru Institute of Management Studies | 88.1 | 36.4 | 52.6 | 39.1 | 50 | 40 |
| NQ3 | Residential near Nayandanahalli RS | 89.5 | 37.6 | 53.5 | 40.8 | 55 | 45 |

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| Location Code | Name of the Location | Noise Level Results (Leq) | | | | Standards* | |
|---|---|---------------------------|-------------|-------------|---------------|-------------|---------------|
| | | Max [dB(A)] | Min [dB(A)] | Day [dB(A)] | Night [dB(A)] | Day [dB(A)] | Night [dB(A)] |
| NQ4 | SreeChakra Industrial Unit Nayandanahalli | 88.7 | 36.1 | 52.8 | 41.4 | 75 | 70 |
| NQ5 | Shiva & Ganesh temple Krishnadevaraya Halt | 90.4 | 35.2 | 57.1 | 43.9 | 55 | 45 |
| NQ6 | Subramanya Swamy Temple, Krishnadevaraya | 90.1 | 36.3 | 56.2 | 42.7 | 55 | 45 |
| NQ7 | Holy Gopsee Prayer House | 90.6 | 36.9 | 52.2 | 41.9 | 50 | 40 |
| NQ8 | Karnataka Welfare Association for the Blind, Sheshadripuram | 90.3 | 37.1 | 54.1 | 42.6 | 50 | 40 |
| NQ9 | Residential near Nehru Circle Sheshadripuram | 89.8 | 39.5 | 54.3 | 44 | 55 | 45 |
| NQ10 | Mount Carmel College Palace Road | 88.7 | 35.2 | 52.2 | 40.4 | 50 | 40 |
| NQ11 | Residential near Cantonment RS | 90.2 | 36.6 | 53.1 | 41.6 | 65 | 55 |
| NQ12 | Anugraha AG church Jeevanahalli | 88.3 | 35.1 | 51.9 | 40.3 | 50 | 40 |
| NQ13 | City Hospital, Pulikeshi Nagar | 89.5 | 35.3 | 52.6 | 42.4 | 50 | 40 |
| NQ14 | Central Library, Jeevanahalli | 88.2 | 33.8 | 51.7 | 40.8 | 50 | 40 |
| NQ15 | Govt. PU College, Hoodi | 91.1 | 34.7 | 52.3 | 40.9 | 55 | 45 |
| NQ16 | Residential at Sadarmangala | 92.2 | 37.1 | 51.4 | 41.4 | 55 | 45 |
| Corridor – 4: Heelalige to Rajanukunte | | | | | | | |
| NQ1 | Banglore Colleague of Engineering, Heelalige | 87.4 | 31.9 | 51.2 | 39.6 | 50 | 40 |
| NQ2 | Norwich High School, Electronic City Phase II | 85.2 | 36.4 | 52.8 | 42.7 | 50 | 40 |
| NQ3 | Carmelram Campus, Chikkabellandur | 87.3 | 38.8 | 51.6 | 43.9 | 55 | 45 |
| NQ4 | iSmile Dental Care, Sapthagiri Layout, Marthalli | 88.2 | 36.9 | 53.1 | 42.8 | 55 | 45 |
| NQ5 | Lions Airport City Hospital, Munnekollal | 88.7 | 36.5 | 52.4 | 41.6 | 55 | 45 |
| NQ6 | Kies mansion School, Chinnappanahalli | 89.1 | 37.1 | 51.7 | 41.2 | 50 | 40 |
| NQ7 | Geethanjali Vidyalaya, Mahadevapura | 89.7 | 37.2 | 50.6 | 43.5 | 50 | 40 |
| NQ8 | Ayappaswamy Temple Kaggadasapura | 90.3 | 36.4 | 52.2 | 42.6 | 55 | 45 |

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| Location Code | Name of the Location | Noise Level Results (Leq) | | | | Standards* | |
|---------------|---|---------------------------|-------------|-------------|---------------|-------------|---------------|
| | | Max [dB(A)] | Min [dB(A)] | Day [dB(A)] | Night [dB(A)] | Day [dB(A)] | Night [dB(A)] |
| NQ9 | Sai Speciality Hospital, Bennaganahalli | 89.5 | 37.1 | 53.7 | 41.9 | 55 | 45 |
| NQ10 | Ebinazer School at Horamavu | 88.5 | 36.8 | 54.8 | 40.9 | 55 | 45 |
| NQ11 | Grace Methodist Church, Shanthinagar | 89.8 | 36.1 | 52.5 | 41.2 | 55 | 45 |
| NQ12 | Ayappaswamy Temple Kaggadasapura | 87.6 | 37.3 | 53.4 | 40.6 | 55 | 45 |
| NQ13 | Govt. PU College, Yelahanka | 88.2 | 37.1 | 53.8 | 39.2 | 50 | 40 |
| NQ14 | Residential Building at Vasudevapura | 87.4 | 36.6 | 54.8 | 42.8 | 55 | 45 |
| NQ15 | Industry, Rajanukunte | 88.5 | 37.9 | 50.3 | 41.4 | 75 | 70 |
| NQ16 | Residential near RGA Tech Park | 88.8 | 37.5 | 52.1 | 40.8 | 55 | 45 |
| NQ17 | Residential near Belandur Pro RS | 88.3 | 36.8 | 53.3 | 43.5 | 55 | 45 |
| NQ18 | Residential near Doddanakundi | 87.6 | 36.5 | 52.9 | 39.7 | 55 | 45 |
| NQ19 | Residential near Pai layout | 88.4 | 36.2 | 51.8 | 42.9 | 55 | 45 |
| NQ20 | Residential near Arkavathi Layout | 89.8 | 37.4 | 52.5 | 41.6 | 55 | 45 |
| NQ21 | Residential near Arkavathi Layout | 88.3 | 36.2 | 53.5 | 43.9 | 55 | 45 |
| NQ22 | Residential near Nagenahalli Village | 89.4 | 37.4 | 51.9 | 41.8 | 55 | 45 |
| NQ23 | Residential near Sai Layout | 88.8 | 36.4 | 53.8 | 43.6 | 55 | 45 |
| NQ24 | Residential near Rajanukunte RS | 92.1 | 37.5 | 52.9 | 40.5 | 55 | 45 |

*Standard as per Environmental Protection Act 1986, the principle rules published for Ambient Noise Level Standard (Area Category: Industrial/Residential/Commercial Area).

Observations:

Corridor 1

Day time Noise Levels

Noise levels during day time were found to be in the average range of 48.9 to 60.8 dB (A). The maximum noise level was observed as 60.8 dB (A) at Yeshwanthapur RS and a minimum of 48.9 dB (A) was observed at Nirmithi Kendra near proposed Akkupete depot.

Night time Noise Levels

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Noise levels observed to fall in the range 37.6 to 48.2 dB (A) during the night time. A maximum of 48.2 dB (A) was observed at Yeshwanthapur RS and a minimum of 37.6 dB (A) was observed at Nirmithi Kendra near proposed Akkupete depot.

Corridor 2

Day time Noise Levels

Noise levels during day time were found to be in the average range of 51.4 to 60.6 dB (A). The maximum noise level was observed as 60.6dB (A) at Residential Building, Chikkabanavara and a minimum of 51.4 dB (A) was observed at National Public School, Shettyhalli.

Night time Noise Levels

Noise levels observed to fall in the range 40.8 to 47.6 dB (A) during the night time. A maximum of 47.6 dB (A) was observed at Residential Building, Chikkabanavara and a minimum of 40.8dB (A) was observed at National Public School, Shettyhalli.

Corridor 3

Day time Noise Levels

Noise levels during day time were found to be in the average range of 51.4 to 57.1 dB (A). The maximum noise level was observed as 57.1dB (A) at Shiva & Ganesh Temple, Chikkabanavara and a minimum of 51.4 dB (A) was observed at Residential at Sadarmangala.

Night time Noise Levels

Noise levels observed to fall in the range 39.1 to 44 dB (A) during the night time. A maximum of 44 dB (A) was observed at Residential near Nehru Circle Sheshadripuram and a minimum of 39.1dB (A) was observed at Bengaluru Institute of Management Studies.

Corridor 4

Day time Noise Levels

Noise levels during day time were found to be in the average range of 50.3 to 54.8 dB (A). The maximum noise level was observed as 54.8dB (A) at Masjid and Residential at Horamavu, and a minimum of 50.3 dB (A) was observed at Industry, Rajanukunte.

Night time Noise Levels

Noise levels observed to fall in the range 39.2 to 43.9 dB (A) during the night time. A maximum of 43.9 dB (A) was observed at Residential near Akravathi layout and a minimum of 39.2dB (A) was observed at Govt. PU College, Yelahanka.

5.8.2. Ambient Vibration Monitoring

Vibration is an oscillatory motion which can be described in terms of the displacement, velocity, or acceleration. As the motion is oscillatory, there is no net movement of the vibration element and the average of any of the motion descriptors is zero. Displacement is the easiest descriptor to understand.

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For a vibrating floor, the displacement is simply the distance that a point on the floor moves away from its static position. The velocity represents the instantaneous speed of the floor movement and acceleration is the rate of change of that speed.

Although displacement is easier to understand than velocity or acceleration, it is rarely used for describing ground-borne vibration. Most transducers used for measuring ground-borne vibration use either velocity or acceleration. Further, the response of humans, buildings, and equipment to vibration is more accurately described using velocity or acceleration.

Ground-borne vibration are generated at the wheel/rail interface, when the vehicle travels on the rail, the quasi-static and the dynamic forces arise from the contact points.

Quasi-static forces are the outcome of the self-weight of the train, and they dominate near the field up to one-quarter of the wavelength. The quasi-static deflection of a typical track is a picture of such forces (and thus of the vibration generated). This is illustrated in **Figure 5.21** and can be deduced from a simple configuration.

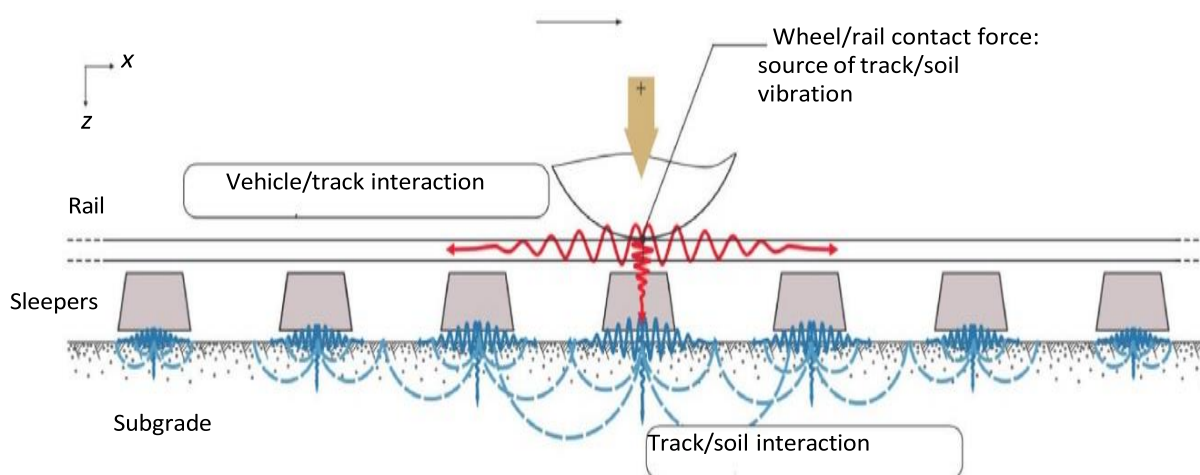


Figure 5.21. Vibration from Rail Sources

The train wheels rolling on the rails create vibration energy that is transmitted through the track support system into the transit structure. The amount of energy that is transmitted into the transit structure is strongly dependent on factors such as the smoothness of the wheels and rails and the resonance frequencies of the vehicle suspension system and the track support system. These systems, like all mechanical systems, have resonances which result in increased vibration response at certain frequencies, called natural frequencies.

The baseline vibration monitoring must be conducted prior to the commencement of actual construction. This process will help to measure any subsequent changes due to actual construction that may be attributed to the ground vibrations. Freezing the baseline of vibration level is done after collecting multiple data sets on all the 12 monitored locations with tri-axial sensors under normal operating conditions. Once a baseline has been established, vibration analysts use the signature as a point of reference to track changes due to construction activities. The monitoring periods ranged was continues 24 hours for each location. Vibration study has been undertaken by Esperto Novero Inspection and Engineering Consultancy (ENIECO) Pvt. Ltd. from 23rd March 2022 to 6th April 2022.

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The monitoring locations were selected in each corridor to represent the actual baseline vibration levels. The selected locations are in close proximity to the (100 m) proposed rail routes. The monitoring locations are near to the urban settlements and thus are sensitive to project development activity.

Vibration impacts for this project are based on the criteria as defined in the FTA guidance manual Transit Noise and Vibration Impact Assessment (FTA Report FTA-VA-90-1003-06, May 2006) and Research Designs & Standards Organisation (RDSO) guidelines. The criteria for acceptable ground-borne vibration are expressed in terms of rms velocity levels in decibels and the criteria for acceptable ground-borne noise are expressed in terms of A-weighted sound levels. The limits are specified for the three land-use categories defined below:

Vibration Category 1 – High Sensitivity: Included in Category 1 are buildings where vibration would interfere with operations within the building, including levels that may be well below those associated with human annoyance. Typical land uses covered by Category 1 are: vibration-sensitive research and manufacturing, hospitals with vibration-sensitive equipment, and university research operations. The degree of sensitivity to vibration will depend on the specific equipment that will be affected by the vibration. Equipment such as electronic microscopes and high-resolution lithographic equipment can be very use when vibration is well below the human annoyance level. Manufacturing of computer chips is an example of a vibration- sensitive process.

Vibration Category 2 – Residential: This category covers all residential land uses and any buildings where people sleep, such as hotels and hospitals. No differentiation is made between different types of residential areas. This is primarily because ground-borne vibration and noise are experienced indoors and building occupants have practically no means to reduce their exposure. Even in a noisy urban area, the bedrooms often will be quiet in buildings that have effective noise insulation and tightly closed windows. Moreover, in certain cities street traffic often abates at night when trains continue to operate. Hence, an occupant of a bedroom in a noisy urban area is likely to be just as exposed to ground-borne noise and vibration as someone in a quiet suburban area. The criteria apply to the transit-generated ground-borne vibration and noise whether the source is subway/tunnel or surface running trains.

Vibration Category 3 – Institutional: This category includes schools, churches, other institutions, and quiet offices that do not have vibration-sensitive equipment, but still have the potential for activity interference. Although it is generally appropriate to include office buildings in this category, it is not appropriate to include all buildings that have any office space. For example, most industrial buildings have office space, but it is not intended that buildings primarily for industrial use be included in this category.

Corridor wise Ambient Vibration monitoring locations are presented in **Table 5.31**. Photographs of the ambient Vibration monitoring locations are presented in **Annexure 5.4**.

Table 5.31. Details of Ambient Vibration Monitoring Locations along the BSRP Corridors

| Corridors | Code | Monitoring Location Name/General | Co-ordinates | Category* |
|------------|------|---------------------------------------|-------------------------|------------|
| Corridor 1 | V-1 | Manipal Hospital, Malleshwaram | 13°0'7"N 77°33'49"E | Category 1 |
| | V-2 | Residential Building at Muthyalanagar | 13°2'22"N 77°32'57"E | Category 2 |

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| Corridors | Code | Monitoring Location Name/General | Co-ordinates | Category* |
|------------|------|--|--------------------------------|------------|
| | V-3 | NITTE Global Institute, Yelahanka | 13°7'45"N 77°35'12"E | Category 3 |
| Corridor 2 | V-1 | Mother Mary English School, Kasturi Nagar | 13° 0'18.79"N 77°38'55"E | Category 3 |
| | V-2 | Residential Building at Lottagollanahalli | 13°2'35"N 77°33'46"E | Category 2 |
| | V-3 | National Public School, Chikkabanavara | 13°4'15"N 77°30'35"E | Category 3 |
| Corridor 3 | V-1 | Suhasini hospital, Kengeri | 12°55'12"N 77°29'7"E | Category 1 |
| | V-2 | Residential House at Telecom Layout, Vijayanagar | 12°57'22"N 77°32'15"E | Category 2 |
| | V-3 | Karnataka Welfare Association for the Blind, Sheshadripuram | 12°59'6.08"N 77°34'29.71"E | Category 3 |
| Corridor 4 | V-1 | Lions Airport City Hospital, Marathahalli | 12°57'18.38"N 77°42'18.68"E | Category 1 |
| | V-2 | Center for Artificial Intelligence and Robotics (CAIR,DRDO), Nagawaraplaya | 12°59'21"N 77°40'9"E | Category 1 |
| | V-3 | Govt. PU College, Yelahanka New Town | 13°5'47"N 77°35'42"E | Category 3 |

*Location categorisation as per Guidelines for Noise & Vibration as per Metro Rail Transit system, RDSO

A summary of the maximum baseline vibration recorded at each location is shown in **Table 5.32**.

Table 5.32. Ambient Vibration Monitoring Results for BSRP Corridors

| Sl. No. | Date of Monitoring | Corridor No./ Vibration Code | Location Details | Trans Peak Value (Mm/S) | Vertical Peak Value (Mm/S) | Long Peak Value (Mm/S) | Peak Particle Velocity (Ppv) (Mm/S) |
|---------|------------------------|------------------------------|---|-------------------------|----------------------------|------------------------|-------------------------------------|
| 1 | 26-27 March 2022 | Corridor 1 V-1 | Manipal Hospital | 0.378 | 1.096 | 0.449 | 1.107 |
| 2 | 25-26 March 2022 | Corridor 1 V-2 | Residential Building at Muthyalanagar | 0.244 | 0.465 | 0.158 | 0.531 |
| 3 | 31 March-01 April 2022 | Corridor 1 V-3 | NITTE Global Institute | 0.102 | 0.087 | 0.110 | 0.128 |
| 4 | 24-25 March 2022 | Corridor 2 V-1 | Mother Mary English School | 0.252 | 0.686 | 0.402 | 0.718 |
| 5 | 5-6 April 2022 | Corridor 2 V-2 | Residential Building at Lottagollanahalli | 0.213 | 0.757 | 0.197 | 0.792 |
| 6 | 23-24 March 2022 | Corridor 2 V-3 | National Public School | 0.370 | 0.701 | 0.331 | 0.705 |

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| Sl. No. | Date of Monitoring | Corridor No./ Vibration Code | Location Details | Trans Peak Value (Mm/S) | Vertical Peak Value (Mm/S) | Long Peak Value (Mm/S) | Peak Particle Velocity (Ppv) (Mm/S) |
|---------|--------------------|------------------------------|--|-------------------------|----------------------------|------------------------|-------------------------------------|
| 7 | 29-30 March 2022 | Corridor 3 V-1 | Suhasini Hospital | 3.878 | 0.315 | 4.800 | 6.171 |
| 8 | 28-29 March 2022 | Corridor 3 V-2 | Residential House at Telecom Layout | 0.307 | 0.654 | 0.284 | 0.675 |
| 9 | 27-28 March 2022 | Corridor 3 V-3 | Karnataka Welfare Association for the Blind | 6.211 | 5.943 | 2.554 | 8.636 |
| 10 | 4-5 April 2022 | Corridor 4 V-1 | Lions Airport City Hospital | 0.418 | 0.741 | 0.891 | 0.949 |
| 11 | 2-3 April 2022 | Corridor 4 V-2 | Centre for Artificial Intelligence and Robotics (CAIR, DRDO) | 0.205 | 1.269 | 0.292 | 1.313 |
| 12 | 1-2 APRIL 2022 | Corridor 4 V-3 | Govt. PU College | 0.331 | 0.591 | 0.355 | 0.634 |

Observations:

Based on the summary of the baseline vibration monitoring performed, except for Corridor 1 V3 location – NITTE Global Institute, Yalahanka where the Peak Particle Velocity (PPV) is 0.128 mm/s which is less the threshold trigger level (05 mm/s). In rest of the locations, the PPV is higher than the threshold trigger level. The maximum PPV recorded was at Corridor 3 V-3 location, Karnataka Welfare Association for the Blind, Sheshadripuram which showed a PPV of 8.636 mm/s. The second highest was recorded at Corridor 3 V-1 location, Suhasini Hospital, Kengeri which recorded a PPV of 6.171 mm/s. These two areas fall under the Corridor 3 and proper action has to be taken to reduce the baseline vibration levels. Corridor 1 V-1 location recorded a PPV of 1.107 mm/s and Corridor 4 V-2 location recorded a PPV of 1.313 mm/s, which is the third highest value and proper remedial actions has to be taken to bring down the vibration level below the threshold trigger level.

All other locations are less than 1.00 mm/s but higher than 0.5mm/s the threshold trigger level. Hence, the construction team must give priority and take proper corrective and preventive action to mitigate and reduce the vibration level.

5.9. Biological Environment

Bengaluru is also known has 'garden city', which has well designed green space and natural and man-made lakes. In recent years, city is experiencing rapid unscientific and unplanned urbanisation due to growing demand for residential and commercial spaces. This resulted in concretisation of the city by losing its green space. In addition, to provide enhanced connectivity for these urban agglomerates,

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many new infrastructure facilities have been introduced, which also created pressure on the biological environment of the region.

Garden City of India has two nationally renowned botanical gardens Cubbon Park which is located at the centre of Bengaluru city at a distance of 2.8 km (nearest aerial distance) from the Corridor 3 of BSRP alignment and Lal Bagh which is also located at the centre of Bengaluru city at a distance of 1.67 km (nearest aerial distance) from the Corridor 3 of BSRP alignment. The Cubbon Park was established in the year 1870 by John Meade and has a history of over 100 years. Indigenous and exotic botanical species are found in the park. There are about 68 genera and 96 species with a total of around 6,000 plants/trees. Some of the indigenous species found in the park are Artocarpus species, Cassia fistula, Ficus species, Polyalthias, etc., and exotic species such as Araucaria, Bamboo, Castanospermum Australe, Grevillea robusta, Millettia, Peltophorum, Schinus molle, Swieteniamahagoni, Tabebuia species, etc. Lalbagh, is a botanical garden and has been a treasure house of plants. The rich floral wealth of Lalbagh extends over an area of 97 hectares (240 acres) accommodating 1,854 species 673 genera and 890 cultivars of plants. It is also home to numerous wild species of birds and other wildlife.

5.9.1. Forests and Protected Areas

5.9.1.1. Forests

In 1982, a Forest Division was created under the name Bengaluru Green Belt Division which was entrusted with the job of greening of Bengaluru Metropolitan Region. Later on, the same has been enlarged to cover the Bengaluru District (including Bengaluru Rural district). The natural vegetation consists of species like Albizzia amara, Albizzia lebbek, Anogeissus latifolia, Acacia species, Shoreatalura and Santalum album, etc.

The total forest area of the Bengaluru Districts are around 2.3 percent (50.55 Sq.km) and 4.93 percent (113.22 Sq.km) respectively of the total geographical area. The forests are of tropical dry deciduous type mostly containing Acacia, Albizia, Wrightia tinctoria, Zizyphus, Dendrocalamus strictus, Anogeissus latifolia etc. Forest areas in the project districts are multitude of Reserved Forest, Plantations, Reserves and protected areas.

Consequent to the division of Bangalore District into Bangalore Urban and rural districts vide Government Order No. Rd/56/LRD/86 dated 31-7-1986, Bangalore urban and rural districts came into existence in 01.4.1988 with the jurisdiction coinciding with that of Bangalore urban and Rural Districts respectively. Subsequently, Bangalore Rural Forest Division came into existence in 21-8-2007.

Bengaluru Urban Forest Division:

Bengaluru Urban division is situated on the southern portion of Karnataka. The division has about 6712.94 Ha of forest area. It has two sub-divisions, namely, Bengaluru North sub-division and Bengaluru South sub-division, and consists of five ranges, namely, Anekal, Bengaluru, Krishna Raja Puram, Kaggalipura and Yelahanka. The forests of Bengaluru Urban division are of dry deciduous scrub type, and consist of species such as Chigare, Pachali, Bekke, Kakke, Kagali, Lantana, Bandarike, Jalari, etc. There are no prominent fauna species present in the forest areas of the division. There was no prominent wild animals noticed during surveys and no wild animal presence mentioned during discussion with concerned forest official of the project region. Abstract of forest land available with Bengaluru Urban division is presented in **Table 5.33**.

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Table 5.33. Abstract of Forest Land Available with the Bengaluru Urban Forest Division

| Sl. No. | Name of the Range | Notified Forest in Ha. | Unclassified (Deemed) Forests in Ha | Total Area in Ha |
|--------------------------------|--------------------|------------------------|-------------------------------------|------------------|
| 1 | Anekal | 333.92 | 476.45 | 810.37 |
| 2 | Bengaluru | 1285.75 | 168.49 | 1454.24 |
| 3 | Krishna Raja Puram | 287.74 | 310.45 | 598.19 |
| 4 | Kaggalipura | 2261.08 | 758.67 | 3019.75 |
| 5 | Yelahanka | 808.45 | 21.94 | 830.39 |
| Total Forest Area in Ha | | 4976.94 | 1736.0 | 6712.94 |

Source: Working Plan Bengaluru Urban Forest Division Year 2021-22.

Bengaluru Rural Forest Division:

The geographical area of the Bangalore rural division is 2266 sq. km or 226600 Ha out of which 18642.92 Ha are forest lands. Forests therefore constitute about 8.25% of the geographical area of the division. The forests are of tropical dry deciduous type mostly containing Acacia, Albizia, Wrightia tinctoria, Zizyphus, Dendrocalamus strictus, Anogeissus latifolia etc. Common fauna found in forest area of the Bengaluru Rural Forest Division are Slot bear, panther, Block buck, Chital, Spotted deer, large variety of retails, Hares, Porcupine, Jackal, Fox, Peacocks etc. However, there was no wild animals noticed during surveys and no wild animal presence mentioned during discussion with concerned forest official of the project region. Abstract of forest land available with Bengaluru Rural division is tabulated in **Table 5.34**.

Table 5.34. Abstract of Forest Land Available with the Bengaluru Rural Forest Division

| Sl. No. | Name of the Range | Notified Forest in Ha. | Unclassified (Deemed) Forests in Ha | Total Area in Ha |
|--------------------------------|-------------------|------------------------|-------------------------------------|------------------|
| 1 | Devanahalli | 2586.32 | 519.14 | 3105.46 |
| 2 | Doddaballapura | 6704.00 | 1279.60 | 7983.60 |
| 3 | Hoskote | 3565.55 | 60.70 | 3626.25 |
| 4 | Nelamangala | 3611.39 | 316.22 | 3927.61 |
| Total Forest Area in Ha | | 15623.19 | 2175.66 | 18642.92 |

Source: Working Plan Bengaluru Rural Forest Division Year 2011-12 to 2020-21.

In order to collect the forest land details in Bengaluru Urban District, consultant team met Territorial Forest Division. It was informed that, there is no forest map readily available for the district. However, it was informed to refer forest land marked in Toposheet prepared by Survey of India for the proposed BSRP project.

As per Survey of India Toposheet, BSRP corridors are not crossing/abutting the forest land except Corridor 1 – Bengaluru City (KSR) to Devanahalli as railway alignment is abutting forest land towards LHS at Chainage km 19/700 (the present landuse in this location is residential). However, suburban rail is proposed on RHS, so there is no impact of flora and fauna of forest and no forest land diversion envisaged. Forest land present within project study area i.e., 5Km on either side of the proposed railway alignment is presented in **Table 5.35**.

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Table 5.35. Forest Area present within Project Study Area (5 Km on either side of the Project)

| Sl. No. | Name of the Forest | Forest Division | Forest Range | Forest Area in Ha. | Nearest Aerial Distance from BSRP Corridor | Remarks |
|---------|---------------------------------------|-----------------|-----------------------|--------------------|--|--|
| 1 | Jarakabande Reserved Forest | Bengaluru Urban | Yelahanka Range | 199.92 | 2.3 Km from Corridor 4 | |
| 2 | Jarakabande Reserved Forest | | | | 4.2 Km from Corridor 4 | |
| 3 | Sulikere Reserved Forest | Bengaluru Urban | Kagalipura Range | 212.48 | 3.8 Km from Corridor 3 | |
| 4 | TurahalliGudda Protected Forest | Bengaluru Urban | Kagalipura Range | 238.97 | 2 Km from Corridor 3 | |
| 5 | TurahalliGudda Protected Forest | | | | 4.9 Km from Corridor 3 | |
| 6 | Badamanavarti Reserved Forest | Bengaluru Urban | Kagalipura Range | 566.80 | 4.8 Km from Corridor 3 | |
| 7 | Reserved Forest | Bengaluru Urban | Bengaluru Urban Range | | 4.9 Km from Corridor 2 | |
| 8 | Yaratiganahalli Reserved Forest | Bengaluru Rural | Devanahalli Range | 215.42 | 0.4 Km from Corridor 1 | Diverted for Kempegowda International Airport. |
| 9 | Rayasandra Reserved Forest | Bengaluru Rural | Devanahalli Range | 93.08 | 3.6 Km from Corridor 1 | Diverted for Kempegowda International Airport. |
| 10 | Reserved Forest | Bengaluru Rural | Devanahalli Range | | 0.1 Km from Corridor 1 | Existing landuse is built-up. |
| 11 | Koramangala Extension Reserved Forest | Bengaluru Rural | Devanahalli Range | 415.65 | 4.1 Km from Corridor 1 | |
| 12 | Bettakote Reserved Forest | Bengaluru Rural | Devanahalli Range | 426.52 | 4.2 Km from Corridor 1 | Diverted for Kempegowda International Airport. |
| 13 | Akkupete Reserved Forest | Bengaluru Rural | Devanahalli Range | 83.77 | 1.1 Km from Corridor 1 | Proposed to divert 18.6Ha for Akkupete Depot for BSRP. |

The forest land located in the indirect impact zone is depicted in Survey of India Toposheet presented in **Annexure 4.1**.

The BSRP alignments are proposed along the existing Indian Railway alignment for the entire length. The nearest forest land as per the above table is TurahalliGudda Protected Forest, which is located at 2.1Km from the proposed Corridor 3 railway alignment. As per the above table, BSRP alignment is not

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crossing/abutting any reserved/ protected forest land. Forest Department has taken up barricading, trenches and fencing of most of these forest lands to conserve wild animals and preventing human-animal conflicts.

Hence, there is no impact on flora or fauna of the forest land considering its proximity and urban growth. Engaging a biodiversity expert to carry out further biodiversity impact assessment due to proposed project on these forest lands does not required.

Further, a suburban railway depot is proposed in reserved forest land at Akkupete (13°14'50.40"N & 77°41'26.37"E) near Devanahalli station, which requires about 18.6 Ha of forest land for construction of depot. As per the information received from Forest Dept., the proposed forest land was taken up for compensatory afforestation for 25 Ha in the year 2001. *Eucalyptus fibrosa* and *Acacia mangium* tree species are predominantly planted in the forest land under Compensatory Afforestation scheme. There is no presence of wild animals observed during site visits. Photographs of the proposed depot at Akkupete is presented in **Figure 5.22**. Google earth image of Akkupete Depot site is presented in **Figure 5.23**.



Figure 5.22. Photographs of Forest Land Considered for Depot at Akkupete

Classification of Habitats

The term “Habitat” is defined as a terrestrial, freshwater, or marine geographical unit or airway that supports assemblages of living organisms and their interactions with the nonliving environment.

Habitats vary in their significance for conserving globally, regionally and nationally important biodiversity, their sensitivity to impacts, and in the significance different stakeholders attribute to them. Because, in most instances, habitat loss, degradation or fragmentation represents the greatest threat to biodiversity, much of the focus of biodiversity conservation actions is on maintaining or restoring suitable habitats.

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Hence, It is the responsibility of the project proponent to compensate the losses incurred due to implementation of the project. As per the World Bank ESS 6, the Habitats are classified into three categories;

- **Modified Habitat:** Modified habitats are areas that may contain a large proportion of plant and/or animal species of nonnative origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition. Modified habitats may include, for example, areas managed for agriculture, forest plantations, reclaimed coastal zones, and reclaimed wetlands.
- **Natural Habitat:** Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition.
- **Critical Habitat:** Critical habitats are areas with high biodiversity importance or value and shall include Critically Endangered or Endangered species as listed in the IUCN Red List of threatened species or equivalent national approaches, endemic or restricted-range species, habitat supporting globally or nationally significant concentrations of migratory or congregatory species. Critical habitats are also highly threatened or unique ecosystems and habitat that maintain ecological functions, which are having key scientific value and/or associated with key evolutionary processes.

As per the biodiversity assessment carried out for the project, there are no Natural and Critical Habitats are present along project. However, there are modified habitats characterising agricultural land and forest plantations (Akkupete depot) present along the project corridors. As mentioned above, these modified habitats are devoid of any IUCN listed threatened, endangered, endemic flora and fauna species.

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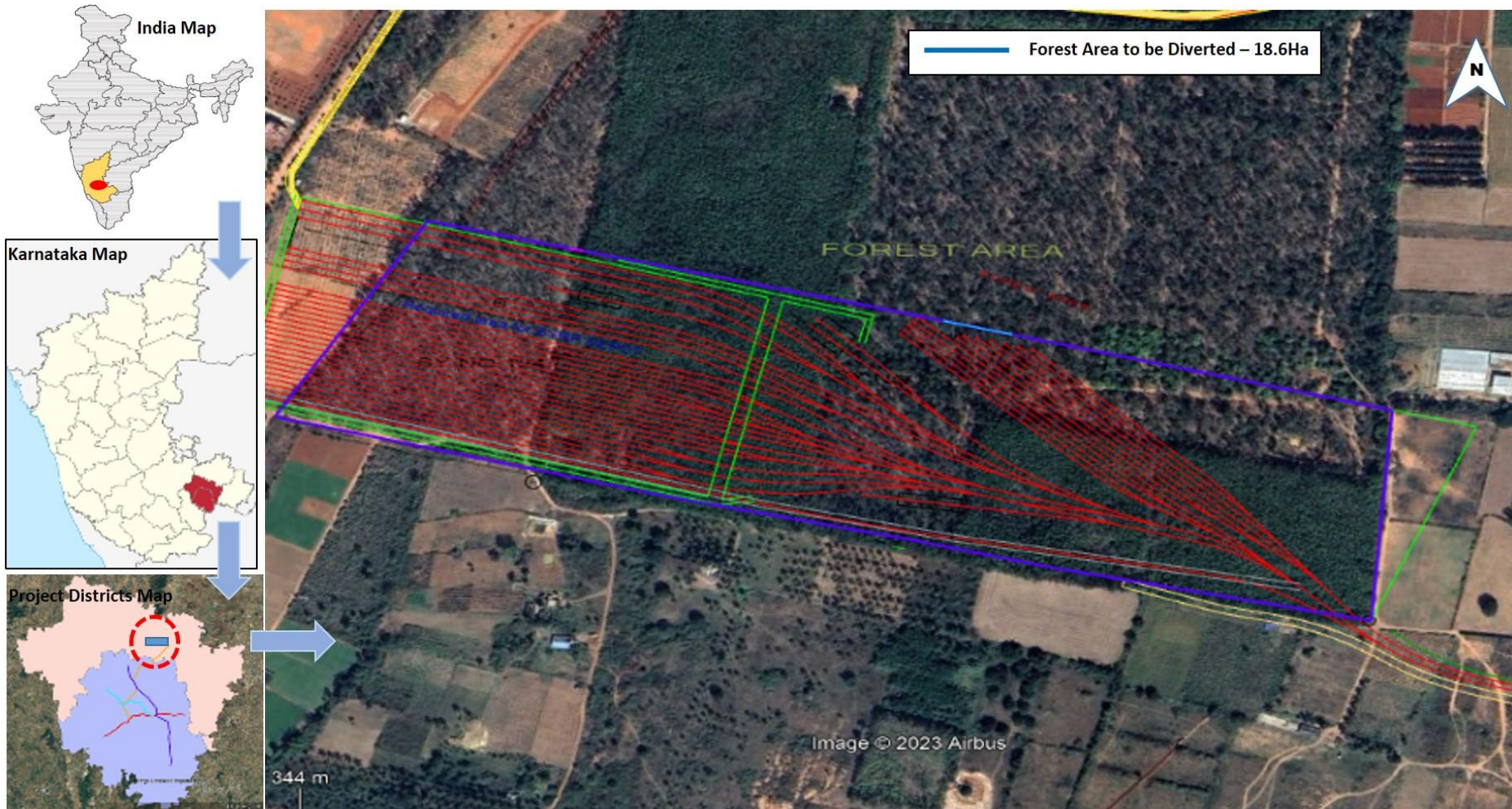


Figure 5.23. Google Earth Image Showing Proposed Akkupete Depot site in Forest land

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5.9.1.2. Protected Areas

The proposed BSRP corridors are not passing through or abutting any protected areas such as National Park, Wildlife Sanctuary and Conservation reserves. The BSRP alignments are proposed along the existing Indian Railway alignment for the entire length. However, there are two protected areas such as Puttenahalli Lake Birds Conservation Reserve and Bannerghatta National Park present in the Bengaluru Urban District. There are no protected area present within indirect impact zone in Bengaluru Rural district.

The nearest protected area present is Puttenahalli Lake Birds Conservation Reserve (13° 6'40.03"N & 77°34'32.63"E) which is 850m (aerial distance) from the Corridor 4 - Heelalige to Rajanukunte railway corridor and 970m from the Corridor 1 - Bengaluru City (KSR) to Devanahalli. Puttenahalli Lake birds conservation reserve is located near Vinayaka Bhadavane on Doddabalapura road. The conservation reserve is surrounded by dense human habitat with multi-storied buildings. The total area of the lake is 15 Ha, which is owned by Forest department. The lake is managed by forest department, which has plant nursery too. The bird species found in the lake are Darters, Painted storks, Black-crowned Night Herons, Purple Herons, Pond Herons, Egrets, Asian Open bill Storks, Eurasian Spoonbills, Spot-billed Pelican, Little Grebe, Little Cormorant, Spot-billed Ducks, Purple Moor-hen, Common Sandpiper, etc.,

It is observed that, the birds identified in the lake are having plentiful of forage and roost in the lake vicinity compared to rather than surrounding urbanised and built-up areas. They are not observed to fly to areas where there is high pollution and disturbance from anthropogenic activities. Google image showing Puttenahalli Lake Birds Conservation Reserve with BSRP corridors in **Figure 5.24**.



Figure 5.24. Map Showing Nearest Distance from Puttenahalli Lake Birds Conservation Reserve to Project Corridors

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Bannerghatta National Park located at 12.7 Km ($12^{\circ}50'5.87''N$ & $77^{\circ}34'53.72''E$) (aerial distance) from the Corridor 4 - Heelalige to Rajanukunte. This national park is peculiarly shaped having a length of 59 km and varying width from 0.3 km to 13.8 km which is mainly due to the impact of urbanization. This park establishes crucial wildlife landscape by connecting the Eastern and Western ghats which mainly support elephant habitat. The State Government has notified the eco-sensitive zones – buffer zones – around this protected space declaring approximately 200 sq km as buffer zone based on the conservation standpoint. Forest Department has taken up barricading, trenches and electrical fences to conserve wild animals and preventing human-animal conflicts. Map showing the aerial distance from Corridor 4 to boundary of Eco-sensitive zone of Bannerghatta National Park is presented as **Figure 5.25**.

There is unlikely any impact on these protected areas either on the land or its flora and fauna from the project because of its distance and presence of urban settlements around it.

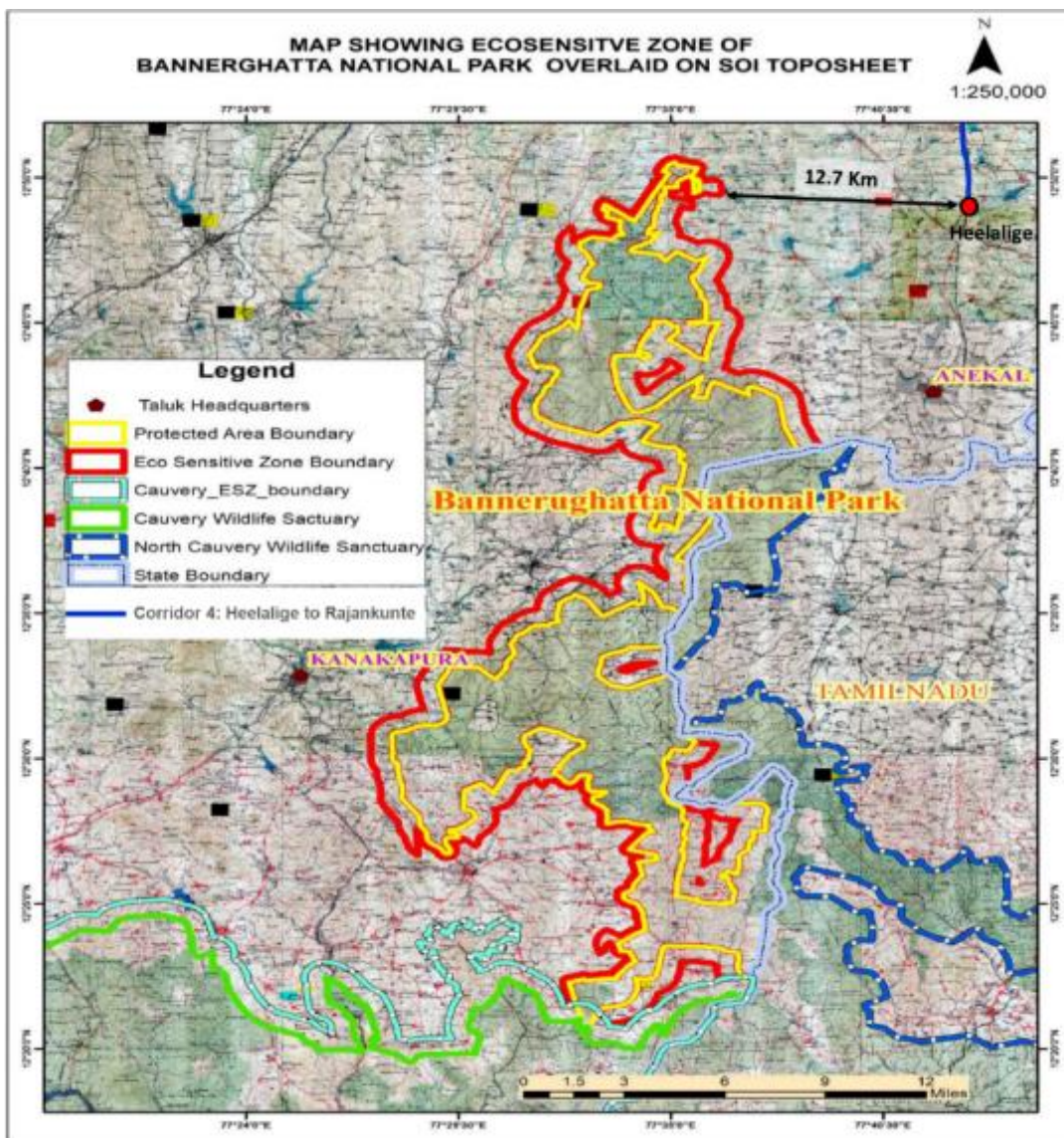


Figure 5.25. Eco- Sensitive Zone Map of Bannerghatta National Park Showing Nearest Distance from Corridor 4 - Heelalige to Rajanukunte

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5.9.2. Flora

Vegetative cover in the proposed BSRP Corridors are ornamental and indigenous tree species. Common tree species present affected due to project is Rain tree (*Samanea saman*), Peepal tree (*Ficus religiosa*), Indian Cork tree (*Millingtonia hortensis*), Gulmohar (*Delonix regia*), Jamun tree (*Syzygium cumini*), Copper pod tree (*Peltophorum pterocarpum Becker*), Tulip tree (*Liriodendron*), Black siris tree (*Albizia odoratissima*), Pongamia tree (*Pongamia Pinneta*) etc..

Tree marking and enumeration has been completed for all the BSRP Corridors. Total trees affected in BSRP Corridors are 32572 trees (Corridor-1 is 7198, Corridor-2 is 3469, Corridor-3 is 2072, Corridor-4 is 2306, Akkupete Depot – 17505 and Soladevanahalli Depot - 22). Survey for recently design modified locations was conducted for any presence of floral species and trees present along these design modified locations are incorporated in the below tables.

List of top ten trees present in BSRP Corridors are presented in **Table 5.36 to 5.39**. Girth wise tree species affected due to project Corridors are listed in **Table 5.40 to Table 5.43**. IUCN Categorization of trees present in BSRP Corridors are presented in **Table 5.44**.

Table 5.36. Top Ten Tree Species Commonly present along Corridor 1 - KSR Bengaluru City to Devanahalli

| Sl. No. | Local Name of the Tree | Scientific Name of the Tree |
|---------|------------------------|--------------------------------|
| 1 | Silver tree | <i>Leucadendron argenteum</i> |
| 2 | Honge Mara | <i>Pongamia pinnata</i> |
| 3 | Bhevu | <i>Azadirachta indica</i> |
| 4 | Neelagiri | <i>Eucalyptus globulus</i> |
| 5 | Iju | <i>Schima liukuensis</i> |
| 6 | Seemethangdi | <i>Senna siamea</i> |
| 7 | Kaagada Uppu Nerale | <i>Broussonetia papyrifera</i> |
| 8 | Maale mara | <i>Samanea saman</i> |
| 9 | Indian rosewood | <i>Dalbergia sissoo</i> |
| 10 | Nerale mara | <i>Acacia acuminata</i> |

Source: Environmental survey

Table 5.37. Top Ten Tree Species Commonly present along Corridor 2 - Baiyyappanahalli Terminal to Chikkabanavara

| Sl. No. | Local Name of the Tree | Scientific Name |
|---------|------------------------|--------------------------------|
| 1. | Kaagada Uppu Nerale | <i>Broussonetia papyrifera</i> |
| 2. | Maale mara | <i>Samanea saman</i> |
| 3. | Honge | <i>Pongamia pinnata</i> |
| 4. | Niligiri | <i>Eucalyptus globulus</i> |
| 5. | Thengu | <i>Cocos nucifera</i> |
| 6. | Seemethangdi | <i>Ailanthus excelsa</i> |
| 7. | Karuhaale | <i>Tremma orientalis</i> |
| 8. | Seeme Hunase | <i>Pithecellobium dulce</i> |
| 9. | Chigugu | <i>Leucaena leucocephala</i> |
| 10. | Bhevu | <i>Azadirachta indica</i> |

Source: Environmental survey

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Table 5.38. Top Ten Tree Species Commonly present along Corridor 3 - Kengeri to Whitefield (via KSR and Cantonment)

| Sl. No. | Local Name of the Tree | Scientific Name of the Tree |
|---------|------------------------|--------------------------------|
| 1. | Gulmhar | <i>Delonix regia</i> |
| 2. | Maale mara | <i>Samanea saman</i> |
| 3. | Flower Tree | <i>Magnoliophyta</i> |
| 4. | Kaagada Uppu Nerale | <i>Broussonetia papyrifera</i> |
| 5. | Seemethangdi | <i>Ailanthus excelsa</i> |
| 6. | Babul | <i>Vachellia nilotica</i> |
| 7. | Honge Mara | <i>Millettia pinnata</i> |
| 8. | Neelagiri | <i>Eucalyptus globulus</i> |
| 9. | Thengu | <i>Cocos nucifera</i> |
| 10. | Hole dasavala | <i>Lagerstroemia speciosa</i> |

Source: Environmental survey

Table 5.39. Top Ten Tree Species Commonly present along Corridor 4 - Heelalige to Rajanukunte

| Sl. No. | Local Name of the Tree | Scientific Name of the Tree |
|---------|------------------------|-----------------------------|
| 1. | Niligiri | <i>Eucalyptus globulus</i> |
| 2. | Jali | <i>Vachellia nilotica</i> |
| 3. | Aurculis | <i>Acacia auriculuous</i> |
| 4. | Seeme Hunase | <i>Pithecellobium dulce</i> |
| 5. | Honge mara | <i>Pongamia pinnata</i> |
| 6. | Bamboo | <i>Bambusa balcooa</i> |
| 7. | Bhevu | <i>Azadirachta indica</i> |
| 8. | Male Mara | <i>Samanea saman</i> |
| 9. | Banni Mara | <i>Senegalia ferruginea</i> |
| 10. | Tabebuia | <i>Tabebuia rosea</i> |

Source: Environmental survey

Table 5.40. Girth Wise Tree Species Affected due to Corridor 1 - KSR Bengaluru City to Devanahalli

| Sl. No. | Forest Range/Dept. | Girth Wise Trees | | | | | Total |
|---|-----------------------|------------------|-------------|-------------|--------------|-----------|-------------|
| | | <30 Cm | 31Cm - 60Cm | 61Cm - 90Cm | 91Cm - 180Cm | >180Cm | |
| 1 | Bengaluru Urban Range | 4 | 370 | 180 | 93 | 41 | 688 |
| 2 | Yelahanka Range | 15 | 1749 | 1240 | 326 | 37 | 3367 |
| 3 | Devanahalli Range | 5 | 1376 | 886 | 129 | 6 | 2402 |
| 4 | BBMP | 0 | 234 | 80 | 59 | 10 | 383 |
| 5 | Airport Link | 0 | 156 | 144 | 57 | 1 | 358 |
| Total Girth Wise | | 24 | 3885 | 2530 | 664 | 95 | |
| Total Girth Wise in Percent | | 0.3% | 54% | 35% | 9% | 1% | |
| Total Number of Trees Affected in Corridor 1 | | | | | | | 7198 |

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Table 5.41. Girth Wise Tree Species Affected due to Corridor 2 - Baiyyappanahalli Terminal to Chikkabanavara

| Sl. No. | Forest Range/Dept. | Girth Wise Trees | | | | | Total |
|---|-----------------------|------------------|-------------|-------------|--------------|------------|-------------|
| | | <30 Cm | 31Cm - 60Cm | 61Cm - 90Cm | 91Cm - 180Cm | >180Cm | |
| 1 | Bengaluru Urban Range | 45 | 791 | 365 | 218 | 42 | 1461 |
| 2 | Yelahanka Range | 134 | 795 | 491 | 442 | 70 | 1932 |
| 3 | KR Puram Range | 13 | 38 | 13 | 9 | 3 | 76 |
| Total Girth Wise | | 192 | 1624 | 869 | 669 | 115 | |
| Total Girth Wise in Percent | | 6% | 47% | 25% | 19% | 3% | |
| Total Number of Trees Affected in Corridor 2 | | | | | | | 3469 |

Table 5.42. Girth Wise Tree Species Affected due to Corridor 3 - Kengeri to Whitefield (via KSR and Cantonment)

| Sl. No. | Forest Range/Dept. | Girth Wise Trees | | | | | Total |
|---|-----------------------|------------------|-------------|-------------|--------------|------------|-------------|
| | | <30 Cm | 31Cm - 60Cm | 61Cm - 90Cm | 91Cm - 180Cm | >180Cm | |
| 1 | Kagalipura Range | 3 | 176 | 191 | 183 | 27 | 580 |
| 2 | Bengaluru Urban Range | 3 | 80 | 254 | 191 | 64 | 592 |
| 3 | Yelahanka Range | 13 | 144 | 146 | 50 | 27 | 380 |
| 4 | BBMP | 0 | 82 | 146 | 195 | 97 | 520 |
| Total Girth Wise | | 19 | 482 | 737 | 619 | 215 | |
| Total Girth Wise in Percent | | 1% | 23% | 36% | 30% | 10% | |
| Total Number of Trees Affected in Corridor 3 | | | | | | | 2072 |

Table 5.43. Girth Wise Tree Species Affected due to Corridor 4 - Heelalige to Rajanukunte

| Sl. No. | Forest Range/Dept. | Girth Wise Trees | | | | | Total |
|---|-----------------------|------------------|-------------|-------------|--------------|-----------|-------------|
| | | <30 Cm | 31Cm - 60Cm | 61Cm - 90Cm | 91Cm - 180Cm | >180Cm | |
| 1 | Bengaluru Urban Range | 80 | 279 | 225 | 649 | 69 | 1302 |
| 2 | Yelahanka Range | 112 | 440 | 233 | 211 | 8 | 1004 |
| Total Girth Wise | | 192 | 719 | 458 | 860 | 77 | |
| Total Girth Wise in Percent | | 8% | 31% | 20% | 37% | 3% | |
| Total Number of Trees Affected in Corridor 4 | | | | | | | 2306 |

Table 5.44. IUCN Categorisation for Trees Present in BSRP Corridors

| Sl. No. | Scientific Name of the Tree | IUCN Categorisation | Sl. No. | Scientific Name of the Tree | IUCN Categorisation |
|---------|--------------------------------|------------------------------|---------|--------------------------------|------------------------------|
| 1 | <i>Leucadendron argenteum</i> | Vulnerable | 38 | <i>Juglons Regia</i> | Categorisation Not Available |
| 2 | <i>Pongamia pinnata</i> | Least Concern | 39 | <i>Erythrina</i> | Categorisation Not Available |
| 3 | <i>Azadirachta indica</i> | Least Concern | 40 | <i>Mangifera indica</i> | Data Deficient |
| 4 | <i>Eucalyptus globulus</i> | Least Concern | 41 | <i>Docony oose tree</i> | Categorisation Not Available |
| 5 | <i>Schima liukuensis</i> | Categorisation Not Available | 42 | <i>Anacardium occidentale</i> | Least Concern |
| 6 | <i>Senna siamea</i> | Least Concern | 43 | <i>Fraxinus</i> | Categorisation Not Available |
| 7 | <i>Broussonetia papyrifera</i> | Least Concern | 44 | <i>Ziziphus mauritiana</i> | Least Concern |
| 8 | <i>Samanea saman</i> | Least Concern | 45 | <i>Moringa oleifera</i> | Least Concern |
| 9 | <i>Dalbergia sissoo</i> | Least Concern | 46 | <i>Podocarpus latifolius</i> | Least Concern |
| 10 | <i>Acacia acuminata</i> | Least Concern | 47 | <i>Tamarindus indica</i> | Least Concern |
| 11 | <i>Delonix regia</i> | Least Concern | 48 | <i>Malus sylvestris</i> | Data Deficient |
| 12 | <i>Vachellia nilotica</i> | Least Concern | 49 | <i>Swietenia</i> | Categorisation Not Available |
| 13 | <i>Albizia lebbeck</i> | Categorisation Not Available | 50 | <i>Albizia lebbeck</i> | Least Concern |
| 14 | <i>Cocos nucifera</i> | Categorisation Not Available | 51 | <i>Dacryodes edulis</i> | Categorisation Not Available |
| 15 | <i>Prosopis juliflora</i> | Categorisation Not Available | 52 | <i>Limonia acidissima</i> | Categorisation Not Available |
| 16 | <i>Coffea</i> | Categorisation Not Available | 53 | <i>Regia</i> | Categorisation Not Available |
| 17 | <i>Pinc poui</i> | Categorisation Not Available | 54 | <i>Terminalia catappa</i> | Least Concern |
| 18 | <i>Markhamia lutea</i> | Least Concern | 55 | <i>Casuarina equisetifolia</i> | Least Concern |
| 19 | <i>Millingtonia hortensis</i> | Categorisation Not Available | 56 | <i>Hages tree</i> | Categorisation Not Available |
| 20 | <i>Tectona grandis</i> | Categorisation Not Available | 57 | <i>Mheothukumara</i> | Categorisation Not Available |
| 21 | <i>Ficus religiosa</i> | Categorisation Not Available | 58 | <i>Sver green Oak</i> | Categorisation Not Available |
| 22 | <i>Ficus benghalensis</i> | Categorisation Not Available | 59 | <i>Kigelia africana</i> | Least Concern |
| 23 | <i>Ziziphus glabrata</i> | Categorisation Not Available | 60 | <i>Magnolia champaca</i> | Least Concern |
| 24 | <i>Saraca asoca</i> | Vulnerable | 61 | <i>Salix babylonica</i> | Data Deficient |
| 25 | <i>Senna alata</i> | Least Concern | 62 | <i>Tecoma stans</i> | Least Concern |
| 26 | <i>Geranium</i> | Categorisation Not Available | 63 | <i>Terminalia arjuna</i> | Categorisation Not Available |
| 27 | <i>Bauhinia purpurea</i> | Least Concern | 64 | <i>Acerifollium</i> | Categorisation Not Available |

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| Sl. No. | Scientific Name of the Tree | IUCN Categorisation | Sl. No. | Scientific Name of the Tree | IUCN Categorisation |
|---------|---------------------------------|------------------------------|---------|-------------------------------|------------------------------|
| 28 | <i>Jacaranda mimosifolia</i> | Vulnerable | 65 | <i>Cassia fistula</i> | Least Concern |
| 29 | <i>Carica papaya</i> | Data Deficient | 66 | <i>Maliama</i> | Categorisation Not Available |
| 30 | <i>Aegle marmelos</i> | Near threatened | 67 | <i>Pithecellobium dulce</i> | Least Concern |
| 31 | <i>Ficus racemosa</i> | Least Concern | 68 | <i>Psidium guajava</i> | Least Concern |
| 32 | <i>Artocarpus heterophyllus</i> | Categorisation Not Available | 69 | <i>Ulmus glabra huus</i> | Categorisation Not Available |
| 33 | <i>Leucaena leucocephala</i> | Categorisation Not Available | 70 | <i>Ailanthus excelsa</i> | Categorisation Not Available |
| 34 | <i>Tremma orientalis</i> | Categorisation Not Available | 71 | <i>Acacia auriculuous</i> | Categorisation Not Available |
| 35 | <i>Bambusa balcooa</i> | Categorisation Not Available | 72 | <i>Senegalia ferruginea</i> | Vulnerable |
| 36 | <i>Tabebuia rosea</i> | Least Concern | 73 | <i>Lagerstroemia speciosa</i> | Categorisation Not Available |
| 37 | <i>Magnoliophyta</i> | Categorisation Not Available | | | |

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5.9.3. Fauna

Faunal distribution along the proposed corridor alignment is limited to common species since being located well within the extensively developed areas of Bengaluru Urban limit. **Table 5.45** presents the list of fauna observed along the project region. Apart from this, common domestic animals such as cow, street dogs, cat, pigs, etc., are found along the project corridor.

Table 5.45. List of Fauna found in the Project Study Area

| Name of the Species | IUCN Category | Conservation Status as per Wildlife act 1972 |
|--|--|--|
| I. AMPHIBIA | | |
| 1. <i>Euphlyctis hexadactylus</i> (Indian Green Frog) | Least Concern | Nil |
| 2. <i>Rana tigrina</i> (Indian bullfrog) | Least Concern | Schedule-IV |
| 3. <i>Duttaphrynus melanostictus</i> (Black-spectacled Toad) | Least Concern | Nil |
| II. REPTILIA | | |
| 1. <i>Chameleon sp.</i> (Green Lizard) | This taxon has not yet been assessed for the IUCN Red List | Schedule-II |
| 2. <i>Calotes verticolour</i> (Garden Lizard) | This taxon has not yet been assessed for the IUCN Red List | Nil |
| 3. <i>Varanus sp</i> (Monitor lizard) | Least Concern | Schedule-II |
| 4. <i>Testudo elegans</i> (Tortoise) | Lower Risk/least concern | Schedule-IV |
| Sub Class : SNAKES | | |
| 1. <i>Naja naja</i> (Indian Cobra) | No Special Status | Schedule-II |
| 2. <i>Ptyas mucosa</i> (Rat Snake) | This taxon has not yet been assessed for the IUCN Red List | Schedule-II |
| III. BIRDS | | |
| 1. <i>Eudynamys scolopaceus</i> (Common Koel) | Least Concern | Schedule-IV |
| 2. <i>Passer domesticus</i> (House Sparrow) | Least Concern | Schedule-IV |
| 3. <i>Acridotheres tristis</i> (Common Mynah) | Least Concern | Schedule-IV |
| 4. <i>Spilopelia chinensis</i> (Spotted Dove) | Least Concern | Schedule-IV |
| 5. <i>Francolinus pondicerianus</i> (Grey Partridge) | Least Concern | Schedule-IV |
| 6. <i>Dinopium benghalense</i> (golden backed wood pecker) | Least Concern | Schedule-IV |
| 7. <i>Corvus splendens</i> (House Crow) | Least Concern | Schedule-V |
| 8. <i>Psittaciformes sp.</i> (Parrot) | Least Concern | Schedule-IV |
| 9. <i>Pavo cristatus</i> (Indian Peafowl) | Least Concern | Schedule-I |
| 10. <i>Merops orientalis</i> (Green Bee Eater) | Least Concern | Schedule-IV |
| 11. <i>Bubulcus ibis</i> (Cattle Egret) | Least Concern | Schedule-IV |
| 12. <i>Halcyon smyrnensis</i> (White-breasted Kingfisher) | Least Concern | Schedule-IV |
| 13. <i>Coracias benghalensis</i> (Indian roller) | Least Concern | Schedule-IV |
| IV. MAMMALIA | | |
| 1. <i>Suncus murinus</i> (House Shrew) | Least Concern | Schedule-V |
| 2. <i>Pteropus giganteus</i> (Indian Flying Fox) | Least Concern | Schedule-V |

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| Name of the Species | IUCN Category | Conservation Status as per Wildlife act 1972 |
|---|--|--|
| 3. <i>Funambulus palmarum</i> (Palm Squirrel) | Least Concern | Schedule-IV |
| Fishes | | |
| <i>Catla catla</i> (Catla) | Least Concern | Nil |
| <i>Oreochromis niloticus</i> (Tilapia) | Least Concern | Nil |
| <i>Labeo rohita</i> (Rohu) | Least Concern | Nil |
| Channa gachua (Snake head fishes) | Least Concern | Nil |
| <i>Poecilia reticulata</i> (Guppies) | Least Concern | Nil |
| <i>Aristichthys nobilis</i> (Bighead Crap) | Data Deficient | Nil |
| <i>Thinnichthys sandkhol</i> (Sandkhol Crap) | This taxon has not yet been assessed for the IUCN Red List | Nil |

Source: Field observations, Consultations with local people and forest department,
<http://envfor.nic.in/legis/wildlife/wildlife1.html> ; <http://www.iucnredlist.org/search>

Impact on local flora and fauna and its mitigation measures are listed in **Chapter 8**. Survey for recently design modified locations was conducted for any presence of faunal species. However, there are no new faunal species present along recently design modified locations.

5.9.4. Presence of Vulnerable, Threatened and/or Endangered Species of Flora and Fauna

As per the IUCN red list for Flora, there are few tree species ie., *Leucadendron argenteum*, *Saraca asoca*, *Jacaranda mimosifolia* and *Senegalia ferruginea* falls under vulnerable category and *Aegle marmelos* tree species falls under near threatened category.

However, there are no vulnerable, threatened or endangered species of fauna present along the project corridors.

5.9.5. Presence of Invasive Alien Species

The MoEFCC in cooperation with Botanical Survey of India, has identified the invasive alien species³ that displace native biota or threatens valued environmental, agricultural or personal resources by the damage it causes are considered invasive. As per the list prepared by MoEFCC, there are no invasive alien flora and fauna species present along the project corridors. Hence, the plants and animals found along the project corridors are common to the region as per MoEFCC and in IUCN list too.

5.10. Socio- Economic Environment

Bengaluru is the sixth largest city of India and one of the fastest growing cities of Asia. It has acquired the name of 'Silicon City', due to its progressive trend in Information technology. Now, after the IT boom, Bengaluru city has suddenly overgrown its size and the district administration is facing a challenging task for providing necessary infrastructures to the related economic activities, trade, commerce and housing facilities. Major revenue generating industries such as Aerospace, aviation, automobile, Biotechnology, IT industry, real estate and hospitality, agriculture, horticulture and dairy and all types of manufacturing industries are present in the district. According to the Oxford

³ http://www.bsienvvis.nic.in/database/invasive_alien_species_15896.aspx

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Economic's Annual Global Cities Report, Bengaluru city will see an annual GDP growth rate of about 8.5% between 2019- 2035. Bengaluru's per capita income is highest in the state for the year 2018-19.

5.10.1. Administrative Profile

In the year 1986, Bengaluru district was divided into Bengaluru Urban and Bengaluru rural districts.

Bengaluru Urban District: The district is located in the south-eastern part of Karnataka. The Bengaluru urban district is divided into five taluks namely: Bengaluru North (Bengaluru), Bengaluru South (Kengeri), Bengaluru East (Krishnaraja Pura), Bengaluru central and Anekal. The taluks are further divided into 17 hoblies, 668 villages, 9 municipal corporations.

Bengaluru Rural District: The district comprises of 4 taluks, 17 hoblis, 951 inhabited and 101 uninhabited villages. 2 towns and 98 Grama Panchayaths. Doddaballapura taluk is the largest taluk with an area of 778 sq.km and Devanahalli is the smallest taluk with an area of 431 sq.km.

5.10.2. Demography

Bengaluru Urban District: As per the 2011 census, total population of the Bengaluru urban district is 95,88,910 with population density of 4,378 persons per sq.km compared to 2,985 persons per sq.km in the year 2001. The sex ratio is 908 females among thousand males and the literacy rate of the district has increased from 83.91% on 2001 to 88.48 % in 2011.

Bengaluru Rural District: The population of Bengaluru rural district as per 2011 census was 9,87,257 persons comprising 5,07,486 males and 4,79,743 females. Urban population accounts for 18% of the population of the district, while the rural population accounts for the balance 82%. The population density in the district as 323 per sq.km.

5.10.3. Economic Profile

Bengaluru Urban District: The GDDP, NDDP, Per Capita income of the district for 2012-13 at constant prices (2004-05) was ₹ 99,325.10 crore, ₹ 85567.26 Cr and ₹ 20240 respectively. The GDDP constituted 33% of the State's GDP. The share of Service Sector (Tertiary) showed an increase of 4% over previous year constituting 69% to the GDDP at ₹ 68329.64 crore followed by manufacturing sector contributing 32% at ₹ 30,012.17 crore while the share of Agriculture and allied activities shrunk further to 1% at ₹ 983.29 crore.

Aerospace, aviation, automobile, IT, Biotechnology and all types of manufacturing activities are predominant in the district. The service space is dominated by IT industry, Real Estate and Hospitality. Major activities under Agriculture are horticulture and Dairy. Major crops in the district are Paddy and Ragi followed by maize, cereals and groundnuts. Apart from IT and Biotechnology sector and their ancillary industries the district is largely moving into protected cultivation for vegetables and cut flowers.

Bengaluru Rural District: The total Gross District Domestic Product (GDDP) of the Bengaluru Rural district estimated during the year 2012-13 is ₹ 77,726. In the year 2012-13, the per capita annual income of the district was ₹ 1,09,380. Small scale industrial activities, agriculture and horticulture activities are the major source of income for the district.

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5.10.4. Agriculture

Bengaluru Urban District: Bengaluru has 14.09% of its land for cultivation. Amongst this, cereals and pulses occupy 66.36% and 9.94% of the land respectively. Bengaluru is best known for ragi, especially in Anekal Taluk which is called 'Ragi Bowl' in the State. Bengaluru Urban is recognized as Class A destination for floriculture projects. Major crops grown are paddy, ragi, maize, horse gram and oilseeds along with horticultural crops like banana, grapes, papaya, mango sapota, pomegranate and plantation crops like coconut and rose. The district also has 649 milk co-operatives that annually produce 119 Million liters of milk, 34.7 million Eggs, and 5,880 tonnes of meat.

Bengaluru Rural District: The main crops grown in the district are Paddy, jowar, Bajara, Maize, Wheat pulses oilseeds like groundnut, sunflower vegetables fruits and cash crop like sugarcane and others. Field crops are cultivated over 50,000 ha of agricultural land and the major crops are finger millet, maize, redgram, fieldbean, bengalgram, horsegram, groundnut and sunflower. Fruits like grapes, mango, banana, etc. are cultivated in over 10,000 ha. Commercial cultivation of vegetables like tomato, potato, cabbage, chilli, brinjal, Green leafy vegetables is practiced in 6,500 ha. Dairy, backyard poultry and fisheries are generating additional income to the farmers. The district's soil and climatic conditions are congenial for the cultivation of mulberry, rearing of silkworms, and production of silk, besides other agro-based industries. There are a number of wineries and quantity of production of wine has been increasing.

5.10.5. Archaeological and Historical Monuments

There are four Archaeological Survey of India notified Archaeological monuments present in project study area. They are 1) Tippu Sulthan's Summer Palace, Bengaluru, 2) Old Dungeon Fort & Gates, Bengaluru, 3) Fort, Devanahalli and 4) Tippu Sulthan's Birth Place. Out of which Tippu Sulthan's Birth place (13°14'57.35"N & 77°42'34.88"E) (aerial distance - 271m) and Fort in Devanahalli (13°14'46.49"N & 77°42'25.90"E) (aerial distance -228m) are falling within Regulated zone i.e., 300 m from the proposed alignment of Corridor 1 - KSR Bengaluru City to Devanahalli. Photographs of ASI protected monument near Devenahalli Station is presented as **Figure 5.26**. Map showing the ASI protected monument in the project study area is presented as **Figure 5.27**. Google image showing Corridor 1 with ASI protected monuments in **Figure 5.28**.



Fort, Devanahalli



Tippu's Birth Place

Figure 5.26. Photographs of ASI Protect Monuments at Devanahalli near Corridor 1 - KSR Bengaluru City to Devanahalli

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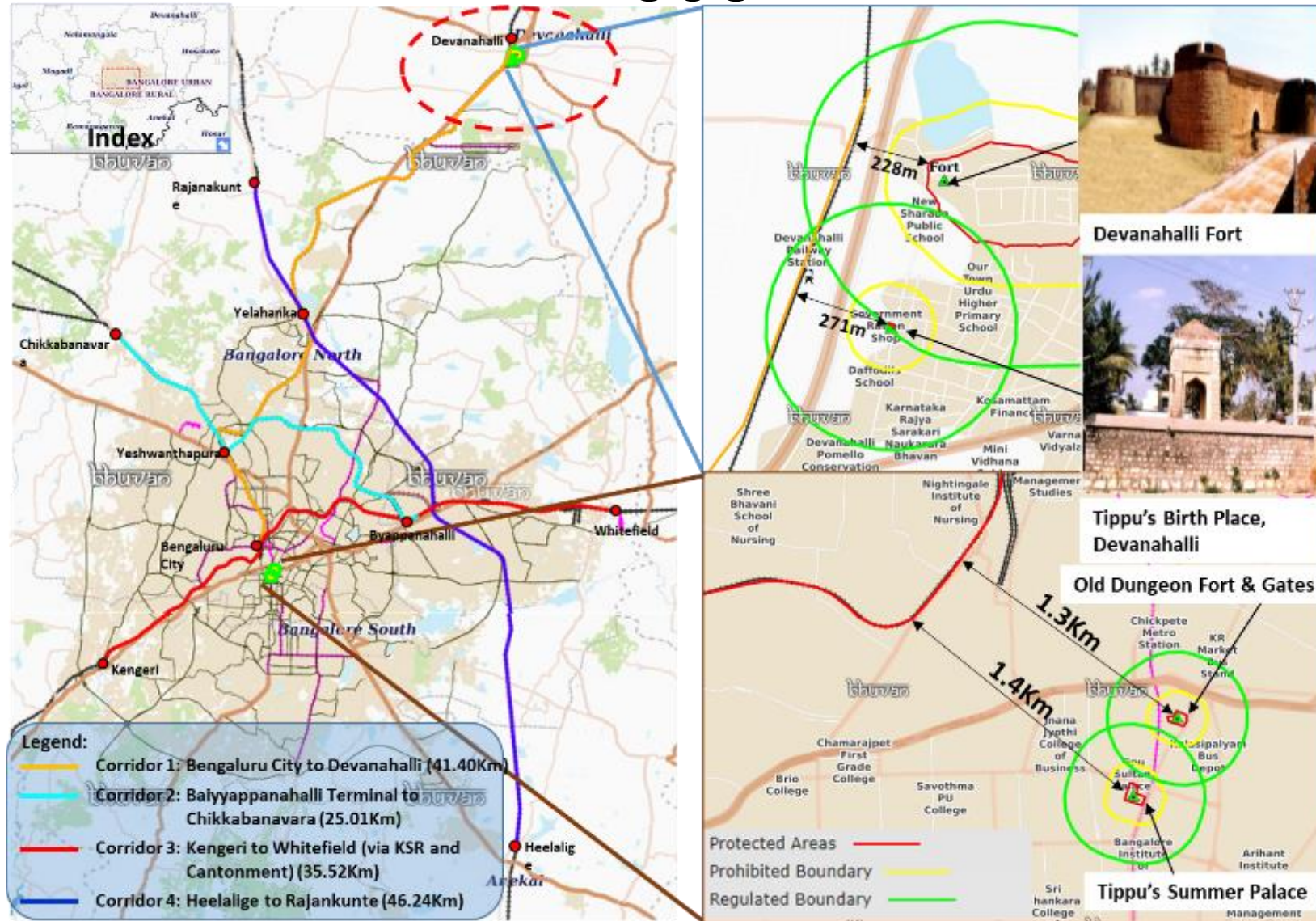


Figure 5.27. Map Showing the Archaeologically Protected Monument by ASI Present along the BSRP Corridors

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Figure 5.28. Google Imagery Showing Land Use around Archaeologically Monuments Protected by ASI Present along the BSRP Corridors

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5.10.6. Environmental & Social Sensitive Features Present along the Project Corridors

Inventories for environmental sensitive features are collected by conducting walk-through survey along the proposed BSRP corridors including stations, Depots and major intersection with roads and other railway alignments. There are 43 environmental sensitive features were listed out and inventories were conducted to record these features along the project corridors. Re-survey for recently design modified locations was conducted. However, there are no environmental features present along recently design modified locations. **Table 5.46** shows the survey outcome of design modification locations. List of environmental features to identify along the project corridors are presented in **Annexure 5.2**. Survey was conducted within direct impact zone i.e., 30m on either side from existing Row as delineated in Section 3.2.2 of Chapter 3. Details of Cultural Resources and Sensitive receptors present along the BSRP corridors are presented in **Table 5.47**;

Table 5.46. Survey outcome of Design Modification Locations of BSRP Corridors

| Corridor no. | Stations | Updates | Remarks |
|--------------|-----------------------------|---|--|
| Corridor 1 | KSR Bengaluru Station | Change in location of Station to Railway Station Road | No Envi. & Social features present. About 56 trees affected. |
| | Srirampura Station | Conversion of Future Station to Present Station | No Envi. & Social features present. No trees affected. |
| | Yesvantpur Station | Change in level and location of the station (to front side of existing station) | No Envi. & Social features present. About 50 trees affected. |
| | Yelahanka Station | Sharing of station with Corridor 4 at Level-1 & Corridor 1 at Level-2 | No Envi. & Social features present. No trees affected. |
| | Nitte Meenakshi & Doddajala | Change in location of station towards KSR Bengaluru City | No Envi. & Social features present. No trees affected. |
| | Airport KIADB | Conversion of present station to future Station | No Envi. & Social features present. About 12 trees affected. |
| | New Future Station | Inclusion of a future station between Airport KIADB and Devanahalli Stations | No Envi. & Social features present. About 33 trees affected. |
| Corridor 2 | Hebbal Station | Change in the location shifted towards Banaswadi side after Hebbal Flyover | No Envi. & Social features present. About 14 trees affected. |
| | Lottegollanahalli Station | Change in location shifted towards Mathikere Junction | No Envi. & Social features present. About 3 trees affected. |
| | Soladevanahalli Depot | Extension of alignment till Soladevanahalli Depot | No Envi. & Social features present. About 55 (33 alignment + 22 Depot) trees affected. |
| Corridor 4 | Yelahanka Station | Sharing of station with Corridor 4 at Level-1 & Corridor 1 at Level-2 | No Envi. & Social features present. No trees affected. |
| | New future station | Inclusion of a future station between Marathahalli and Doddanekundi Stations | No Envi. & Social features present. About 7 trees affected. |

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5.10.6.1. Cultural Resources

There are considerable amount of cultural and religious structures present along the BSRP corridors. Structures like Temples, Tree shrines, Shrines, Mosques, Darghas, Churches, Grave Yards etc., were recorded. There are no archaeologically protected monuments present along the BSRP corridors except Corridor 1, where Devanahalli Fort and Tippu Sulthan's Birth Place monuments are present within Regulated Area i.e., 300 m from the Rail alignment and Devanahalli Railway Station as mentioned in Section 5.1.6.2. Re-survey for recently design modified locations was conducted. However, there are no cultural resources present along recently design modified locations. Details of cultural resources found along the BSRP is presented in **Table 5.47** and the details of the same with photographs is incorporated **Annexure 5.5**. Photographs of cultural resources found along the BSRP is presented in **Figure 5.29**.

Table 5.47. Details of Cultural Resources found along the BSRP Corridors

| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | Remarks |
|--|---------------------------------|---|-------------------------------------|---------------------------|----------------------------|------------------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | |
| Corridor 1: KSR Bengaluru City to Devanahalli | | | | | | |
| LHS | | | | | | |
| 1 | 0/100 | Shree Ram Mandir, Sevashram. | - | 80 | 2 | No Compound Wall |
| 2 | 0/180 | Ganapathi Temple, Sevashram. | 10 | 50 | 8 | - |
| 3 | 1/750 | Veeranjaneya Temple Sevashram. | - | 15 | 6 | No Compound Wall |
| 4 | 1/850 | Ganapathi Temple, Shrirampura. | - | 10 | 8 | No Compound Wall |
| 5 | 3/200 | Tree Shrine | - | - | - | No Compound Wall |
| 6 | 3/200 | Shree Varasiddivinayaka Temple, Malleshwaram. | - | 5 | 6 | No Compound Wall |
| 7 | 3/200 | Shree Veeranjaneyaswamy Temple, Malleshwaram. | - | 5 | 5 | No Compound Wall |
| 8 | 3/220 | Tree Shrine, Malleshwaram | - | 5 | 2 | No Compound Wall |
| 9 | 3/550 | Shakthi Mariamma Temple, Malleshwaram. | 10 | 5 | 3 | - |
| 10 | 3/600 | Shree Bhaktanjaneyaswamy Temple, Kirloskar Road, Milk Colony, | - | 3 | 5 | No Compound Wall |
| 11 | 3/660 | Tree shrine | - | 7 | - | Along with 5m |
| 12 | 3/700 | Tree shrine | - | 7 | - | No Compound Wall |
| 13 | 9/450 | Shani Mahatma Temple, Poornappa Garden, Mathikere. | - | 5 | 4 | No Compound Wall |
| 14 | Dec-30 | Shree Muneshwara Temple | - | 30 | 1 | No Compound Wall |
| 15 | 23/50 | Burial Ground, Devanahalli | - | 30 | - | - |

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| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | |
|--|---------------------------------|---|-------------------------------------|---------------------------|----------------------------|------------------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | Remarks |
| RHS | | | | | | |
| 1 | 0/800 | Temple | 30 | 30 | 4 | - |
| 2 | 2/700 | Shree Varadanjaneya Temple, Malleshwaram. | - | 30 | 8 | - |
| 3 | 3/430 | Shree Shakhi Temple, Malleshwaram. | - | 10 | 11 | No Compound Wall |
| 4 | 3/750 | San Claret Publications, Church | 10 | 20 | 18 | - |
| 5 | 8/650 | Shree Shree Shree Shanthamoorthi Shanideva Temple, Bandappa Garden. | 20 | 20 | 6 | - |
| 6 | 9/600 | Sri Devi Karumariyamman Temple, R M V 2nd Stage, Lottegollahalli. | - | 25 | 5 | - |
| 7 | 11/300 | Temple, Lottegollahalli. | 20 | 20 | 8 | - |
| 8 | 5/00 | Shree Anjaneyaswamy Temple | - | 30 | 6 | No Compound Wall |
| 9 | 9/210 | Tree shrine | - | 10 | 3 | No Compound Wall |
| 10 | 11/390 | Temple, Chikkajalla | - | 15 | 6 | No Compound Wall |
| 11 | 12/350 | Shree Anjaneyaswamy Temple, Doddajala. | - | 50 | 2 | No Compound Wall |
| 12 | 12/680 | Temple, Doddajala. | 15 | 15 | 5 | - |
| 13 | 17/050 | Anjaneya Temple | 15 | 40 | 5 | - |
| Corridor 2: Baiyyappanahalli Terminal to Chikkabanavara | | | | | | |
| LHS | | | | | | |
| 1 | 208/400 | APM Church Maruthi Seva Nagar. | 7 | 10 | 18 | - |
| 2 | 208/950 | Sri Vinayaka Swamy Temple, Maruthi Seva Nagar. | - | 12 | 4 | No Compound Wall |
| 3 | 209/150 | Paniel Assembly of God Church, Maruthi Seva Nagar. | 10 | 11 | 18 | - |
| 4 | 211/230 | Temple, Kadugondanahalli. | 15 | 15 | 8 | - |
| 5 | 212/350 | Temple | - | 20 | 5 | No Compound Wall |
| 6 | 213/920 | Temple | 15 | 20 | 7 | - |
| 7 | 215/870 | Tree shrine | - | 15 | - | No Compound Wall |
| 8 | 216/200 | Yallamma Temple, Hebbal. | 20 | 23 | 8 | - |
| 9 | 216/700 | Sri Pillekamma Temple, Hebbal. | - | 20 | 8 | No Compound Wall |
| 10 | 217/780 | Tree shrine temple | - | 10 | - | No Compound Wall |
| 11 | 218/830 | Shree Nagasubramanya Swamy Temple. | - | 15 | - | No Compound Wall |

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| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | |
|------------|---------------------------------|---|-------------------------------------|---------------------------|----------------------------|------------------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | Remarks |
| 12 | 220/400 | Sri Karumariamman Temple, Yeshwanthpur. | 8 | 8 | 30 | - |
| 13 | 15/120 | Ashwathkatte, 103, 1st main road, M R J Colony, Mathikere, Bengaluru, Karnataka | - | - | - | Realignment |
| 14 | 15/300 | Trinity Assembly of god Church, 1st main road, Gokula Extension, Mathikere. | - | - | 4 | Realignment |
| 15 | 20/300 | Temple, Kemmagondanahalli. | 7 | 10 | 3 | - |
| 16 | 20/730 | Muneshwara Temple, Kemmagondanahalli. | - | 7 | 5 | No Compound Wall |
| 17 | 22/970 | Anjaneya Temple, Shettihalli Road, Chikkabanavar. | 40 | 45 | 10 | - |
| RHS | | | | | | |
| 1 | 204/850 | Jesus Grace Church, Doorvani Nagar. | 34 | 34 | 14 | - |
| 2 | 205/170 | Muneshwara Temple, Koli Chikkanna Colony. | - | 30 | 2 | No Compound wall |
| 3 | 205/860 | Maha Ganapathi Temple, Dooravani Nagar. | - | 45 | 4 | - |
| 4 | 207/750 | Full Gospel Bethesda AG Church, Kanaka Nagar, Hebbal. | 20 | 21 | 6 | - |
| 5 | 208/820 | Shree Muneshwaraswamy Temple, Maruthi Seva Nagar. | - | 13 | 3 | No Compound wall |
| 6 | 208/690 | Shree Kateramma Temple, Maruthi Seva Nagar. | - | 5 | 4 | No Compound wall |
| 7 | 208/950 | Temple | - | 20 | 3 | No Compound wall |
| 8 | 211/080 | Temple | - | 50 | 4 | No Compound wall |
| 9 | 212/780 | Hosanna mandir, (Nagawara), Kadugondanahalli Railway Gate. | 60 | 60 | 9 | - |
| 10 | 213/750 | Jauhar Shifa Khana, Clinic in Byrappa Layout, R M V 2nd Stage. | - | 35 | 8 | No Compound wall |
| 11 | 213/800 | Sunni Masjid -e -Garib Nawaz, mosque, M R Garden, Govindapura, Hebbal. | - | 32 | 8 | No Compound wall |
| 12 | 213/850 | Indian Evenjaelical Church, Govindapura Main Road, Byrappa Layout, Nagavara. | 20 | 21 | 8 | - |

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| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | |
|---|---------------------------------|---|-------------------------------------|---------------------------|----------------------------|------------------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | Remarks |
| 13 | 214/460 | Shree Muneshwaraswamy Temple, Nagavara. | - | 21 | 2 | No Compound wall |
| Corridor 3: Kengeri to Whitefield (via KSR and Cantonment) | | | | | | |
| LHS | | | | | | |
| 1 | 9/020 | Shree Abhaya Anjaneyaswamy, Mysore Road. Temple, | 7 | 25 | 20 | - |
| 2 | 9/010 | Mutturayaswamy Temple, Mutturaya Nagar. | - | 5 | 8 | No Compound Wall |
| 3 | 9/000 | Tree shrine Mutturaya Nagar. | - | 10 | - | No Compound Wall |
| 4 | 8/100 | Tree shrine, Mallathahalli | - | 14 | - | No Compound Wall |
| 5 | 7/250 | Gangamma Temple | - | 15 | 5 | No Compound Wall |
| 6 | 7/250 | Muneshwara Temple | - | 15 | 15 | No Compound Wall |
| 7 | 6/940 | Prasanna Gangadhareshwara Temple, Nayandahalli | 14 | 15 | 15 | - |
| 8 | 4/680 | Shiva Temple, Hampinagar. | - | 15 | 7 | No Compound Wall |
| 9 | 4/580 | Shree Siddhi Vinayaka Temple, Hampinagar. | - | 10 | 10 | No Compound Wall |
| 10 | 4/440 | Venkateswara Temple | - | 11 | 15 | Along with 110m |
| 11 | 2/735 | Maramma Temple, Binnipete, Kempapura. | 10 | 10 | 8 | - |
| 12 | 2/450 | Kadpa Swamy Temple, Binnipete, Kempapura, Agrahara. | - | 12 | 8 | No Compound Wall |
| 13 | 1/795 | Shree Poonavardham Temple, Cottonpet. | 8 | 11 | 7 | Along with 50m |
| 14 | 1/670 | Nagaveni Temple, Nagamma Nagar, Cottonpet. | 7 | 7 | 15 | - |
| 15 | 1/888 | Church, Cottonpet. | 10 | 10 | 8 | - |
| 16 | 1/520 | Muneshwara Temple, Nagamma Nagar, Cottonpet. | 10 | 14 | 10 | - |
| 17 | 1/00 | Nagasubramanya Swamy Temple, Binnipete. | 5 | 5 | 8 | Along with 50m |
| 18 | 353/930 | Vinayakaswamy Temple | 10 | 15 | 15 | - |
| 19 | 353/240 | Church | 10 | 15 | 35 | - |
| 20 | 353/980 | Sadhasiva Ashram | 10 | 10 | 30 | - |
| 21 | 349/600 | Sri Lakshmi Venkateshwaraswamy Temple. | 25 | 40 | 6 | - |
| 22 | 344/400 | St Anthony Church, Bharathi Nagar. | - | 15 | 1 | No Compound Wall |

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| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | |
|------------|---------------------------------|--|-------------------------------------|---------------------------|----------------------------|------------------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | Remarks |
| 23 | 347/500 | Shree Vinayaka Temple | 15 | 20 | 15 | Along with 150m |
| 24 | 347/180 | Saraswathi Temple, KHB Colony. | 19 | 25 | 7 | - |
| 25 | 339/400 | Eid gah e Jahangheer Trust, Masjid, Haledevasandra, Krishnarajapuram. | 10 | 35 | 20 | Along with 500m |
| 26 | 388/830 | Temple | 20 | 25 | 10 | - |
| 27 | 377/400 | Sappamma Temple, Saketha Nagar,Hoodi. | 5 | 15 | 4 | No Compound Wall |
| RHS | | | | | | |
| 1 | 8/700 | Temple | - | 11 | 3 | No Compound Wall |
| 2 | 6/970 | Temple | 10 | 14 | 4 | - |
| 3 | 5/900 | Masjid E Salmania, Mosque, Roshan Nagar. | - | 12 | 30 | No Compound Wall |
| 4 | 5/450 | Ganapathi Temple, Deepanjali Nagar. | - | 15 | 5 | No Compound Wall |
| 5 | 4/500 | Vidyaganapathi Temple | - | 10 | - | No Compound Wall |
| 6 | 3/450 | Shree Muneshwara Temple, Hosahalli Main Road, Padarayanapura. | 10 | 12 | - | - |
| 7 | 2/930 | Masjid-E-Mustafa, Mosque, Padarayanapura. | 10 | 12 | - | - |
| 8 | 2/250 | Shree Swayambhu Nagaraja, Balasubramanyaswamy, Temple, Padarayanapura. | - | 14 | - | No Compound Wall |
| 9 | 2/500 | Shree Chowdeshwari Temple | - | 10 | - | No Compound Wall |
| 10 | 1/980 | Hanuman Temple Jagajeevanram Nagar. | - | 10 | - | No Compound Wall |
| 11 | 1/850 | Holy Gospel Prayer Church, Kempapura Agrahara. | 10 | 12 | 20 | - |
| 12 | 1/500 | Nagamma Temple | - | 18 | 5 | No Compound Wall |
| 13 | 354/560 | Shri Vasupujyaswami Shwetamber Jain Temple, Madhava Nagar, Gandhi Nagar. | 8 | 12 | 10 | - |
| 14 | 353/800 | Nagamma Temple, Kumarkrupa East. | 10 | 12 | - | - |
| 15 | 352/330 | Veeranjaneya Swamy Temple | 10 | 10 | - | - |
| 16 | 352/210 | Shiva Temple | 8 | 10 | - | - |
| 17 | 351/850 | Durgadevi Temple | 15 | 15 | - | - |

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| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | |
|---|---------------------------------|---|-------------------------------------|---------------------------|----------------------------|------------------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | Remarks |
| 18 | 349/970 | Benguluru Telugu Church, Pulikeshi Nagar. | 20 | 20 | - | - |
| 19 | 349/610 | St, Anthony Church, Pulikeshi Nagar. | 10 | 10 | - | - |
| 20 | 349/580 | Ganesha Temple, Pulikeshi Nagar | 10 | 10 | - | - |
| 21 | 348/280 | Temple, Pulikeshi Nagar. | 10 | 10 | - | - |
| 22 | 347/680 | Ganapathi Temple | 8 | 10 | - | - |
| 23 | 346/900 | Church | 10 | 15 | 20 | - |
| 24 | 346/510 | Kuru Mariyamma Temple | - | 12 | 10 | No Compound Wall |
| 25 | 346/400 | Church | 10 | 13 | 15 | - |
| 26 | 342/900 | Shree Ramalaya Temple | 10 | 10 | 10 | - |
| 27 | 339/000 | Shree Shaneshwara Temple | 20 | 25 | 10 | - |
| 28 | 338/860 | Temple | 15 | 20 | 5 | - |
| 29 | 337/650 | Om Shakthi Temple | 10 | 15 | 8 | - |
| 30 | 337/650 | Shiva shakthi , Hoodi. | 10 | 14 | 20 | - |
| Corridor 4: Heelalige to Rajanukunte | | | | | | |
| LHS | | | | | | |
| 1 | 193+450 | Masjid | 10 | 13 | 15 | |
| 2 | 6+610 | Ganesha Temple | - | - | - | No Compound wall |
| 3 | 6+700 | New Jerusalem Church | 30 | 32 | 5 | |
| 54 | 18+100 | Masjid | 10 | 11 | 10 | |
| RHS | | | | | | |
| 1 | 203+050 | Shree narayana matrudevi ayyappa Devasthanam Kaggadasapura. | 30 | 30 | 5 | - |
| 2 | 5+50 | Grace Methodist Church, Horamavu. | 15 | 15 | 9 | - |
| 3 | 8+200 | Church | | 60 | 3 | No Compound Wall |
| 4 | 15+580 | Shree Sankatahara Ganapathi Temple | | 25 | 10 | No Compound Wall |
| 5 | 15+750 | Temple | | 15 | 6 | No Compound Wall |
| 6 | 21+700 | Temple | | 15 | - | No Compound Wall |
| 7 | 23+950 | Temple | - | 10 | - | No Compound Wall |
| 8 | 25+330 | Temple | - | 32 | - | No Compound Wall |

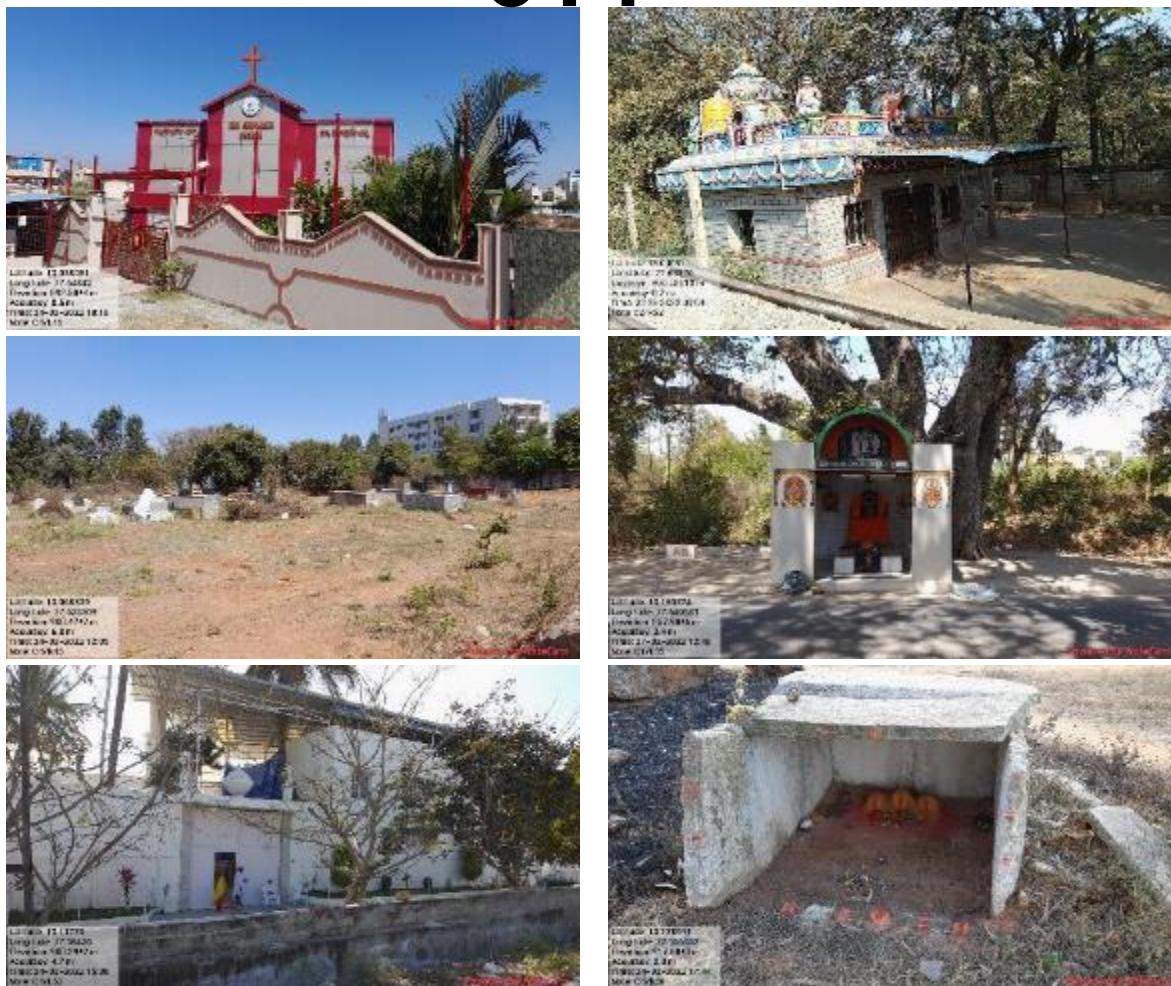


Figure 5.29. Photographs of Cultural Resources Present along BSRP Corridors

5.10.6.2. Sensitive Receptors

Sensitive receptors includes educational institutes, hospitals, Clinics, etc. All these features are socially very sensitive and needs critical care in preserving them during implementation of Suburban rail project. There are no environmental sensitive features present in proposed Akkupete and Soladevanahalli Depots. Survey for recently design modified locations was conducted for any presence of environmental features. However, there are no new sensitive features present along recently design modified locations.

Summary of sensitive receptors found along the BSRP is presented in **Table 5.48** and the details of the same with photographs is incorporated **Appendix 5.4**. Photographs showing sensitive receptors present along the project corridors are presented in **Figure 5.29**.

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Table 5.48. Details of Environmental Sensitive Receptors Present along the BSRP Corridors

| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | Remarks |
|--|---------------------------------|---|-------------------------------------|---------------------------|----------------------------|------------------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | |
| Corridor 1: KSR Bengaluru City to Devanahalli | | | | | | |
| LHS | | | | | | |
| 1 | 9/900 | BEL Academy, Sundarnagar, Gokula Extention Mathikere. | 15 | 25 | 15 | - |
| RHS | | | | | | |
| 1 | 2/100 | New Clinton Public High School, Srirampura. | 35 | 38 | 18 | - |
| 2 | 2/770 | Manipal Hospital, Malleshwaram. | 45 | 47 | 18 | - |
| 3 | 3/200 | Cluny Convent High School Malleshwaram | 10 | 30 | 18 | - |
| 4 | 10/900 | Bishop Sergeant Central School, Lottegollahalli. | 10 | 10 | 12 | - |
| 5 | 3/100 | Nitte Global Institute, Yelahanka. | 25 | 50 | 25 | Along with 700m |
| 6 | 3/150 | Hostel, Nitte Global Institute, Yelahanka. | 30 | 50 | 20 | - |
| 7 | 10/00 | Sri Revana Siddeswara Institute of Technology, Chokkanahalli, Chikkajala. | 20 | 35 | 18 | - |
| Corridor 2: Baiyyappanahalli Terminal to Chikkabanavara | | | | | | |
| LHS | | | | | | |
| 1 | 205/360 | Government Higher Primary School, Benniganahalli. | 30 | 32 | 14 | - |
| 2 | 205/780 | Little Angels Modern High School, NGEF Layout, Sadananda Nagar, Benniganahalli. | 32 | 34 | 14 | - |
| 3 | 210/210 | School, Lingarajapuram. | - | 15 | 10 | No Compound Wall |
| 4 | 210/600 | Eunice English Medium High School, Thomas Town, Lingarajapuram, Bengaluru. | 15 | 20 | 20 | - |
| 5 | 210/650 | Manahil English High School, Kadugondanahalli. | 5 | 8 | 18 | - |

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| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | Remarks |
|------------|---------------------------------|---|-------------------------------------|---------------------------|----------------------------|------------------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | |
| 6 | 213/250 | Beacon English High School, 1st main Road, Shampura, Kaval Bairasandra. | 15 | 18 | 18 | - |
| 7 | 213/640 | School, Kaval Bairasandra. | 30 | 34 | 23 | - |
| 8 | 214/380 | BIG Institute of Managerial | 15 | 20 | 22 | - |
| 9 | 215/50 | Government School | 20 | 22 | 9 | - |
| 10 | 216/900 | Hebbal Agriculture School | 15 | 18 | 12 | - |
| 11 | 218/830 | BBMP, Public Library | - | 15 | 4 | No Compound Wall |
| 12 | 220/410 | Anganawadi Kendra, Yeshwanthpur. | - | 8 | 30 | No Compound Wall |
| 13 | 15/550 | St. Antony primary School, Mathikere. | - | - | 18 | Realignment |
| 14 | 16/150 | P.R Public School, Mohankumar Nagar, Yeshwanthpur. | - | - | 16 | Realignment |
| 15 | 23/460 | Cecilia English Nursery & High School, Maruthi Seva Nagar. | 25 | 35 | 30 | - |
| RHS | | | | | | |
| 1 | 204/890 | New Pratham Public School, Mahadevapura. | 34 | 35 | 15 | - |
| 2 | 207/440 | Mother Mary English School, Chikkabanasawadi. | - | 30 | 14 | No Compound wall |
| 3 | 210/710 | Siddhartha PU College, 7th Cross Lingarajapura Hennur Main Road. | 60 | 70 | 6 | - |
| 4 | 214/680 | St Pauls Public School and Apartment, Arabic college Road, Jogappa Layout Nagavara. | 30 | 45 | 130 | - |
| 5 | 15/550 | Clinic | - | - | 15 | Realignment |
| 6 | 15/800 | Hospital | - | - | 20 | Realignment |
| 7 | 16/500 | Clinic | - | - | 14 | Realignment |
| 8 | 23/700 | R.R Institute college | 5 | 35 | 24 | - |
| 9 | 23/900 | National Public School, Chikkabanavara. | 10 | 15 | 27 | - |

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| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | Remarks |
|---|---------------------------------|---|-------------------------------------|---------------------------|----------------------------|------------------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | |
| Corridor 3: Kengeri to Whitefield (via KSR and Cantonment) | | | | | | |
| LHS | | | | | | |
| 1 | 11/950 | Dr.Suhasini Hospital, Kengeri Satellite Town. | - | 18 | 30 | No Compound Wall |
| 2 | 11/470 | National Public School, Kengeri Satellite Town. | 20 | 24 | 35 | - |
| 3 | 9/320 | Indian Statistical Institute, Mysore Road, RVCE Post. | 10 | 20 | - | - |
| 4 | 8/150 | Sports Authority of India, Opposite Bengaluru University Hostel, Mallathahalli. | 5 | 15 | 15 | - |
| 5 | 5/150 | Ananya Hospital | 15 | 16 | 25 | - |
| 6 | 4/950 | Dhanvantari Clinic, Railway Parallel Road, Vijayanagar. | - | 15 | 20 | No Compound Wall |
| 7 | 4/925 | St. Michaels, High School, Hampinagar. | - | 15 | 22 | |
| 8 | 2/130 | Roses Convent School, Binnipete, Kempapura. | 10 | 14 | 20 | - |
| 9 | 353/890 | Star Health Allied | 10 | 13 | 30 | Along with 50m |
| 10 | 353/680 | Eye Hospital and Squite Centre. | 14 | 15 | 12 | - |
| 11 | 377/340 | Chaithanya Clinic, Saketha Nagar, Hoodi. | 10 | 10 | 8 | No Compound Wall |
| 12 | 336/350 | Shree Balaji Medical Clinic, Kadugodi. | 10 | 10 | 10 | No Compound Wall |
| RHS | | | | | | |
| 1 | 10/500 | BIMS, Boys Hostel, Kengeri Satellite Town. | 15 | 17 | 40 | - |
| 2 | 10/400 | Orchids School, Mysore Road, Kengeri satellite Town. | 10 | 15 | 30 | 3 |
| 3 | 10/300 | Benguluru Institute of Management, Mysore Road, Kengeri Satellite Town. | 10 | 15 | 10 | - |
| 4 | 8/150 | College | 12 | 15 | 15 | - |

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| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | Remarks |
|---|---------------------------------|---|-------------------------------------|---------------------------|----------------------------|------------------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | |
| 5 | 6/830 | Piles and Fistula Clinic | - | 15 | 9 | No Compound Wall |
| 6 | 5/900 | Madarasa Women's Arabic School, Roshan Nagar. | - | 10 | - | No Compound Wall |
| 7 | 5/860 | Government Urdu Primary School, Roshan Nagar. | 10 | 11 | 10 | - |
| 8 | 354/700 | Karnataka Chitrakala Parishath, Kumarkrupa East. | 10 | 20 | 30 | - |
| 9 | 349/570 | City Multi Speciality and Trauma Centre, Hospital, Pulikeshi Nagar. | 15 | 16 | 20 | - |
| 10 | 348/540 | Government Primary School, Pulikeshi Nagar | 12 | 14 | 25 | - |
| 11 | 339/250 | The Brigade School, Mahadevapura. | 15 | 25 | 20 | - |
| Corridor 4: Heelalige to Rajanukunte | | | | | | |
| LHS | | | | | | |
| 1 | 180/600 | Athreya Hospital Anekal main Road, Suryanagar phase 1. | 40 | 45 | 30 | - |
| 2 | 181/290 | Green dot Montessori School, Chandapura. | - | 60 | 10 | No Compound wall |
| 3 | 182/800 | Banglore college of Engineering, Heelalige, Bommasandra. | 40 | 50 | 15 | |
| 4 | 184/100 | School | 20 | 25 | 10 | |
| 5 | 203/050 | Dental Hospital | 20 | 22 | 15 | |
| 6 | 23/100 | Sai Speciality Center,Hospital East of NGEF Layout, Kasturi Nagar. | - | 10 | 15 | No Compound wall |
| 7 | 15/650 | Dental Health Center | - | 10 | 5 | No Compound wall |
| RHS | | | | | | |
| 1 | 191/050 | College | 25 | 30 | 4 | - |
| 2 | 197/790 | Smile Dental Care,Munnekollal, Marathahalli. | | 20 | 14 | No Compound Wall |

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| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | Remarks |
|---------|---------------------------------|--|-------------------------------------|---------------------------|----------------------------|---------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | |
| 3 | 198/580 | Lions Airportcity Hospital, Munnekollal, Marathahalli. | 22 | 30 | 10 | - |
| 4 | 199/290 | Kids Mansion School, Chinnappanahalli. | 15 | 18 | 9 | - |
| 5 | 202/400 | Geethanjali Vidyalaya & Montress, Kaggadapura. | 40 | 50 | 18 | - |



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Figure 5.30. Photographs of Sensitive Receptors Present along BSRP Corridors

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Chapter 6. Public Consultation and Stakeholder Engagement

Stakeholders are those who have a direct interest in project development and whose participation needs to be ensured in consultations at various stages. Stakeholders include project affected people, project beneficiaries, elected representatives of legislative assembly, parliament and local self-government bodies and officials of various Government departments.

To ensure that stakeholder concerns are incorporated in the project design and to promote public understanding about the project and its implications, public consultation and information dissemination is treated as a two way process where the information is passed on to public and their feedback is sought to understand their issues. The consultative process is continued throughout the project period – design preparation, implementation and post implementation periods. The preparatory stage consultation helps to explore alternative design options, to avoid very adverse social and environmental impacts and to reduce the magnitude of the impacts of the project by suggesting suitable measures, to identify the environmental hotspots for further enhancement, while consultations during implementation stage helps to facilitate a smooth resettlement of the PAFs thereby enabling speedy implementation of the project.

As part of the project preparation, screening stage Public consultation and stakeholder engagement was conducted along the BSRP corridors to gather the information on environmentally sensitive sites which needs to be taken care during designing of the rail alignment and issues identified as the regulatory requirements of the GoI, GoK and World Bank's ESS. Further, more consultation and stakeholder engagement program has been designed through various project cycle which is detailed in **Annexure 6.4.**

6.1. Types / Categories of Stakeholder Consultation

For consultation and participation, primary and secondary stakeholders will be identified. Major stakeholders to be consulted are as follows.

- All Project Affected Persons (PAPs) and Beneficiaries of the Project, including representatives of project users;
- Elected representatives, Community leaders of PAPs, representatives of CBOs;
- Representatives of local NGOs
- Officials of Government Departments related to Environment and Climate Change

6.2. Methodology Adopted for Stakeholder Consultation

The overall goal of the consultation programme is to disseminate project information and to incorporate PAPs views in the Suburban Railway proposal and social and environmental risks & impacts. The specific objectives of the consultations are to:

- Improve project design and lead to fewer conflicts and delays in implementation;
- Facilitate development of appropriate and acceptable entitlement options;
- Increase long-term project sustainability and ownership;

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- Reduce problems of institutional coordination;
- Address the environmental concerns of public in design interventions and enhance project benefits; and
- To make project environmental friendly and climate resilient.

6.2.1. Stages of Consultation and Information Dissemination

The consultation process formulated for the project employs a range of formal and informal consultative methods including in-depth interviews with key informants, focus group discussions, meetings, and public interactions. The consultation programmes are scheduled at for several stages of the project, which can be broadly classified as:

- Project preparation phase – Information gathered from field surveys/consultation on project to be incorporated in the design phase of the project.
- Project initiation phase – It is the site preparation stage where necessary consultation to obtain approvals/NOC/Clearance from various regulatory bodies, site preparation for Construction and labour camp and ensuring initiation of proper resettlement and rehabilitation of project affected parties is carried out.
- Project implementation phase – Consultation during construction stage with regulatory bodies & other stakeholders, public residing next to construction site and Labours engaged in work and project affected parties on implantation of resettlement and rehabilitation measures.
- Post implementation phase – Consultation with Public using Suburban Railway, community residing next to project and regulatory bodies and other stakeholders and feedback from project affected parties who are rehabilitated due to project.

Project Preparation Phase: The current phase is the project preparation phase where in the information gathered from field surveys are incorporated in the design phase of the project and preparation of Environmental Screening Report and Social Screening Report. At this stage following methodologies were used by the Consultants for public consultation and information dissemination.

- Public Interactions/Focus Group Discussions
- Institutional Level Stakeholder Consultation
- Public Consultation Meetings

Consultations with PAPs ensured that views of PAPs are fully incorporated in finalizing the rail route alignment and formulation of compensation and rehabilitation measures.

6.2.1.1. Public Interactions/Focus Group Discussions

Public interactions/Focus group discussions were conducted at representative settlements, near sensitive locations etc. in order to collect the opinions of public regarding the BSRP corridors. Represent of consultant described the objectives of the project to the public and documented their opinions, suggestions, objection in the prescribed forms. Public residing next to proposed railway alignment were interacted to understand the pollution levels for air and noise and any incidents of flooding in the region. Also any historical monuments present along the project corridors and

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suggestions sought for any environmental issues due to existing rail and its improvements in the regions. Lists of attendance sheet on public interacted is provided in **Annexure 6.1**. Summary of location wise public interactions/ FGDs and issues discussed for the BSRP corridors are presented in **Annexure 6.2**.

Public interactions/FGDs were conducted at 30 locations in Corridor 1, 46 Locations in Corridor 2, 20 locations in Corridor 3 and 39 locations in Corridor 4. Various categories of people from housewives to Auto drivers to govt. officers were interacted to understand the environmental condition of the region and to obtain the views/suggestions/opinion on the project for the betterment of environment. Also, FGD was conducted at proposed Soladevanhalli Depot to understand baseline conditions and environmental and social sensitivity of the depot site. In general, public present along the proposed Suburban Railway track were asked about the Air Quality, Noise level and water logging issues. Graphical representation showing Corridor wise opinion received on the pollution levels in the region is presented in **Figure 6.1 to Figure 6.4**.

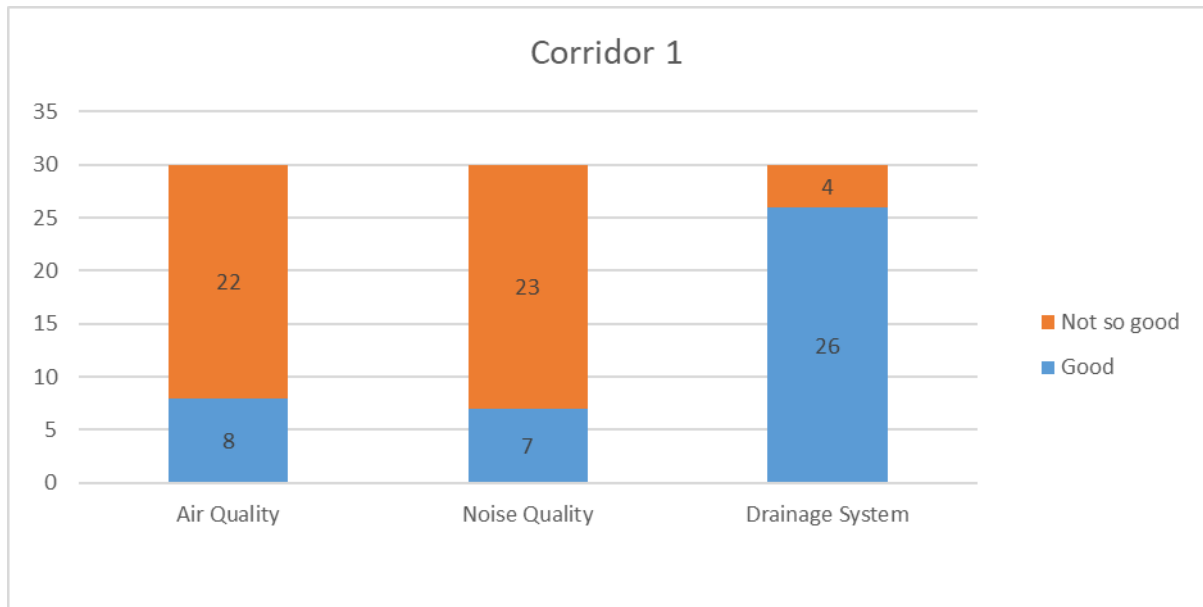


Figure 6.1. Graphical chart showing Public Opinion on Pollution Level in Corridor 1 - KSR Bengaluru City to Devanahalli

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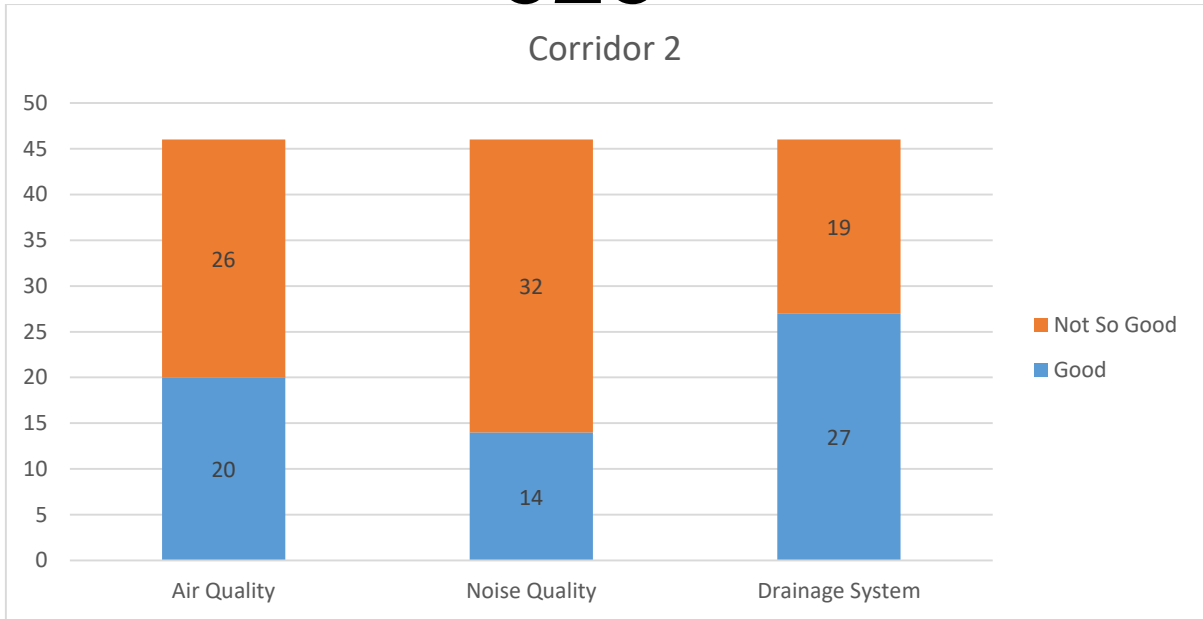


Figure 6.2. Graphical chart showing Public Opinion on Pollution Level in Corridor 2 - Baiyyappanahalli Terminal to Chikkabanavara

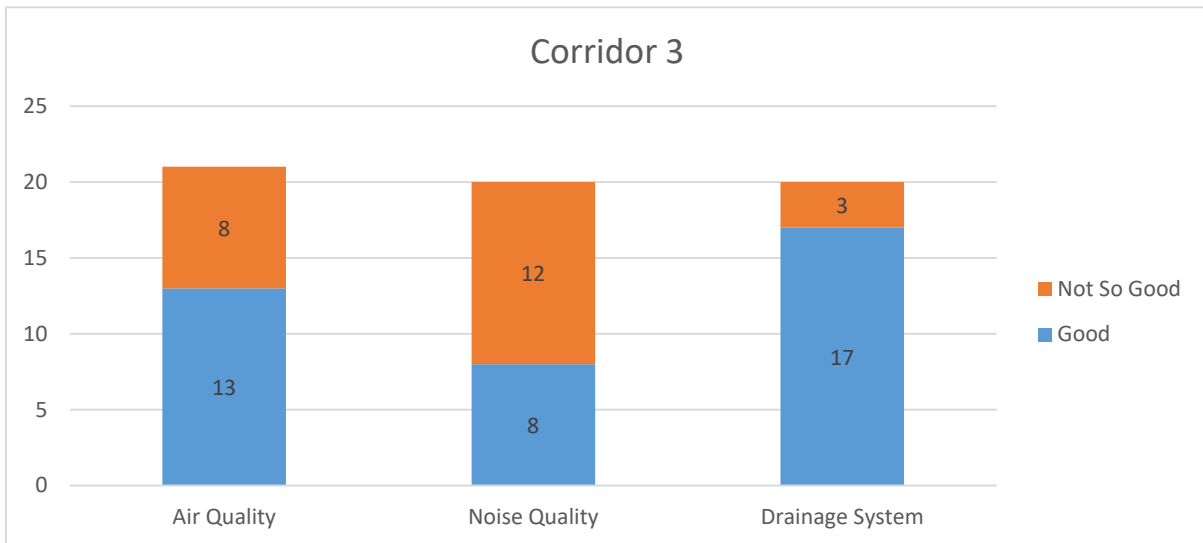


Figure 6.3. Graphical chart showing Public Opinion on Pollution Level in Corridor 3 - Kengeri to Whitefield (via KSR and Cantonment)

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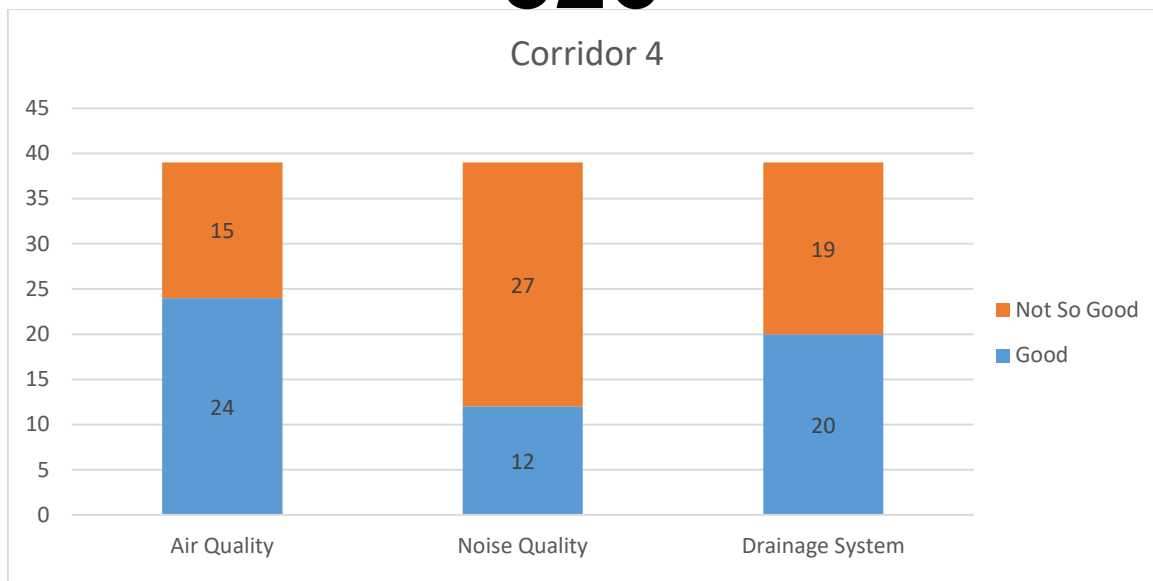


Figure 6.4. Graphical chart showing Public Opinion on Pollution Level in Corridor 4 - Heelalige to Rajanukunte

Further, out of 135 public interactions/FGDs, 81 FGDs i.e., 60% informed that, introduction of Suburban Railway will enhance the overall environmental condition of the region, however remaining 54 FGDs i.e., 40% told that, Suburban Railway project will not make any difference to the environment and public transportation system. Following are the key demands/ suggestions/ opinion received from Public during the interaction;

- Requested for appropriate noise control measures also suggested to not to honk within the city limit.
- Suggested to provide adequate drainage system along the BSRP corridors to avoid inundation/ water logging during rainy seasons and proper maintenance of the same.
- Demanded for adequate underpasses to cross railway from one side to another side.
- Requested for proper fencing at road junctions to avoid dumping of construction waste and garbage along the alignment.
- Demanded to minimise the tree felling and undertake tree plantation and landscaping along the railway track to enhance the green cover and to improve aesthetics of the region.
- Suggested to complete the construction of Suburban Railway project quickly within a given timeframe.
- Proposed improvement should be limited and to have minimum impact on their land and their property.
- Demanded for appropriate compensation for loss of land property and livelihood.

Stakeholders have made various suggestions during implementation of the project. These suggestions are being considered by the K RIDE during the project implementation duly considering local regulations, legal requirements and safety measures to the extent practicable and feasible.

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6.2.1.2. Institutional level stakeholder consultation

Institutional level stakeholder consultation was conducted to collect their opinion about the project and collected secondary details for the study area. Details of government officials consulted during FGDs and information disseminated for the project are presented in **Table 6.1**. Photographs showing Institutional level consultations conducted are presented as **Figure 6.5**.

| | |
|--|-------------------------------------|
| | |
| Assi. Superintending Archaeologist, ASI, RO, Bengaluru | Senior Environmental Officer, KSPCB |
| Divisional Safety Officer, South Western Railways | |

*The name, Photo and contact details (Mobile No. & email ID) of the Institutional Stakeholder consultation participants are available in KRIDE records, but due to its sensitivity, the same is not disclosed.

Figure 6.5. Photographs showing Institutional Level Consultation

Table 6.1. Details of Institutional Level Interactions for the BSRP Corridors

| Sl No | Name of the Person | Date | Position | Opinion/suggestion/data sought |
|-------|--------------------|------------|--|---|
| 1 | | 22.12.2021 | Deputy Conservator of Forest, Bengaluru Forest Division – [REDACTED] | Requested for Forest map for Bengaluru Urban Forest Division, and understood forest clearance and tree felling permission (non-forest) process. |
| 2 | | 05.03.2022 | First Division Clerk, Bengaluru Rural Forest | Discussed about status of Akkupete Forest Land and clarified Forest clearance process. |
| 3 | | 12.04.2022 | Range Forest Officer, ICTC Cell, Forest Head Office, Bengaluru – Ph: | Discussed on forest spread along project corridors and requested to provide the digitised forest map for Bengaluru rural and Urban Districts. |
| 4 | | 22.12.2021 | First Division Clerk, Bengaluru Urban Forest – Ph: [REDACTED] | Discussed on forest spread along project corridors |
| 5 | | 22.12.2021 | First Division Clerk, Bengaluru Urban Forest– Ph: [REDACTED] | Discussed on forest spread along project corridors and requested to provide the forest |

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| Sl No | Name of the Person | Date | Position | Opinion/suggestion/data sought |
|-------|--------------------|------------|---|--|
| | | | | map for Bengaluru Urban District. |
| 6. | | 21.03.2022 | Divisional Safety Officer, South Western Railways – Ph: | Discussed on safety aspects with respect to Indian Rail alignment and at Stations in project area. Further, clarified any contaminated area/hazard area identified along the project railway alignment to undertake extra-care during the baseline study. However, it was confirmed that, no such areas were located along the project corridors. |
| 7. | | 20.04.2022 | Assistant Superintending Archaeologist, Regional Office, Archaeological Survey of India, Bengaluru – Ph: 080- [REDACTED] | Information disseminated on project corridors and presence of ASI monuments in Devanahalli near Corridor 1. Information gathered on ASI clearance process. |
| 8. | | 20.04.2022 | Senior Environmental Officer, Bengaluru City Zone, KSPCB, Bengaluru – Ph: 080 [REDACTED] | Discussed on improvement proposal of project corridors. Requested for data on contaminated area/hazard areas/waterbodies identified along the project railway alignment to undertake extra-care during the baseline study. However, it was confirmed that, no such area was located along the project corridors. Also applicability of Air & Water Acts to the project were discussed. |
| 9. | | 27.04.2022 | Engineer (Civil), Ground floor, Karnataka Seed Bhavan, Bellary Road, Near Hebbal, Bengaluru – Mob- | Discussed on improvement proposal of project corridors. And informed that, corridor 1 & 4 are abutting few lakes and crossing stormwater drains. It was advised to undertake necessary mitigation measures to avoid any pollution or |

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| SI No | Name of the Person | Date | Position | Opinion/suggestion/data sought |
|-------|--------------------|------------|---|---|
| | | | | affecting the carrying capacity of the lakes/stormwater drains. Further, It was told by concerned Engineer that, legal obligation of Karnataka Tank Conservation and Development Act is applicable for the projects and explained that necessary permission required to obtain from this Authority prior to initiating the site activity. |
| 10. | | 27.04.2022 | Manager, BBMP Forest Wing, Annex Building, BBMP, Corporation Circle, Bengaluru. Ph. – 080 [REDACTED] | Information disseminated on project corridors. Details of gaint trees and historical trees present within the limit. It was informed that, no such trees present align the railway alignment. Requested on procedure involved in tree felling permission (within BBMP limit) process. It was informed to submit the tree felling application with tree details such as tree species, girth, height, tree coordinates and photos for obtaining permission for the project. |

*The name and contact details (Mobile No. & email ID) of the Institutional Stakeholder consultation participants are available in KRIDE records, but due to its sensitivity, the same is not disclosed.

Opinion/suggestions and data gathered with respect to legal implications of the project and mitigation measures are suitably considered in the preparation of EIA report. Also, guidelines and application forms collected from these statutory bodies are being utilized for obtaining NOC/permissions.

Proceedings of institutional level consultation conducted with South Western Railway Dept. official, Forest officials, Archaeological Survey of India officials and Pollution Control Board officials, Lake Authority and BBMP Forest wing dept. are presented in **Annexure 6.3**. Stakeholder engagement plan prepared for the project cycle is presented as **Annexure 6.4**.

6.2.1.3. Stakeholder Consultation at Cultural Heritage Sites

As part of Public interaction and information dissemination process, a consultation has been undertaken near ASI protected cultural heritage sites ie., 1) Fort, Devanahalli and 2) Tippu Sulthan's Birth Place, which are falling within 300m from the project site. Since, there are no communities/

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organisation managing these protected monuments, regular users and public residing near these monuments were consulted to receive the opinion/suggestions on the project.

As per the interactions, the public residing the monuments didn't anticipate any threat to the monuments due to the project. Instead they opined that, due to introduction of suburban rail, there will be arrival of more visitors to these ASI monuments resulting economic development of the region. Some of the suggestion/opinions expressed by the public are as follows;

- They demanded for a rest area/toilet facility near these monuments for the visitors
- Requested to provide proper storm water drainage situated along northern part of the fort to avoid flooding during rainy season
- Suggested to develop Sihineerina Kere/Lake (adjacent to Fort) under CSR to attract more tourists.

Photographs of the Public interaction near ASI Monuments are presented as **Figure 6.6**.

**The name, Photo and contact details (Mobile No. & email ID) of the Institutional Stakeholder consultation participants are available in KRIDE records, but due to its sensitivity, the same is not disclosed.*

Figure 6.6. Photographs showing Stakeholder Consultation near ASI Monuments

6.2.1.4. Public Consultation Meetings

Public Consultation refers to the process by which the concerns of local affected persons and others who have plausible stake in the environmental impacts of the project or activity are ascertained with a view to taking into account all the material concerns in the project or activity design as appropriate. Local affected persons are the stakeholders (such as land owners, tenants) who are directly affected by the proposed project activities. Other concerned persons are local NGOs, officials of various government departments and local residents who are indirectly affected by project activities. A structured pre-informed public consultation meeting will be organised to disseminate the project improvements once after finalising the draft EIA & SIA reports.

6.2.2. Summary of Public Consultation and Stakeholder Engagement held as part of EIA

Summary of consultation conducted during the EIA report preparation process is presented in below Table;

Table 6.2. Summary of Public Consultation and Stakeholder Engagement held as part of EIA

| Sl. No. | Types of Consultation | Time Period | Number of Locations/ Departments | Number of Participants |
|---------|-----------------------|-------------|----------------------------------|------------------------|
| | | | | |

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| | | | | |
|----|---|-----------------------------------|--|---|
| 1. | Focus Group Discussion | From March 2022 to December 2022* | Corridor 1 - 30 Corridor 2 - 46 Corridor 3 - 20 Corridor 4 - 39 | Corridor 1 - 92 Corridor 2 - 146 Corridor 3 - 72 Corridor 4 -161 |
| 2. | Institutional Level Stakeholder Consultation | December 2021 to April 2022 | 7 Departments | 14 |
| 3. | Consultation with individuals near Cultural Heritage site (ASI Monuments) | March 2023 | 10 locations | 21 |

* FGDs including modified Locations.

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Chapter 7. Analysis of Alternatives

7.1. Introduction

This chapter presents a comparative analysis of various alternatives considered to avoid or minimize impacts that would be inevitable if technically (based on design speed and geometrics) and environmentally best-fit, alignment is followed. Cross sections adopted for the development component are flexible in design to avoid most of the impacts within RoW. An analysis of various alternatives is attempted to arrive at the technically and environmentally best-fit alignment.

7.2. Integration of Environmental Consideration in the Alternatives

The social and environmental considerations were integral parts of the design and environmental assessment process. There are considerable number of building both commercial and residential as seen in the baseline environmental scenario along the corridors, where there is constricted existing Indian railway RoW and as well as various environmental impacts. Several alternatives are analysed for avoiding localized environmental impacts and arriving at the best-fit alignment. The analysis of alternatives has been prepared in accordance with the requirements of the World Bank and Gol guidelines.

7.3. “With” And “Without” Scenarios

In the case of the current project, consideration of the ‘No Action’ and ‘Action Alternatives’ have been examined as provided in the following subsections;

7.3.1. No Action Alternative

The no action alternative will result in an increase in accidents, deterioration of air and noise quality and pedestrian safety. This will be acute during the peak hours. As per the recent study, average traffic speed is about 12 Kmph in peak hour. The project area is relatively undergoing an increased scale of developments and vehicular growth. Thus the “No action alternative” will not reduce the current traffic chaos.

The steady increase in number of new and better vehicles will increase the number of vehicle year after year and will lead to traffic congestion and leads to economic loss. Accidents and road safety will remain as an issue to be resolved. The present traffic demand will increase primarily due to growth in activities earmarked for developments besides socio-economic growth of the influencing areas.

Metro rails are easing the traffic congestion to the limited extent specific to certain areas. However, about 80% of the other city areas still in the need of better eco-friendly public connectivity. Apart from routine maintenance and rehabilitation of existing at-grade and elevated city roads, there is no augmentation of roads to increase its carrying capacity. Limited road infrastructures such as parking asphaltting, street lightings maintenance of drain cum footpaths, reinforcement of traffic signals, there are no alternative mode of transportation proposed to resolve the traffic conditions.

In the absence of adequate public transport system, people are using the personalized modes which is not only leading to congestion on limited road network but also increasing environmental pollution.

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An average citizen of Bengaluru spends more than 240 hours stuck in traffic every year. Such delays result in loss of productivity, reduced air quality, reduced quality of life, and increased costs for services and goods.

The unsafe conditions and the environmental consequences (air and noise pollution and degraded environmental conditions) will continue and worsen. The no improvement condition in the long term would be a serious obstacle to the development of the economy and thus to the improvement of conditions for all sections of the population.

7.3.2. Action Alternative

Population and traffic growth will continue to occur and exacerbate in an already critical situation. The "Action Alternative" scenario, has been determined to be economically viable and would meet the local communities aspirations to a large degree. It would, thereby, contribute to ease the existing traffic congestion, enhance economic efficiency and growth potential of the area, and improve the well-being and livelihood of those within the potentially affected area of the project region. Potential negative environmental impacts associated with the "Action Alternative" scenario can be reduced through good engineering practice and, where warranted, appropriate mitigation and enhancement actions as specified herein.

A comparative statement of No Action Alternative and Action Alternative is shown in **Table 7.1**.

Table 7.1. Comparison of No Action and Action Alternatives

| No Action Alternative | Action Alternative |
|---|---|
| Congested corridor remains | It will ease the road congestion, by introducing suburban railway which will link Bengaluru to its satellite townships, suburbs, surrounding areas and provide a mass rail based rapid transit system |
| Chaotic traffic scenario will continue | Streamline the traffic control system |
| Travel time saving does not arise | Plenty of time is saved avoiding congestion |
| No interaction & awareness will be built in the local Groups and NGOs | There will be a number of interaction & awareness meetings to the local people & NGOs |
| Accidents and safety issues will continue to be the same | Proposed suburban reduce the risk of accidents |
| Aesthetic quality remains dull | Aesthetic quality of the corridor will increase. (One can enjoy the panoramic view of the city) |
| Vehicular emission will increase over a period of time | Reduce the vehicular emission |
| There will not be any environmental enhancement to the project region | There will be a number of measures for improving the environmental conditions. |
| Increased financial burden of the personal vehicle users and other public transport commuters | Affordable fares compared to other mode of transport will help lakhs of daily commuters |

The analysis clearly shows that the 'no action' alternative is not a prudent course of action. This alternative "do nothing" is not acceptable and has already been rejected by the Project Authorities.

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7.4. Structure Alternative Options

The BSRP Corridors are passing through both busy central business district and peri-urban areas of Bengaluru City. Since, about 90% of the land required for BSRP is with existing ROW of Indian railway line, there is no major land acquisition issues raised during project design. However, at certain locations (especially rail alignment within Bengaluru City limit), there is no sufficient RoW available with Indian railway to propose at-grade suburban railway facility. Hence, at those locations (refer Figure 2.1 BSRP System map) elevated railway system is proposed in order to avoid land acquisition and social issues. Typical Cross Section of Elevated & At-grade Structures is presented in **Figure 7.1**. Benefits of elevated structure alternative are detailed listed as follows;

- Elevated structures can be constructed at location where limited Indian railway existing RoW to avoid additional private land acquisition and due existing infrastructure like Metro, existing grade separators, major storm water drain, etc.,
- No fresh land acquisition, rehabilitation and resettlement of PAPs is required
- Very impacts on community division compared to At-grade railway alignment
- At elevated structure tracks will not be submerged during heavy rainy days
- There is no stagnation of water or inundation of surroundings due to surface runoff from high raised embankment railway tracks
- Rate of attenuation of noise & vibration is more in elevated structures compared to At-grade railway alignment
- Elevated structure feels more liberated than reinforce at-grade structure, but the design needs to consider the landscape
- Very less impact on trees and no fragmentation of biodiversity

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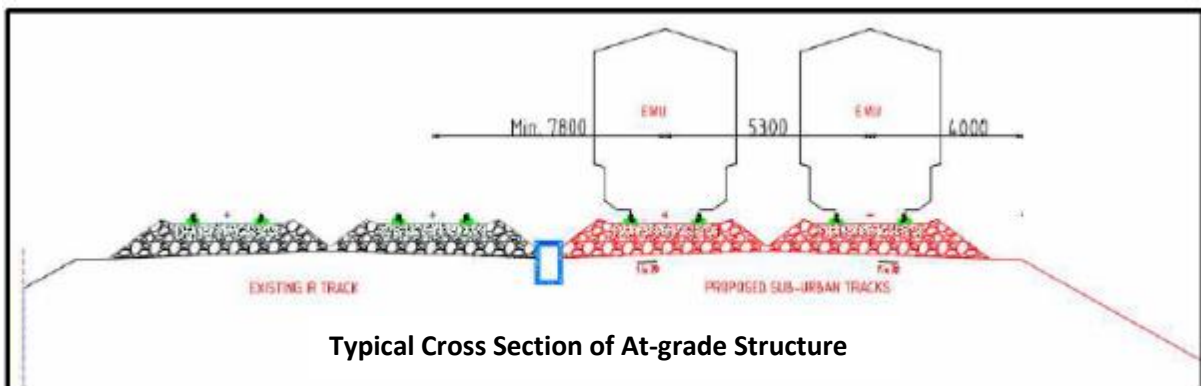
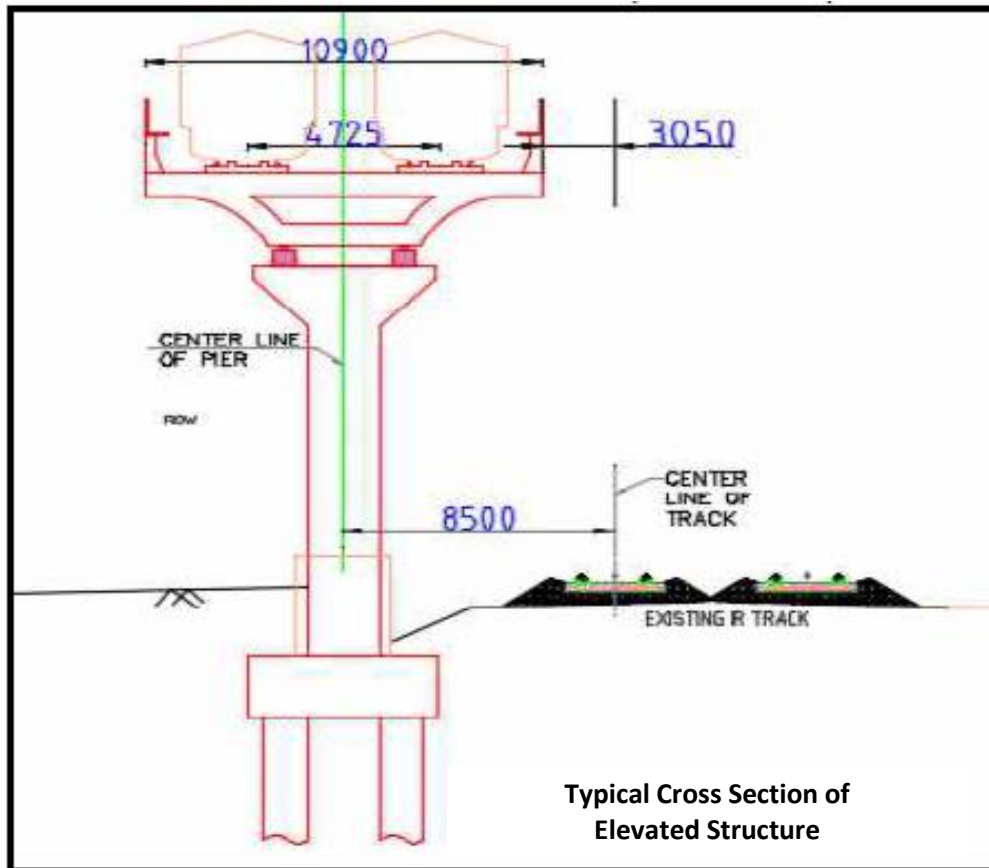


Figure 7.1. Typical Cross Sections of Elevated and At-grade Structures

7.5. Alternative Alignment Options

As discussed earlier, about 90 percent of the BSRP alignment is proposed within the existing Indian Railway land, which are connected to the city in five radial rail corridors and connecting north-south and east-west part of the city. Hence, it has been proposed to utilize maximum extent of Indian Railway land to develop BSRP corridors. Developing the BSRP by acquiring fresh land within the city limit to de-route from existing Indian railway alignment will not be a feasible option for the project. Hence, studying alternative options for the alignment is not warranted for the project.

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7.6. Stations Alternative Options

Stations are inevitable part of suburban railway project, which connects various commuter destinations within the city limits and suburban areas. BSRP Corridors Stations are proposed at the locations of existing Indian railway stations in order to avoid the fresh land acquisition. Hence, there are no alternative options studied for Stations in BSRP corridors.

7.7. Depot Alternative Options

As part of BSRP, two depot is proposedie., Soladevanahalli village and Akkupete village. Total extent of land area required for Soladevanahalli and Akkupete depots are 9.3 Ha and 18.6 Ha respectively. The depots are strategically selected by considering accessibility to BSRP Railway alignment and availability of large extent of land. The land identified for the Akkupete depot belongs to State Forest Dept. Google images of Akkupete Depot are presented in **Figure 3.23** and **Figure 5.23** of this report. Considering land scarcity the Akkupete depot land is proposed in forest land.

7.8. Technology Options

BSRP will be developed utilizing Electric Multiple Unit (EMU) train, which consist of self-propelled carriages that uses electricity as the motive power. EMU does not required separate locomotive engine, as one or more electric traction motors will be incorporated in the train. An EMU is usually formed of two or more semi-permanently coupled carriages, but electrically powered single-unit railcars are also generally classified as EMUs.

EMUs are popular on commuter and suburban rail networks around the world due to their fast acceleration and pollution-free operation. Being quieter than Diesel Multiple Units (DMU) and locomotive-drawn trains, EMUs can operate later at night and more frequently without disturbing nearby residents.

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Chapter 8. Assessment of Potential Environmental Risks and Impacts with Mitigation Measures

8.1. General

This Chapter highly points the potential Environmental impacts anticipated during project implementation. The potential environmental impacts could be positive or negative, direct or indirect and induced and localized or regional and reversible or irreversible impacts. The potential impacts due to proposed project activities have been analyzed and assessed based on the project description (Chapter 3); and identified impacts from primary and secondary baseline information and data as presented in the (Chapter 5). The quantitative and qualitative assessment has been carried out for the identified potential environmental impacts. Matrix method has been adopted to evaluate the impacts on the environment.

Attempts have been made to envisage the impacts due to proposed project during construction and operation. The project impacts on ambient air quality, noise and vibration level have been quantified while project impacts on water, soil and archaeological / heritage assets are evaluated considering the stipulated norms and standards. National Standards for Air, Water, Noise and effluent discharge standards are given as **Annexure 8.1 to 8.5**. Impact on ecology has been assessed quantitatively in terms of total trees to be felled / relocated and in terms of adverse impact on aquatic species or their habitats. Other impacts have also been prophesied. Significant impacts during pre-construction, construction and operation of the project have also been assessed.

Impact identification and assessment starts with scoping and continues through the remainder of the IA Process. The principal IA steps summarized in figure below and comprises of:

- Impact prediction: to determine what could potentially happen to resources/receptors because of the Project s and its associated activities.
- Impact evaluation: to evaluate the significance of the predicted impacts by considering their magnitude and likelihood of occurrence, and the sensitivity, value and/or importance of the affected resource/receptor.
- Mitigation and enhancement: to identify appropriate and justified measures to mitigate negative impacts and enhance positive impacts.
- Residual impact evaluation: to evaluate the significance of impacts assuming effective implementation of mitigation and enhancement measures.

The methodology adopted in assessment of potential positive and negative impact during construction and operation phase is given in below paragraph and presented as Environmental Impact assessment matrix below in the **Table 8.1**.

The evaluation of the environmental impacts is based on Matrix system derived from the analysis and assessment of primary and secondary data collected through direct and indirect communication/consultation with local people and concerned authorities. Environmental impact scores developed in the EES are based on the magnitude of specific environmental impacts and their relative importance. The impacts assessed prior to the provision of mitigation measures.

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Table 8.1. Environmental Impact Assessment Matrix

| S. No. | Environmental Impacts | Impact Rating | Impact Characteristics |
|--|---|--------------------------------|--|
| A. IMPACTS DUE TO PROJECT LOCATION AND DESIGN | | | |
| 1. | Displacement and loss of livelihood of Project Affected People (PAPs) | Assessed as part of SIA Report | Permanent, negative, small scale and mitigable. |
| 2. | Change of Land use | R2 | Permanent, negative, small scale and mitigable. |
| 3. | Loss of trees and impact on ecology | R1 | Permanent with both positive and negative impact, Small scale and mitigable. |
| 4. | Drainage and Utilities: Diversion/shifting | R2 | Short term and/or permanent, negative, small scale and mitigable. |
| 5. | Impact on Archaeological Monuments and Heritage Assets | R2 | Permanent with both positive and negative impacts, Small scale, and mitigable. |
| 6. | Use of Energy and Water at stations and depots | R1 | Permanent with both positive and negative impact, mitigable. |
| 7. | Risk Due to Natural Hazards | R1 | Permanent, negative, Small scale and mitigable. |
| B. IMPACTS DUE TO PROJECT CONSTRUCTION | | | |
| 1. | Air pollution: Particulate air pollution due to activities like excavation; emissions due to transportation of muck and material Noise, Vibration | R1 | Large scale, permanent,, negative and mitigable. |
| 2. | Disposal of muck, C&D waste and hazardous waste; pre-casting and material yards | R2 | Temporary, negative, small scale and mitigable |
| 3. | Water demand and water quality | R2 | Temporary, negative, small scale and mitigable. |
| 4. | Soil erosion and land subsidence | R2 | Temporary, negative, small scale and mitigable. |
| 5. | Traffic diversions | R2 | Temporary, negative, small scale and mitigable. |
| 6. | Labor camp and on-site labour safety/welfare | R2 | Temporary, negative, small scale and mitigable. |
| 7. | Supply of construction material | R2 | Temporary, negative, small scale and mitigable. |
| C. IMPACTS DUE TO PROJECT OPERATION | | | |
| 1. | Noise and Vibration | R1 | Permanent, negative, large scale and mitigable. |
| 2. | Energy and water supply at stations and depots | R2 | Permanent, negative, Small scale and mitigable. |

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| S. No. | Environmental Impacts | Impact Rating | Impact Characteristics |
|---|---|-----------------|---|
| 3. | Traffic congestions around stations | R2 | Permanent, negative, Small scale and mitigable. |
| 4. | Impacts due to Depots: Water supply, Waste water disposal, Oil Pollution, Noise Pollution, Solid Waste disposal, Loss of trees. | R2 | Permanent, negative, small scale and mitigable. |
| D. POSITIVE IMPACTS DUE TO PROJECT | | | |
| 1. | Employment Opportunities | Positive impact | Permanent, positive and large scale. |
| 2. | Benefits to Economy: access, reduced costs of road infrastructure, vehicle operating & time, accidents. | Positive impact | Permanent, positive and large scale. |
| 3. | Reduction in road traffic | Positive impact | Permanent, positive and large scale. |
| 4. | Reduction in road accidents | Positive impact | Permanent, positive and large scale. |
| 5. | Reduction in fuel consumption | Positive impact | Permanent, positive and large scale. |
| 6. | Reduction in air pollutants and savings in GHG emissions. | Positive impact | Permanent, positive and large scale. |

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

This Chapter is concerned about the potential negative impacts on the environment due to proposed project activities. It is noticed that only pollutants which are solid, liquid and gaseous in nature will be generated due to the proposed project activities mainly during construction and operation stages. Additionally, negative impacts on various aspects of the environment likely to result from the proposed development activity are identified, analyzed and assessed in this Chapter. The potential positive impacts are elucidated in the next **Chapter 9**. The recommendations for mitigating measures have been elaborately provided in **Chapter 10**.

8.2. Potential Negative Environmental Impacts

The potential negative impacts due to proposed project on the following environmental components have been identified and appraised during various phases of project cycle namely project Location, design, construction and operation.

- Land Environment,
- Water Environment,
- Air Environment,
- Noise Environment,
- Biological /Ecological Environment
- Historical, Archaeological and Cultural heritages
- Socio-economic Environment

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The potential negative impacts have been described under the listed headings below:

- Impacts due to Project Location and Design (Pre-construction Phase)
- Impacts due to Project Construction (Construction Phase), and
- Impacts due to Project Operation (Post-construction or Execution Phase).

8.3. Risks and Impacts due to Project Location & its Mitigation Measures

The potential risks and impacts predicted due to the project layout and design have been assessed in this section. These are listed below and discussed in the following sub-sections:

The potential impacts due to project location se are listed below and discussed in the following sub-sections:

- Land requirement and its impact on Displacement of People, Encroachment Clearance and loss of livelihood of Project Affected People (PAPs)
- Risks & Impacts on land and Change in Land Use
- Risks & Impacts on Diversion of Forest land
- Risks & Impacts on Biological/Ecological Environment
- Risks & Impacts on Climate Change
- Risks & Impacts on Utility/Drainage System
- Potential Social Impacts
- Risks & Impacts on Religious Structures /Archaeological / Historical and Cultural Monuments/ Heritage Sites
- Risks and Impacts on Environmental Sensitive Receptors
- Risks and Impacts on Local Transport Facilities

The potential impacts enlisted due to project design are as given below :

- Platform Inlets and outlets
- Illumination and Ventilation
- Impact of Noise and Vibration
- Right of Way Alignment, Stations, Track Design and Architecture
- Spatial Planning of Stations and Inter Modal Integration
- Consumption of Energy for Illumination, Ventilation and Water at Stations and Depots
- Risks Due to Natural Hazards
- Robust Design with Provisions for Green Buildings
- Efficient Material Re-use and Conservation
- Conservation of Flora/Preservation of Trees
- Utility Plan
- Design Improvement to Minimise the Vibration

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8.3.1. Land requirement and its impact on Displacement of People, Encroachment Clearance and loss of livelihood of Project Affected People (PAPs)

Risks and Impacts : A minimum to moderate impact on land and people were noticed due to the project, since the project utilizes government land in majority for the project.

Mitigation Measures : Alignments are designed to utilise Government and Indian Railway lands to the maximum and to avoid or minimize impacts on private land or properties, in accordance with Land Acquisition Act, 1894 and Rehabilitation and Resettlement Act, 2013 and WB ESS 5 & EIB's ESS 6.

Residual Impacts and Measures : Impact on the livelihood of Project Affected People (PAPs) due to displacement will be suitably compensated as per the R&R plan. Hence, there is no residual impacts anticipated. The project affected people (PAPs) including both title holder and non-titled holder land owners and their loss of livelihood are addressed separately under Rehabilitation and Resettlement (R&R) Section of the Social Impact Assessment (SIA) Report.

8.3.2. Risks & Impacts on land and Change in Land Use

Corridor wise land requirement including private land acquisition details is presented in table below. The area estimated for corridor -2 is final as the joint measurement is completed and the land acquisition works are in final stage. The details provided for the other corridors are based on the draft design report. The proposed BSRP requires acquisition of land permanently for stations, depots and running corridor sections. Both government and private land will be acquired for the project. The Government land includes about 145.3 Ha of Railway Land, 18.62 Ha of Forest Land, 8.66 Ha of State Govt. land, and 3.63 Ha of other government land. The private land required is about 56.88 Ha. The railway land would be transferred to K-RIDE for a nominal fee of INR 1/Acre. The details of the same are given in civil engineering section in the FPR. About 233.09 Ha is required for the proposed project corridors, depots and Stations. Corridor wise land requirements including private land acquisition is tabulated in **Table 8.2**. Corridor wise land free stretches and land acquisition stretches are presented in **Figure 8.1**.

Table 8.2. Corridor wise Land Requirements including Private Land Acquisition

| S.No. | Corridor/ Depot | Government Land, Ha | | | | | Private Land, Ha | Total |
|----------|--------------------------------|---------------------|--------------|--------------|------------------|-----------------|------------------|---------------|
| | | Railway Land | GoK Land | Forest land | Other Govt. Land | Total Govt Land | | |
| 1 | Corridor- 1 | 46.80 | 0.83 | 0.00 | 0.00 | 47.62 | 4.90 | 52.52 |
| 2 | Corridor- 2 | 34.70 | 2.83 | 0.00 | 3.63 | 41.16 | 2.07 | 43.23 |
| 3 | Corridor- 3 | 17.05 | 1.03 | 0.00 | 0.00 | 18.09 | 8.39 | 26.47 |
| 4 | Corridor- 4 | 46.75 | 1.94 | 0.00 | 0.00 | 48.69 | 16.31 | 65.00 |
| 5 | Depot - 1 (Devanahalli) | 0.00 | 2.03 | 18.62 | 0.00 | 20.65 | 4.16 | 24.81 |
| 6 | Depot - 2 (Soladevanahalli) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 21.05 | 21.05 |
| 7 | Total | 145.30 | 8.66 | 18.62 | 3.63 | 176.21 | 56.88 | 233.09 |
| 8 | Percentage | 62.34% | 3.71% | 7.99% | 1.56% | 75.6% | 24.4% | |

Source: BSRP - Feasibility Report & details from Land Acquisition team

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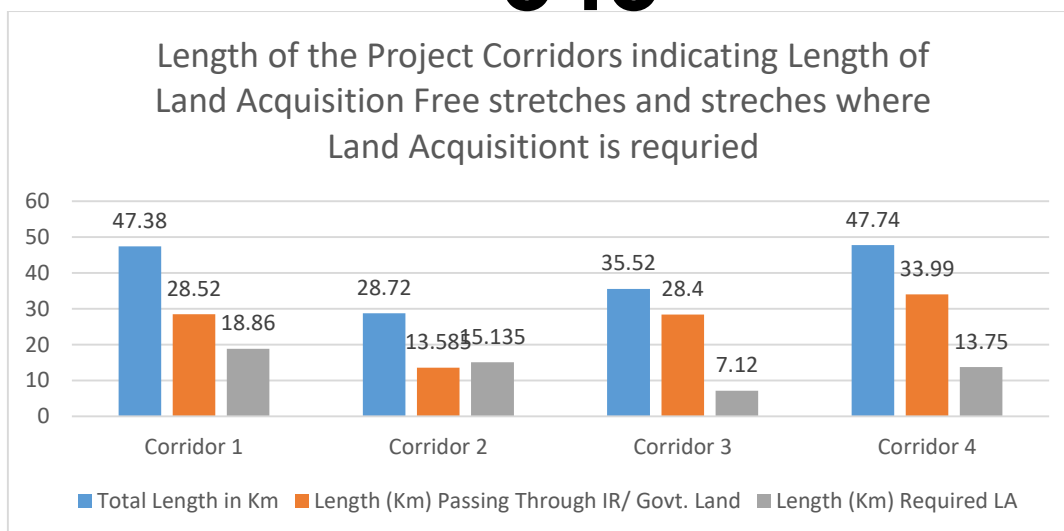


Figure 8.1. Corridors - Land Acquisition Free Stretches & Land Acquisition Stretches

Corridor – 1: The comprehensive walk-through survey conducted by the SIA team shows that around 88.28% of land is government land and about 11.72% is private land. The structures in the private land that are affected are Residential (54.12%), Commercial (4.71%), residential cum commercial (1.18%) and CPRs (1.18%), while 38.82% are non-responsive.

Corridor – 2: The comprehensive walk-through survey conducted by the SIA team shows that around 76.46% of land is government land and about 23.54% is private land. The structures in the private land that are affected are Residential (61.25%), Commercial (18.69%), residential cum commercial (14.88%) and CPRs (5.19%), while all PAHs were responsive.

Corridor – 3: The comprehensive walk-through survey conducted by the SIA team shows that around 68.3% of land is government land and about 31.7% is private land. The structures in the private land that are affected are Residential (35.56%), Commercial (10.37%), residential cum commercial (2.96%) and CPRs (4.44%), while 46.67% are non-responsive.

Corridor – 4: The comprehensive walk-through survey conducted by the SIA team shows that around 74.91% of land is government land and about 25.09% is private land. The structures in the private land that are affected are Residential (43.57%), Commercial (3.57%), residential cum commercial (0.00%) and CPRs (3.57%), while 49.29% are non-responsive. The outcome of the comprehensive walk-through survey is shown in Figure above.

Status of Land Acquisition: Joint Measurement Survey has been completed in Corridor 2, and the same is in progress in other project corridors. The ownership of the land, extent of loss of land, asset loss and any other losses due to the land acquisition will be assessed and confirmed during joint measurement survey by the Special Land Acquisition Officer, KIADB and the land acquisition notice to the landowners would be issued. The concerned land owners will also participate in the survey. The joint measurement survey will be conducted after the de-signs are finalized and the land requirement is finalized. It is expected that the joint measurement surveys will be taken up sequentially for all corridors; these are expected to be completed by June 2024.

Mitigation Measures : The compensation for land is detailed in Social Impact Assessment Study Report. Impact on Private land comprises of residential land, commercial land and vacant land. As per

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RAP notice shall be given in advance to the encroachers (and squatters, if any) present in the Corridor of Impact, who need to be relocated. All R and R activities shall be undertaken as per the relevant acts and also comply with WB's ESS 5 and EIB's ESS6. Entitlements as per K RIDE entitlement framework shall be completed before construction starts.

8.3.3. Risks & Impacts on Diversion of Forest land

BSRP project requires diversion of 18.6 Ha Forest land for the construction of Akkupete (13°14'50.40"N & 77°41'26.37"E) Depot. Forest land shall be diverted in accordance with the Forest (Conservation) Act, 1980 and WB's ESS 6 & EIB's ESS 4. Compensatory afforestation is one of the most significant conditions stipulated by the Central Government for diversion of forest land for infrastructure projects such as Suburban Railway Project in Bengaluru. Obtaining Forest Clearance is still under progress at K RIDE level. Compensatory afforestation land has been identified by K RIDE in consultation with Forest Dept. & deposit amount in Compensatory Afforestation Fund Management & Planning Authority (CAMPA), which is required to carryout compensatory afforestation. Concerned Divisional forest department will prepare compensatory afforestation scheme and undertake afforestation using CAMPA fund.

Clearing of vegetation in proposed Akkupete depot site shall be undertaken manually through Bengaluru Rural Forest division as per statutory guidelines laid out under Karnataka Preservation of Tree Act, 1976 and amendments and Forest Conservation Act, 1980. Further, compensatory afforestation and its maintenance for loss of trees will be undertaken by Bengaluru Rural Forest division as per these Acts/guidelines. Hence, preparation of separate Pest Management Plan does not required.

Total number of trees to be felled in forest land is 17,323. The number of trees to be transplanted depends on the site condition and root condition & health of tree. This will be ascertained by forest dept. Maximum effort will be done to save trees and transplant with all required measures. Those trees which cannot be transplanted at all will only be removed. The total area required for afforestation of these trees comes out to about 18.6 ha, which is identified by K RIDE in consultation with Forest Dept. The proposed CA land is located in survey no. 65 (13°24'24.08"N & 77°24'21.09"E) of Sasalu Village of Doddabalapura Taluk. The identified land is approx. 35km from the proposed Akkupete Depot land. As per the preliminary interaction of forest officials and site visit, the identified CA land is suitable for compensatory afforestation and has no thick vegetation in it. Topography of the CA land is plane to undulating and has katcha road available to access the land. From the prima facies, there will not be any adverse impact on existing vegetation cover and fauna due to undertaking CA. Google imagery of the CA land identified for diversion of forest land is presented in **Figure 8.2**. Photographs of the CA land is presented in **Figure 8.3**.

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Figure 8.2. Google Earth image Showing Proposed Compensatory Afforestation Land Identified for Diversion of Forest Land

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Figure 8.3. Photographs of the Compensatory Afforestation Land Identified for Diversion of Forest land for Depot in Akkupete

8.3.4. Risks & Impacts on Biological/Ecological Environment

8.3.4.1. Risks & Impacts and Mitigation Measures on Flora

The proposed project runs within the city limits and the surrounding a few village limits. A Tree inventory for the total project has been carried out. As per the assessment the total number of trees likely to be affected as a result of the proposed project is about **32,572 trees**. Most of the trees affected are at median of the existing road along the corridor and on either side of the existing road and railway lines for the proposed Suburban Railway stations and corridors. Shrubs and small trees under Social Forestry are affected due to establishment of Depots at Akkupete and Soladevanahalli. The inventory of trees for Corridors including stations and Depot is summarised in the **Table 8.3**. There are no rare or endangered tree species as per site observation and condition.

Table 8.3. Number of Trees along the Corridor/Depots

| Sl. No. | Alignment/Depot | Total No. of Trees | |
|---|---|--------------------|-------|
| 1. | Corridor 1 (KSR Bengaluru City - Devanahalli) | 7198 | |
| 2. | Corridor 2 (Baiyyappanahalli Terminal – Chikkabanavara) | 3469 | |
| 3. | Corridor 3 (Kengeri – B'lore Cantonment – Whitefield via SBC) | 2072 | |
| 4. | Corridor 4 (Heelalige – Rajanukunte) | 2306 | |
| Sub-Total along the Alignment & Stations (A) | | 15,045 | |
| 5. | Akkupete Depot | Forest land | 17323 |
| | | Non – forest land | 182 |
| | Sub total | 17505 | |
| 6. | Soladevanahalli Depot | 22 | |
| Sub-Total at Depots (B) | | 17527 | |
| Total Trees (A+B) | | 32,572 | |

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It is observed during field survey that most of the tree species are common trees, particularly ornamental or horticulture trees/plants. As per the field study, except *Aegle marmelos* (near threatened) there are no rare endangered endemic and threatened (REET) species were noticed to be present in the proposed project area. IUCN Categorization of trees present in BSRP Corridors are presented in **Table 5.44**.

Depot Areas : The land for establishing the depot is at Akkupete and Soledavanahalli. It is proposed to mobilize the Akkupete land of about 18.6 Ha by the Forest Dept. Whereas soledavanahalli depot is proposed in private land. Akkupete Depot is identified on Forest land where compensatory Afforestation has been taken-up forest dept. in the year 2001 and the land diversion to Railway Authority is under process. The project area is covered largely with shrubs of *Melia dubia* (wild neem – Hebbevu in Kannada), Eucalyptus and Acacia species. Tree enumeration and identification of plant species is under progress, whereas the same for plants in the proposed project coming under forest area need to be carried out by the Bengaluru Rural Forest Division, Devanahalli.

Mitigation Measures : Transplantation of trees shall be carried out by the BBMP Forest Wing and Forest Authority in consultation with K RIDE. Tree removal shall be carried out in accordance with the Karnataka Forest Act, 1963 (Karnataka Act 5 of 1964) amended with Karnataka Forest Rules, 1969, The Karnataka Preservation of Trees Act, 1976 and The Karnataka Preservation of Trees (amendment) Act, 2014, Forest Conservation Act 1980 and ESS 6 of World Bank & EIB's ESS 4.

The trees considered for removal & Translocation in BBMP Limit for the project needs to be compensated with afforestation by tree planting ten trees for every tree cut i.e. in the ratio 1:10 (considering at least survival of 5 trees per a tree removed) by the BBMP Forest Wing in coordination with K RIDE. However, Trees to be removed in Forest land shall be carried out by Forest Dept. in coordination with K RIDE and in accordance with the Compensatory Afforestation Fund Management & Planning Authority (CAMPA). The Forest Department will be responsible for the Afforestation Programme and Tree Maintenance during project implementation.

Residual Impacts: Loss of Flora leading to reduction in absorption of CO₂ and release of O₂ along the project areas for initial few years, may be upto 5 years at the maximum. This will be overcome in due course of time by the Tree Plantation and Tree Maintenance through Afforestation Programme by the Forest Department during project implementation.

8.3.4.2. *Compensatory Afforestation for Felling on Trees along Existing Railway Alignment*

There are about 32572 trees are affected due to BSRP Rail alignment and stations. Transplantation of trees will be carried out by the BBMP Forest Wing and Forest Authority in consultation with K RIDE. Tree removal shall be carried out in accordance with The Karnataka Preservation of Trees Act, 1976 and The Karnataka Preservation of Trees (amendment) Act, 2014 and ESS 6 of World Bank & EIB's ESS 4.

The trees consider for removal & Translocation in BBMP Limit for the project needs to be compensated with afforestation by tree planting ten trees for every tree cut i.e., in the ratio 1:10 by the BBMP Forest Wing as per the statutory guidelines in coordination with K RIDE.

At present, manual clearing of vegetation along the railway tracks is practiced by Indian Railway. It is proposed to adopt same method to clear the vegetation for BSRP. Vegetation (shrubs, climbers and

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small plants) along the proposed BSRP tracks will be cleared manually without using weedicide and herbicides. Due to this, there is no contamination of soil or nearby water bodies.

Clearing of trees along railway side shall be undertaken through BBMP forest wing/ Forest as per statutory guidelines laid out under Karnataka Preservation of Tree Act, 1976 and amendments and Forest Conservation Act, 1980. Further, compensatory afforestation and its maintenance for loss of trees will be undertaken by BBMP forest wing/ Forest dept. as per these Acts/guidelines. Hence, preparation of separate Pest Management Plan does not required.

8.3.4.3. Risks & Impacts and Mitigation Measures on Fauna

As per the interaction with forest officials, there are no wildlife crossings present in the project corridors. There are no impact on aquatic life, since construction activity will not take place inside the lakes. And as mentioned in Section 5.6.3 and outcome of Surface water quality test results, storm water drainages/Rajakaluves are polluted by sewage and industrial discharges. There is no aquatic fauna observed in these storm water drains/ rajakaluves.

As mentioned in above section, there will be considerable impact on avifauna due to felling of trees along the existing railway alignment, stations and depots locations. Even though, trees will be felled only on one side of the existing railway alignment, impacts can be avoided by translocation of the trees to adjacent vacant railway land.

It is observed that, the birds identified in the lake are having plentiful of forage and roost in the lake vicinity compared to rather than surrounding urbanised and built-up areas. They are not observed to fly to areas where there is high pollution and disturbance from anthropogenic activities.

Lakes in the side of the project site will not be disturbed due to project, some birds especially those which are native/residents and/or residents will not leave or leave for a time, but may eventually come back.

Most of the avifaunal species observed during monitoring are observed to be already acclimatized to anthropogenic activities such as fishpond operations, construction of buildings, disturbance near residential areas, etc. If these species will be displaced by the activities of the BSRP, it is surmised that in time, they will come back to their old haunts and habitats near the project site.

Hence, it is advised to carryout following few pre-construction measures to avoid/minimize the impact on avifauna, forage, roost/nesting and disturbance to young ones in the region.

- Tree felling should not be undertaken during night time.
- Tree felling should be minimized as far as possible, if unavoidable importance should be given for translocation to nearby vacant locations.
- Tree felling should be avoided during nesting and breeding time especially in April and May months.

Residual Impacts: There is no residual impacts anticipated.

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8.3.5. Risks & Impacts on Climate Change

This Section is concerned with the Assessment of associated risks on climate due to project (which is positive through predicted reduction of GHG emissions) as well as Vulnerability of project to Climate Risks and their management.

8.3.5.1. Climate Change Risks due to Project

The Climate change includes both the global warming driven by human emissions of greenhouse gases and the resulting large-scale shifts in weather patterns. The development and operation of the BSRP has the potential to contribute to the greenhouse effect through emissions produced by various activities throughout the construction and operation of the Project. The 3 main GHGs include carbon dioxide (CO₂), Hydrocarbons (HC) and nitrous oxide (N₂O).

An initial screening process was conducted as part of the project preparation to analyze the possibility of any potential to reduce GHG emissions or increase the reduction of GHG emissions. Also it included the potential to sequester carbon in soils and in vegetation. Risk Assessment study has been conducted focusing on the project approach to reduce GHG emissions and to avoid excess GHG emissions.

Based on the initial screening study relevant possibilities for adaptation have been identified, analyzed and assessed. The methodology followed is based on the methodology for analysis of Climate Risks as described in the Fifth Assessment Report (AR5), 2014 and Sixth Assessment Report (AR6), 2022 of United Nation's Intergovernmental Panel on Climate Change (IPCC).

Risk of climate-related impacts result from the interaction of climate-related hazards (including hazardous events and trends) wherein associated with vulnerability and exposure of human and natural systems, including their ability to adapt. Their identification is based on large magnitude or high probability of impacts: irreversibility or timing of impacts; persistent vulnerability or exposure; or limited potential to reduce risks.

High emissions leading to increased magnitudes of warming which in turn increase the likelihood severity, pervasive and irreversible impacts for people, species and ecosystems. Continued high emissions would lead to mostly negative impacts on biodiversity, ecosystem services and economic development and amplify risks for livelihoods; and risks for food and human security.

Climate change is a major threat to equitable and sustainable development infrastructure Projects such as the proposed Suburban Railway Project. Amongst all climate change consequences, the following may impact on the proposed Suburban Railway operation: (i) increase in Air temperature with increase in amplitude of temperature fluctuation during the year and (ii) changes in distribution of precipitations during the year. However, adaptation, mitigation and sustainable development are closely interrelated with potential synergies and trade-offs.

8.3.5.2. Assessment of Carbon Foot Print (GHG Emissions) during Construction Phase

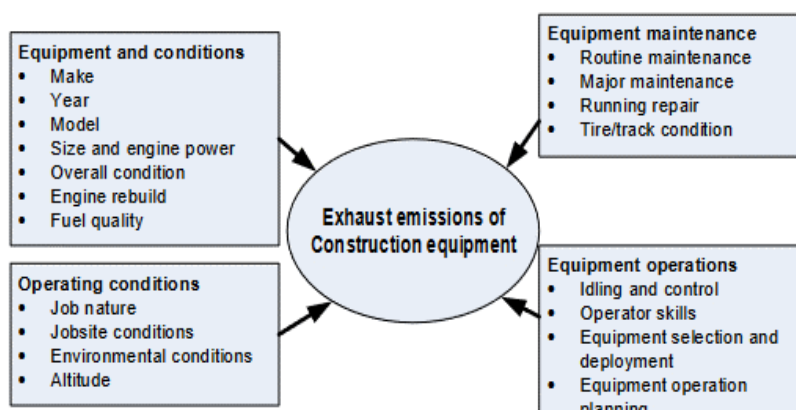
During the construction of the Project (BSRP) the GHG emissions will result from pollutants generated during vegetation removal, wastewater treatment, transport, manufacturing and construction of building materials and energy usage. These GHG emissions will be relatively low, produced over a short time period and are therefore unlikely to contribute significantly to overall GHG emissions from BSRP.

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- Due to tree felling and vegetation clearance (along alignment and for depots), increase in Carbon Emission during pre- construction and construction phase is 710 tonnes of CO₂e for one year of activities. This contributes to 31% of the GHG emissions.
- Compensatory afforestation will be done for the tree felling, resulting in about 7,100 tonnes of CO₂e per year reduced for the year 2025 (compensation of new trees for trees felled in the ratio of 10:1) (Ref. Section 9.1.9 of EIA Report)
- Construction equipment and vehicular emissions account for major contribution of about 69% towards GHG emissions, particularly 1566.81 tonnes of CO₂e for a total period of 3 years of construction.

Factors affecting the construction equipment emissions

There are a large number of factors affecting the exhaust emissions of construction equipment or machinery or vehicles, many are difficult to measure and quantify their degree of impact on the rate of emissions. Overall the factors can be categorized into four groups as shown in **Figure 8.4**. **Table 8.4** depicts net GHG Emission from BSRP construction equipment, Machinery and vehicles during project Construction phase.



Source : H. Fan, 2017 - A Critical Review and Analysis of Construction equipment emission factors

Figure 8.4. Factors of impact on construction equipment exhaust emissions

Table 8.4. Net Carbon Foot Print as GHG Emissions during Construction Phase (for a period of 3 Years)

| GHGs | Emission in g/Km | Emission in g/Km for total Project | Emission in Tonnes/Km | Emission in Tonnes/Km for total Project |
|-----------------|------------------|------------------------------------|-----------------------|---|
| CO | 75,54,525.00 | 4,51,46,74,794.30 | 7.55 | 4,514.67 |
| HC | 4,72,901.40 | 28,26,11,551.46 | 0.47 | 282.61 |
| NO _x | 1,14,86,736.00 | 6,86,46,11,274.43 | 11.49 | 6,864.61 |
| CO ₂ | 95,58,53,230.80 | 5,71,22,93,60,964.85 | 955.85 | 5,71,229.36 |
| PM | 15,32,002.80 | 91,55,43,257.31 | 1.53 | 915.54 |

Source: Estimate prepared for the CRVA Report based on "Carbon Emission factors from CPCB/MoEF, 2008 (for HCV Construction Vehicles) and BSRP Feasibility Report (for Personal Vehicles)"

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Construction Phase Mitigation Measures

Mainly Construction Phase Mitigation Measures are required to save CO2 emission. Adverse impacts of GHG emissions arising from the construction of the proposed Rail Project (BSRP) have been addressed according to the hierarchy of avoidance, mitigation and efficiency in management of adverse impacts, implemented where possible through the planning and design process and the development of on-going standard practices.

Reduction and Avoidance

Implementation of vehicle operating guidelines to encourage correct and efficient operation of vehicles

- The implementation of a traffic management plan, that:
 - Reduces the number of vehicles and/or trips required for transport
 - Uses buses for transportation of large numbers of personnel to minimise number of vehicles operating
 - Implementation of a wider fuel management strategy which encourages use of more efficient plants and vehicles, planning, logistics, driver education and maintenance
 - Efficient management of procurement and product supply
 - Reduction on the amount of waste disposed to landfill and reuse of waste on site as much as possible, which will subsequently reduce the amount of vehicle movements and therefore fuel usage
 - Use of teleconferencing and video conferencing to reduce travel to and from offices and associated gaseous emissions from fuel combustion
 - GHG emissions and energy consumption will be measured in accordance with current legislative requirements
 - Fuel consumption, energy use and GHG emissions will form part of reporting requirements to K-RIDE
 - GHG emissions and energy consumption will be reported to relevant authorities in accordance with current legislative requirements
 - A more comprehensive GHG emissions inventory will be addressed by the Contractor with approval by Environmental Specialist of General Consultant prior to construction that provides greater detail on construction emissions.
 - The next step will be to set achievable and realistic reduction targets and identify and investigate potential reduction opportunities to realise these targets. A site specific marginal abatement cost curve for identified reduction opportunities will be developed to assist K-RIDE to prioritise these opportunities and be useful in determining what particular opportunities can be employed to reach a specific carbon reduction goal. Activities such as vegetation clearing will be restricted to the required footprint only through the implementation of the EMP which will identify clearing limits. The concept design also re-uses excavated spoil material onsite as fill for the Suburban Rail line embankment, thereby reducing transport distances and heavy vehicle trips to an offsite disposal area. While fuel usage is a necessary

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requirement for construction of the BSR Project, so far as to reduce GHG emissions the following measures will be implemented as far as practicable:

- Adopting vehicle pooling for transport of construction personnel to minimise the number of vehicles operating
- Procurement of generators which use biodiesel or natural gas, where possible

The preventive measures detailed in the EMAP (EMAP Table 10.2, Section 10.9 of Chapter 10 – Environmental Management Plan of EIA Report), will be followed by the Contractor during Construction to avoid reduce the GHG emissions to the environment to the maximum possible and thereby, avoiding or reducing any significant impact on climate change.

Mitigation

On 10.08.2015, Government allowed direct sale of Biodiesel (B100) for blending with diesel to Bulk Consumers such as Railways, State Road Transport Corporations. On 29.06.2017 Government allowed sale of biodiesel to all consumers for blending with diesel. India's Ministry of Petroleum and Natural Gas published its "National Policy on Biofuels" in 2018, and further amended it in June 2022. The policy's objective is to reduce the import of petroleum products by fostering domestic biofuel production (MoPNG, GoI Guidelines, 2018).

Biodiesel blends (diesel that has a percentage of the fuel replaced with biodiesel) may reduce greenhouse gas emissions due to fuel consumption. However, this is dependent on a number of factors including the origin of the biodiesel feedstock. When sourced from appropriate feed-stocks, the reduction in emissions is approximately equivalent to the percentage of biodiesel in the blend (for example diesel with 20 per cent biodiesel will reduce greenhouse gas emissions by approximately 20 per cent). Opportunities for the use of biodiesel will be further examined and used where possible on the BSRP.

The application of technical efficiencies in construction plant and equipment will also provide more efficiency. These options will be further investigated, including any new technologies available, expected benefits, potential risks and costs.

Through the EMAP (EMAP Table 10.2, Section 10.9 of Chapter 10 – Environmental Management Plan of EIA Report), appropriate management will be integrated into all construction activities and processes and GHG emissions will be monitored. Through assessment and review, the BSRP will seek continuous improvement in compliance and emissions reduction.

Energy Efficiency and Management

Given that energy is the largest source of GHG emissions, appropriate mitigation measures will be implemented to reduce energy use as far as practicable through the following:

- Identification of the significant energy consuming equipment and recognising opportunities where technical efficiencies in plant and equipment can be applied. To improve fuel efficiency, an understanding of energy uses and corresponding fuel consumption would help K-RIDE to identify further opportunities where reduction in sources is most feasible and effective
- Site offices and accommodation buildings will be designed and constructed so as to include energy and water efficient equipment

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- Implementation of a Construction EMP which establishes the baseline water, materials and energy use objectives and targets with the aim of introducing resources and emissions reductions targets through the construction phase
- The EMP will set out appropriate management and encourage integration of key activities and processes so as to effectively monitor GHG emissions

Implementation of mitigation measures such as resource efficiency, adoption of less carbon-intensive or renewable energy sources to reduce fugitive emissions will be followed as per the EMP to save CO₂ emission (EMAP Table 10.2, Section 10.9 of Chapter 10 – Environmental Management Plan of EIA Report).

8.3.5.3. Assessment of Carbon Footprint with Mitigation

Trees play a significant role in reduction of CO₂ by sequestering it from the atmosphere during photosynthesis to produce carbohydrates that are used in plant structure/function and return O₂ back into the atmosphere as a by-product. Roughly half of the greenhouse effect is caused by CO₂. Therefore, trees act as carbon sinks, alleviating the greenhouse effect. As per the project study, the process for CO₂ conversion will get affected as a result of removal of trees for the project. The total loss due to tree removal is evaluated as given in the **Table 8.5**.

Table 8.5. Assessment of Carbon Footprint due to Tree Loss

| Si. No. | Description | Quantity |
|---------|---|----------------------------------|
| 1. | Total no. of Trees to be cut | 32572 |
| 2. | Increase in CO ₂ in the atmosphere (or Decrease in CO ₂ absorption by tree) @ 21.8 Kg/year/tree | 710069 Kg/Year (710 Tons/Year) |
| 3. | Decrease in Oxygen production @ 49 Kg/year/ tree | 1596028 Kg/Year (1596 Tons/Year) |

Source: EIA Survey & Study

Mitigation Measures:

The climate change mitigation activities to avoid or reduce any impact on Climate particularly during Construction Stage include the following :

- to avoid or reduce air pollutants causing raise in Temperature and
- to avoid or reduce activities leading to Flooding during rains.

The biosphere does have an impact on global CO₂ levels by tree removal or planting trees. Tree planting helps to tackle climate change. The combination of CO₂ removal from the atmosphere, carbon storage in wood and the cooling effect makes trees extremely efficient tools in fighting the greenhouse effect. Planting trees remains one of the most cost-effective means of drawing excess CO₂ from the atmosphere. The tree removal for the project needs to be compensated with afforestation by tree planting in the ratio 1:10 by the Forest Department in consultation with K RIDE and in accordance with CAMPA. Carbon Credits are discussed in Chapter 9 – Project Benefits.

Trees also remove other gaseous pollutants through the stomata in the leaf surface by absorbing them with normal air components. It is also observed from the study (Coder and Kim, 1996) that Tree cover removed 48 lb or 21.77 Kg (22 Kg) of particulates, 9 lb or 4.08 Kg of nitrogen dioxide, 6 lb or 2.72 Kg

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of sulfur dioxide, 0.5 lb or 0.226796 Kg or 227 g of carbon monoxide and 100 lb or 45.36 Kg of carbon – daily.

Assessment of Carbon Foot Print (GHG Emissions) during Operation Phase and Mitigation Measures

According to a 2007 estimate, electricity generation in India contributes 37.8% of CO₂ eq. emissions – CO₂, SO₂, NO₂ (MOEF, 2010) and is mainly by coal-based thermal power plants. Since the coal in India has a higher fly ash content (30–40%), electricity generation leads to the formation of particulate matter (PM₁₀ /PM_{2.5}) – a source of air pollution in the form of fly ash (Senapati, 2011). Therefore, the BSRP has no direct emissions from its operation as the source of energy is electricity from power plants. However, it contributes to carbon emissions at power plants during the generation of electricity used for its operation. BSRP operations will save time and distance for commuters and avoid or reduce the need for other forms of travel (for eg. diesel buses, cars, motorbikes), thus avoiding CO₂ emissions. CO₂ predicted for the proposed project is given in **Table 8.6**.

Table 8.6. Predicted CO₂ Emission due to Project (in Crore Tons)

| CO ₂ Emission Source | 2025 | 2031 | 2041 | 2051 |
|--|------|------|------|------|
| Plying Vehicular Emission during Construction of BSRP implementation | 0.02 | 0.02 | 0.03 | 0.04 |
| Emission due to Power generation during operation stage (from power source source) | 0.02 | 0.02 | 0.02 | 0.02 |
| Emission due to Construction Equipment, Machinery & Vehicles during Construction stage | 0.06 | 0.00 | 0.00 | 0.00 |
| Total CO ₂ Emission with BSRP Implementation | 0.10 | 0.04 | 0.05 | 0.06 |

The climate risk mitigation measures are provided in the Environmental Management Action Plan (EMAP) and Environmental Pollution Monitoring, Section 10.9 of Chapter 10 – Environmental Management Plan of EIA Report. The Cost of EMP includes the Climate Mitigation cost also. Through the EMAP appropriate management will be integrated into all construction activities and processes and GHG emissions will be monitored and measures such as resource efficiency, adoption of less carbon-intensive or renewable energy sources to reduce fugitive emissions will be followed as per the EMP to save CO₂ emission. Through assessment and review, the BSRP will seek continuous improvement in compliance and emissions reduction.

8.3.5.4. Operation Phase Risks and Adaptation Measures

The project involves the running of electrical energy based suburban rail cars during operation. GHG emissions during project operation, while running of the BSRs are negligible. However, CO₂ Emission will be mainly during the production of electricity at base source i.e. at Power Plants. Annual CO₂ emission at base source during electricity generation for running of BSRs is presented in the **Table 8.7**.

Table 8.7. Assessment of Annual Carbon Foot Print (GHG Emissions) due to power consumption at Base Source during Operation Phase

| Prediction Years | Energy Consumption (in Crore KWh) | GHG Emission | | | | | |
|------------------|-----------------------------------|-----------------|--------|-----------------|---------|-----------------|----------|
| | | CO ₂ | | SO ₂ | | NO ₂ | |
| | | kg | Tonnes | g | Tonnes | g | Tonnes |
| 2025 | 25.5 | 242250000 | 242250 | 1836000000 | 1836.00 | 1116900000 | 1116.900 |
| 2026 | 26.08 | 247760000 | 247760 | 1877760000 | 1877.76 | 1142304000 | 1142.304 |

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| Prediction Years | Energy Consumption (in Crore KWh) | GHG Emission | | | | | |
|------------------|--------------------------------------|-----------------|--------|-----------------|---------|-----------------|----------|
| | | CO ₂ | | SO ₂ | | NO ₂ | |
| | | kg | Tonnes | g | Tonnes | g | Tonnes |
| 2027 | 26.65 | 253175000 | 253175 | 1918800000 | 1918.80 | 1167270000 | 1167.270 |
| 2028 | 27.23 | 258685000 | 258685 | 1960560000 | 1960.56 | 1192674000 | 1192.674 |
| 2029 | 27.81 | 264195000 | 264195 | 2002320000 | 2002.32 | 1218078000 | 1218.078 |
| 2030 | 28.39 | 269705000 | 269705 | 2044080000 | 2044.08 | 1243482000 | 1243.482 |
| 2031 | 28.97 | 275215000 | 275215 | 2085840000 | 2085.84 | 1268886000 | 1268.886 |
| 2032 | 29.35 | 278825000 | 278825 | 2113200000 | 2113.20 | 1285530000 | 1285.530 |
| 2033 | 29.75 | 282625000 | 282625 | 2142000000 | 2142.00 | 1303050000 | 1303.050 |
| 2034 | 30.14 | 286330000 | 286330 | 2170080000 | 2170.08 | 1320132000 | 1320.132 |
| 2035 | 30.54 | 290130000 | 290130 | 2198880000 | 2198.88 | 1337652000 | 1337.652 |
| 2036 | 30.92 | 293740000 | 293740 | 2226240000 | 2226.24 | 1354296000 | 1354.296 |
| 2037 | 31.3 | 297350000 | 297350 | 2253600000 | 2253.60 | 1370940000 | 1370.940 |
| 2038 | 31.68 | 300960000 | 300960 | 2280960000 | 2280.96 | 1387584000 | 1387.584 |
| 2039 | 32.06 | 304570000 | 304570 | 2308320000 | 2308.32 | 1404228000 | 1404.228 |
| 2040 | 32.46 | 308370000 | 308370 | 2337120000 | 2337.12 | 1421748000 | 1421.748 |
| 2041 | 32.84 | 311980000 | 311980 | 2364480000 | 2364.48 | 1438392000 | 1438.392 |
| 2042 | 33.24 | 315780000 | 315780 | 2393280000 | 2393.28 | 1455912000 | 1455.912 |
| 2043 | 33.63 | 319485000 | 319485 | 2421360000 | 2421.36 | 1472994000 | 1472.994 |
| 2044 | 34.03 | 323285000 | 323285 | 2450160000 | 2450.16 | 1490514000 | 1490.514 |
| 2045 | 34.41 | 326895000 | 326895 | 2477520000 | 2477.52 | 1507158000 | 1507.158 |
| 2046 | 34.79 | 330505000 | 330505 | 2504880000 | 2504.88 | 1523802000 | 1523.802 |
| 2047 | 35.18 | 334210000 | 334210 | 2532960000 | 2532.96 | 1540884000 | 1540.884 |
| 2048 | 35.57 | 337915000 | 337915 | 2561040000 | 2561.04 | 1557966000 | 1557.966 |
| 2049 | 35.96 | 341620000 | 341620 | 2589120000 | 2589.12 | 1575048000 | 1575.048 |
| 2050 | 36.35 | 345325000 | 345325 | 2617200000 | 2617.20 | 1592130000 | 1592.130 |

Note : CO₂ = 0.95 kg/kWh, SO₂ = 7.2 g/kWh; NO₂ = 4.38 g/kWh: Traction Energy Consumption is 66%

Source : Estimated for the Climate Change Study of BSRP, 2022-23

Adaptation Measures

As mentioned earlier under Construction Phase mitigation measures Energy efficient system will be adopted at stations and depots. Energy efficient lighting and ventilation will be implemented at Stations, depots and trans-modal cars. Additionally, Solid Waste Management and Waste water recycling systems will be adopted at stations and depots (Section 8.11.7 – Risks and Impacts due to Depots and Stations for Solid Waste and Waste water Management during Operation Phase).

In future, there is possibility of BSRP to switch on to total harnessing of natural sources of energy, such as solar power for lighting and ventilation, which will further contribute to savings in CO₂ emission during maintenance facilities at stations and Depots. Additionally, the application of technical efficiencies in construction plant and equipment will also provide opportunities for greater efficiency; expected benefits, reduction in potential risks and costs.

Table 8.8 presents total savings in reduction in CO₂ Emission due to reduced plying Vehicles as positive impact because of BSRP implementation along with annual projected estimate. **Table 8.9** presents net savings in CO₂ emission during operation of BSRP after 5 Years (includes plying vehicular CO₂ emission

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and CO₂ emission during operation of Suburban Rails). Net saving is approximately 710.45 Cr Tonnes of CO₂ emission due to BSRP.

Table 8.8. Net Savings in plying Vehicular CO₂ Emission (in Tonnes/Year) due to Project Implementation

| CO ₂ Reduction due to BSRP | 2025 | 2031 | 2041 | 2051 |
|---|--------------|--------------|--------------|--------------|
| Reduction in CO ₂ Emission with BSRP | 1,50,598.58 | 2,05,183.65 | 2,69,340.17 | 3,53,557.05 |
| CO ₂ Emission without BSRP | 21,16,764.97 | 25,06,695.54 | 29,94,108.38 | 35,76,296.27 |
| Overall Reduction in CO ₂ Emission | 19,66,166.38 | 23,01,511.89 | 27,24,768.21 | 32,22,739.22 |
| Reduction in CO ₂ Emission in % | 92.89 | 91.81 | 91.00 | 90.11 |

Source : Feasibility Report, 2019 and EIA Report of DPR for BSRP, 2022

Table 8.9. Savings in CO₂ Emission during Operation of BSRP after 5 Years

| Savings in CO ₂ Emission during BSRP Implementation | 2031 | 2041 | 2051 |
|---|-------------------|-------------------|-------------------|
| Savings of CO ₂ Emission | 7,10,49,63,677.88 | 7,10,53,86,934.26 | 7,10,58,84,905.30 |
| Total CO ₂ Emission with BSRP Implementation (in Tons) | 4,47,433.60 | 5,11,590.18 | 5,95,807.00 |
| Net Savings in CO ₂ Emission (in Tons) | 7,10,45,16,244.28 | 7,10,48,75,344.08 | 7,10,52,89,098.30 |
| Net Savings in CO ₂ Emission (in Million Tons) | 7,104.52 | 7,104.88 | 7,105.90 |
| Net Savings in CO ₂ Emission (in Crore Tons) | 710.45 | 710.49 | 710.53 |

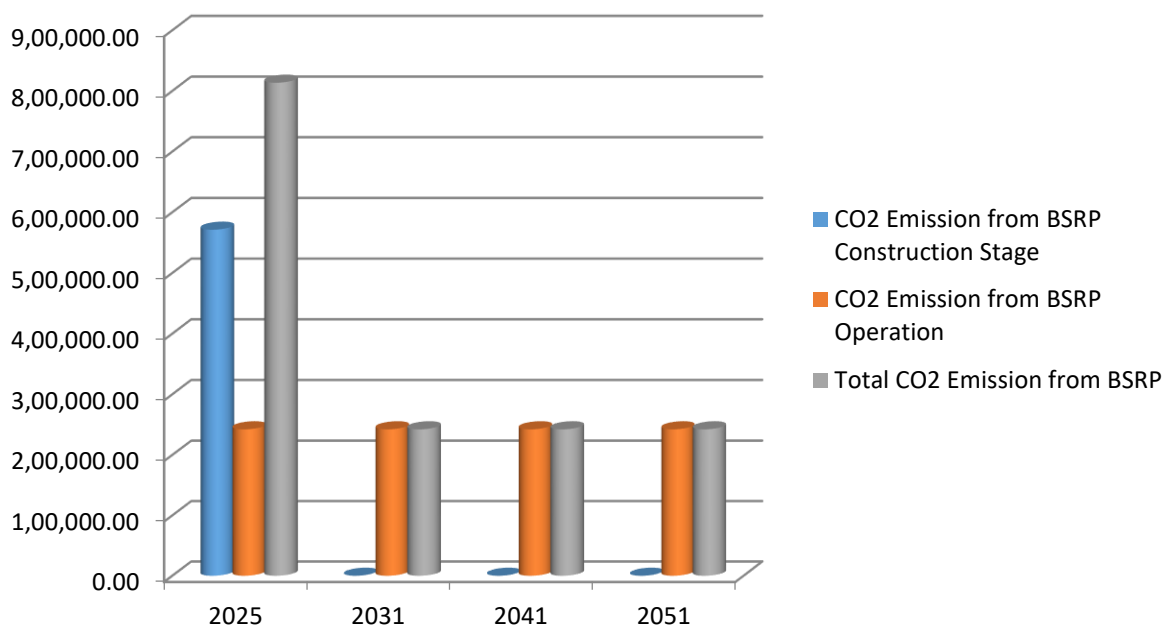


Figure 8.5. CO₂ Emission during BSRP Execution

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Figure 8.5 depicts the CO2 emission during the Construction and Operation Stages of BSRP. Emissions from power generation necessary for Suburban Rail operation have been deducted from the CO2 emission savings. Electricity consumption of the train operation depends on the Specific Electricity Consumption of the train (0.045 kilowatt hour per gross ton kilometer), the total line length, the number of trips per day, the composition of the train, the number of persons transported, and the amount of electricity regenerated by the train itself (30% regeneration as per DPR). Electricity consumption of stations and depots is calculated with a 50% increase over the lifetime of the project, corrected for the expected amount for electricity generated by solar power at stations and depots.

Gross CO2 emissions from the operations of WB-EIB funded proposed rail transport project were estimated as 4,47,433.6 tons, or an decadal average of 5,18,276.93 Tons. CO2 emission and Savings in CO2 Emission for decadal predictions is presented in Tables 8.10 and 8.11 and depicted in **Figure 8.6** and **Figure 8.9**.

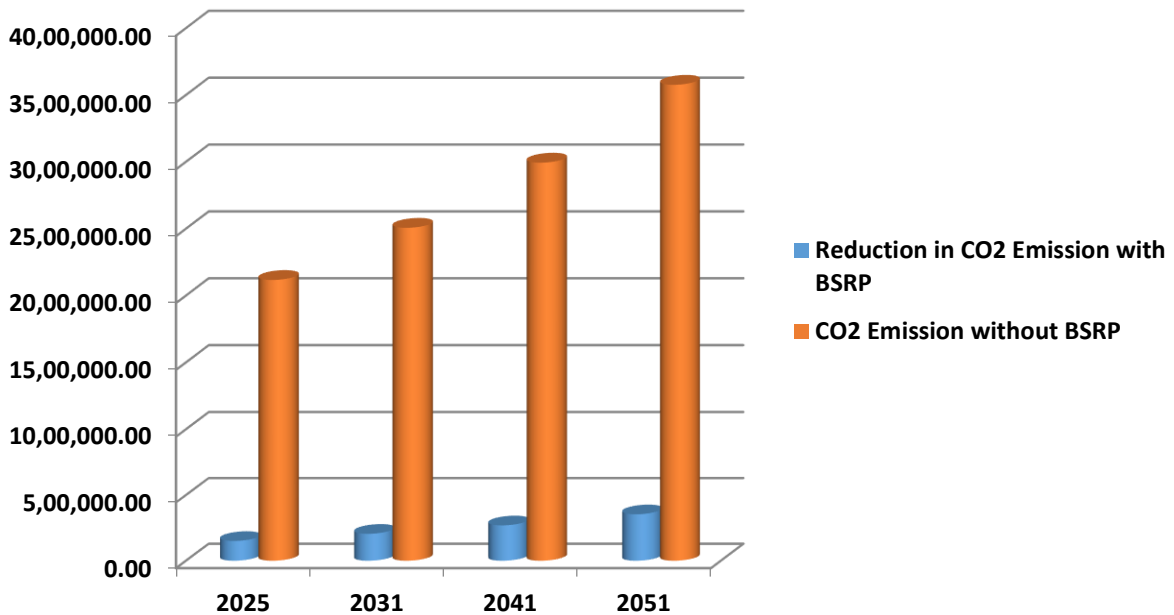


Figure 8.6. CO2 Emission with and without BSRP Implementation

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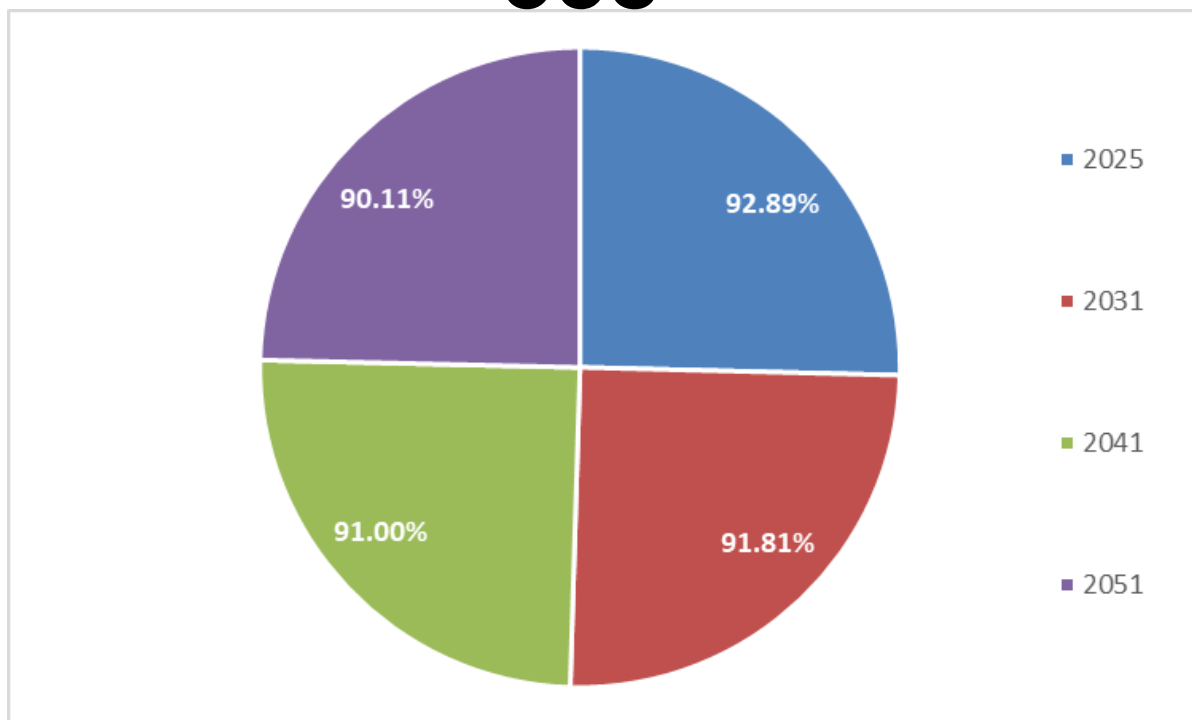


Figure 8.7. Savings of CO2 Emission during BSRP Implementation

8.3.5.5. Climate Change Risks and Vulnerability Assessment (CRVA)

The methodology for CRVA study is based on the Desk Study & Reviews and on-line Consultations with stakeholders, Engineers and Experts. World Bank (WB ESS 3 – ‘A’ Management of air Pollution under Resource Efficiency and Pollution Prevention and Management) and EIB Guidelines (EIB ESS 5 – Climate Change) have been followed during this study for Climate Change Risks Vulnerability Assessment (CRVA). The summarised Assessment is presented in this Section. A detailed CRVA Report is enclosed as **Annexure 10.41**.

8.3.5.6. Climate Change in the Project Area (Bengaluru)

Over the past decade, the climate of Bengaluru is observed to have changed as a result of rapid urbanization and heat island effect, increasing pollution, and obliteration of vegetation and water bodies. The maximum temperature in Bengaluru Urban has risen to as high as 38°C to 39°C during April–May while in earlier decades it hardly exceeded 35°C. The summer season extends from March to May and the winter extends from January to February.

Average Annual rainfall in Karnataka is 1,151 mm. About 80% of rainfall is received during the southwest monsoon, 12% in the post-monsoon period, 7% during summer, and 1% in winter. The mean annual rainfall is around 875 millimeters (mm) spread over about 50 days in a year. Over half of the rainfall comes during the late monsoon months of August to October. Cyclonic rains occur during November and December while there is virtually no rainfall during January–March. Bengaluru receives both southwest as well as northeast monsoons.

8.3.5.7. Baseline Natural Hazards

In the name of development and demand for land, low-lying flood plains as well as the city’s numerous lakes are transformed for urban infrastructure with previous lessons unaccounted. The conversion of

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natural land to impervious surfaces has resulted in faster rainfall–runoff processes and reduced recharge. The city was affected by recent flood in 2022 due to intense rainfall. Flood waters entered into buildings, leaving people stranded in knee-deep water. The recent flood affected the city with inundation of water, particularly low lying areas and roads without proper draining facilities. The overflowing drains inundated roads and low-lying areas of the city, took 6 days to recede due to inadequate storm water drain infrastructure. The municipality has taken required action to improve the storm water drain infrastructure. Currently, necessary measures have been adapted by the Municipality i.e. Bruhat Bengaluru Mahanagara Palike, to climate change aspects such as urban floods.

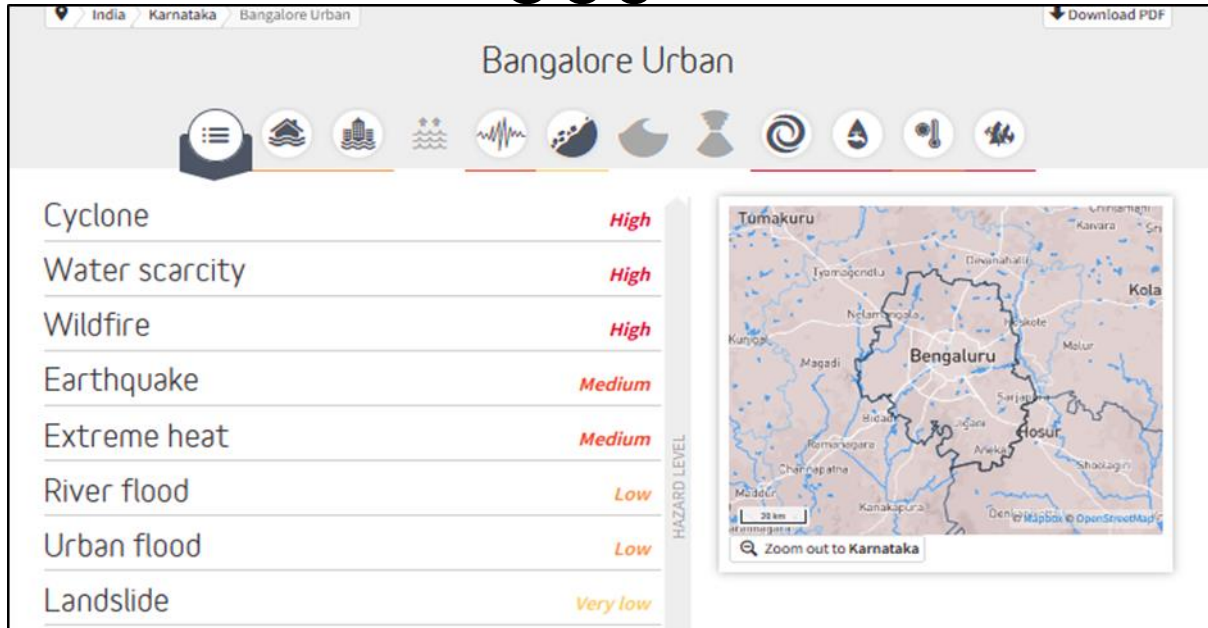
Climate change raises very concrete challenges for the project. With majority of the lines being elevated, structures are exposed to excessive heat, causing damage and disruption of rail operations. Increased temperature, heavy precipitation and risks of fluvial flooding are the common Climate change concerns along with cyclonic winds and showers. It is to be remarkably noted that cyclone wind risks cannot be totally mitigated, and damages are not limited to wind but also include cyclone-induced heavy rainfall and subsequent flooding.



Figure 8.8. Exhibits of Flood impacts on Bengaluru's Transport System

By using the web based tool and applying it specifically to Bengaluru, the likelihood of natural hazards such as cyclones, water scarcity, earthquake, extreme heat, river flood, and urban flood is identified with risk levels categorized as very low, low, medium, and high. The screenshot shown in **Figure 8.9** is reproduced from the ThinkHazard webpage for Bengaluru Urban.

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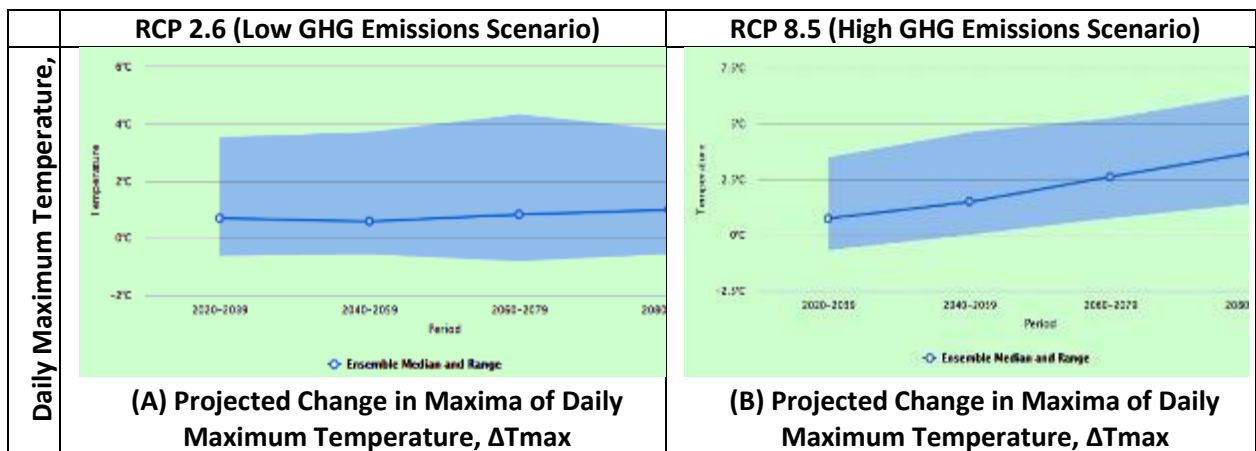
Source: ThinkHazard

Figure 8.9. Likelihood of Natural Hazards in Bengaluru

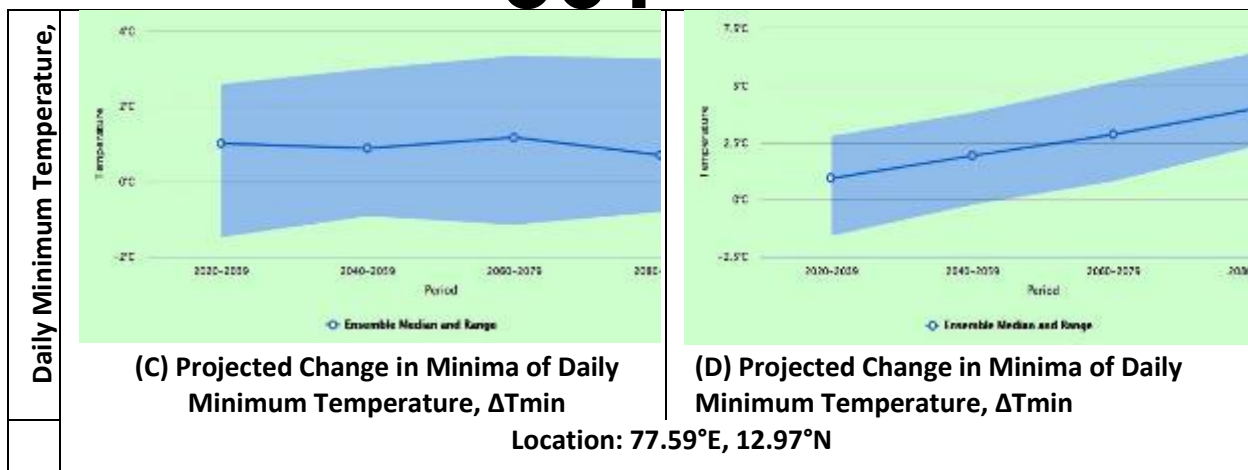
8.3.5.8. Future Climate Projections

Temperature

A set of worldwide climate models are cradled in the World Bank’s Climate Change Knowledge Portal (CCKP) (World Bank Group) to help decision makers understand the projections of future climate change and related impacts. The significant variables in the design of various civil elements of land transport infrastructure include mainly temperature extremes with their diurnal ranges rather than average temperatures. The projected changes (anomalies) in daily maximum temperature (Tmax) and daily minimum temperature (Tmin) over the period of interest and relative to the reference period (1986–2005) for Bengaluru located at around 77.59°E, 12.97°N, are illustrated in **Figure 8.10**. The contrast in temperature anomalies estimated under lower and upper representative concentration pathways (IPCC, 2014) RCP2.6 and RCP8.5, respectively, are presented in the charts below.



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GHG = greenhouse gas, RCP = representative concentration pathway, T_{max} = daily maximum temperature, T_{min} = daily minimum temperature.

Source: World Bank’s Climate Change Knowledge Portal.

Figure 8.10. Projected Changes in Temperature for Various Timeframes

The **Table 8.10** presents the midterm (2021–2050) projections of temperature and precipitation for the districts of Bengaluru Urban and Bengaluru Rural.

Table 8.10. Projected Increase in Mean, Maximum, and Minimum Temperatures, 2021– 2050

| Districts | Projected Increase in Mean Temperature | | |
|-----------------|--|---------------------|---------------------|
| | $T_{av}, ^\circ C$ | $T_{max}, ^\circ C$ | $T_{min}, ^\circ C$ |
| Bengaluru Urban | 1.96 | 2.06 | 1.88 |
| Bengaluru Rural | 1.97 | 2.06 | 1.91 |

T_{max} = mean maximum temperature, T_{min} = mean minimum temperature, T_{av} = mean temperature.

Source: Karnataka Climate Change Action Plan.

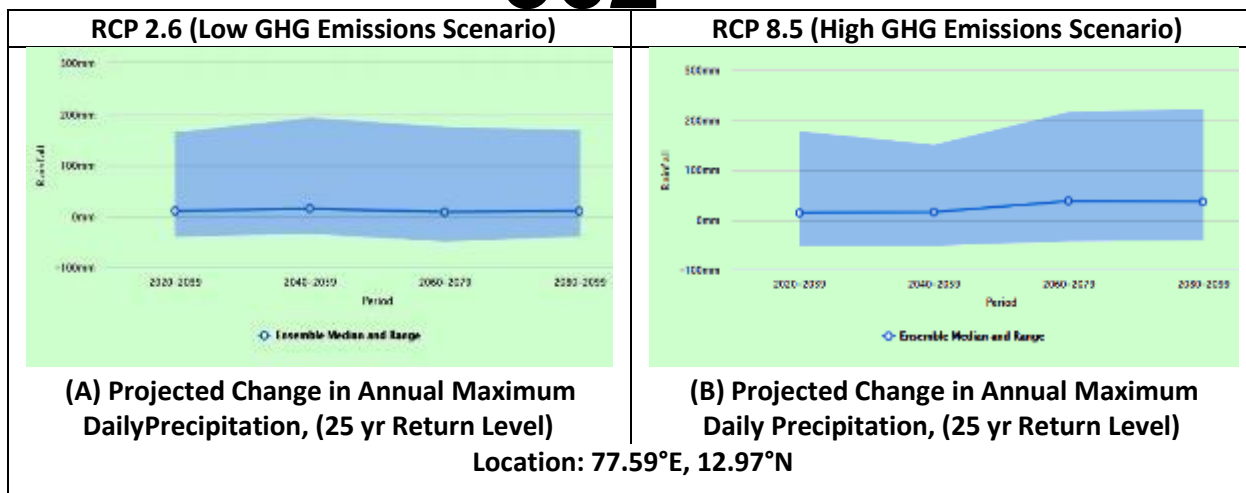
Heat Waves

It is predicted that extreme heat waves will become more and more common worldwide because of raise in average global temperature. The mean maximum temperature in Bengaluru is projected to increase by around 2.06°C in the 2030s, which means the extreme upper temperature is also progressively pushed up.

Rainfall

Usually changes in extreme precipitation are analyzed based on the evolution of the percentiles of the daily precipitation. However, in engineering design application, the magnitude of daily maximum rainfall or return level and the associated frequency of extreme rainfall event or return period, are imperative. The projected rainfall changes for 25-year return periods under lower RCP 2.6 and upper RCP 8.5 scenarios are illustrated in **Figure 8.11**. A 25-year return level of daily precipitation is the maximum daily rainfall that can be expected once in an average 25-year (i.e., 4% chance) period with the possibility that two or more events of that magnitude can occur in much shorter intervals.

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GHG = greenhouse gas, RCP = representative concentration pathway.

Source: World Bank’s Climate Change Knowledge Portal.

Figure 8.11 Projected Change in 25-year Return Level of Maximum Daily Precipitation (mm)

As per Karnataka Climate Change Action Plan, the climate change projections are given for mean change in annual and seasonal precipitation and are compared with the reference period (1961–1990) for Bengaluru Urban and Bengaluru Rural. The same is illustrated in **Table 8.11**. In general, the value of seasonal precipitation change varies between -15% and +36%.

Table 8.11. Projected Change in Annual and Seasonal Rainfalls, 2021–2050 (SRES A1B Emissions Scenario)

| No. | Districts | Projected Change for | | | | |
|-----|-----------------|----------------------|----------------|-----------------|----------------|-----------------|
| | | JFMonths (%) | MAM Months (%) | JJAS Months (%) | OND Months (%) | Annual Mean (%) |
| 1 | Bengaluru Urban | -15.11 | 29.92 | -2.89 | 10.14 | 3.66 |
| 2 | Bengaluru Rural | 3.05 | 36.30 | -2.31 | 9.61 | 3.56 |

JF = January/February, JJAS = June/July/August/September, MAM = March/April/May, OND = October/November/December.

Source: Karnataka Climate Change Action Plan

8.3.5.9. Climate Change Risks and Adaptation Measures

The potential impacts of climate change on BSR infrastructures/assets are compiled and briefly outlined here. These impacts call for careful consideration of rail design, construction, and maintenance to achieve lasting benefits.

Weather-related hazards are already among the factors most frequently causing disturbances for railways. Temperature, rainfall along with Flooding, storm and humidity are the major climate parameters that could impact the suburban railway infrastructure in Bengaluru, whereas snow, permafrost, storms and sea-level rise factors are not applicable to BSRP as the city is far away from Sea and snow falling regions. Climate risks are summarized as given below :

- Primary climate change risks that can impact the project in the short to medium term are temperature increase and variability of rainfall, particularly the increases during the monsoon seasons.

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- Observed trends in the state show a slight increase in annual maximum and mean temperatures, which are also reflected in future projections (SRES A1B and RCPs 2.6 and 8.5) of annual and monthly average temperature, and minimum and maximum temperatures.
- Long-term climate change risks that could impact projects are flooding from extreme rainfall events, particularly during monsoon periods, and increases in annual average temperature in the project area that could increase the risk of extreme hot days. Heat waves and flooding appear as priority threats, particularly urban flooding as a result of increase in impermeable surfaces due to rapid urbanization.
- Storms and more frequent strong cyclones can bring about increased flooding, greater probability of infrastructure failures, erosion of rail track foundation and bridge supports, bridge scour, reduced clearance under bridges, wind damage to roofs of stations, lighting, overhead cables, rail signals, and other tall structures. Power outages during such events will also hamper operations.
- The increase in frequency and magnitude of extreme heat conditions in turn increases the risk of failures due to track expansion. Pervasive changes induced by extreme heat may also lead to deformations and failure of reinforced cement concrete structures. Abrupt temperature changes can cause cracking and spalling of concrete due to thermal shock, and aggregate expansion can also produce distress within the concrete.

Overall Climate Change Risk Assessment is presented in a Matrix, as given below in **Table 8.12**.

Table 8.12. Impact Matrix of Climate Change on Vulnerable Assets of BSRP

| Vulnerable Infrastructure/Assests | Climate Variation/Change | | | | |
|--|--------------------------|----------|-------|------|-----------------------|
| | Temperature | Rainfall | Flood | Wind | Storm/ Cyclone impact |
| Bridges | √ | √ | - | √ | √ |
| Drainage Systems | - | √ | √ | - | √ |
| Railway Tracks | √ | √ | √ | - | √ |
| Culverts | - | √ | √ | - | √ |
| Slip Slopes | - | √ | √ | - | √ |
| Signalling, telecommunication and solar panels | √ | - | - | √ | √ |

Based on the Overall Climate Change Risk Assessment Results the Climate Risks of BSRP are categorised as Medium Risks.

The consequences of these failures can lead to risks such as inconvenience, economic losses due to disruptions, and an increase in carbon emissions due to additional transportation effects to reach the destination; also including serious consequences such as train derailments, damage to the railway infrastructure, and danger to human life.

Other Risks due to Climate Change

Other risks due to climate change include Risks on Biodiversity, Food Safety and Nutrition, Health and Transition climate risks are addressed in the CRVA Report (**Annexure 10.41**).

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Consequences of Climate Risks on Project Infrastructure

The impact of these climate change parameters on vulnerable railway assets leading to several consequences are as follows : track movement, track buckling, track washout, erosion of track bed, over-flooding, falling of trees, higher winds, visibility, drainage system clogging, landslips, disruption of bridge foundations, settlement of edifices, arcing of conductive components, wayside fires, vegetation, etc.

These above events have extreme consequences for the dependability of railway infrastructure and the acceptable level of services by the executing agency - K-RIDE and other stakeholders. Severity of risks may lead to the following :

- Stoppage and / or cancellation of Rail services
- Inefficient acceleration and braking, slower speeds and delays
- Accidents
- Material damage to Rail fleet, equipment and infrastructures

Risk assessment Matrix

Figure 8.12 shows that Risk assessment Matrix with different colours based on likelihood and severity. High risks are highlighted in red, moderate risks in yellow (amber) and low risks in green. Adaptation measures will reduce the high risks to moderate and low risks. Color-coding for a 5×5 risk assessment matrix is to represent the combination level of probability and impact of the identified risks.

| | | Severity | | | | |
|------------|----------------|------------|-------|----------|-------|--------------|
| | | Negligible | Minor | Moderate | Major | Catastrophic |
| Likelihood | Almost certain | 5 | 10 | 15 | 20 | 25 |
| | Likely | 4 | 8 | 12 | 16 | 20 |
| | Possible | 3 | 6 | 9 | 12 | 15 |
| | Unlikely | 2 | 4 | 6 | 8 | 10 |
| | Rare | 1 | 2 | 3 | 4 | 5 |

Figure 8.12. Risk Assessment Matrix (5 X 5)

The performance of adaptation measures depends on their robustness against various possible futures, with varying climate change impacts. Residual impact is associated for each adaptation measures due to the heavy rains, temperature & Wind speed etc. **Figure 8.13** shows that Residual Risk assessment Matrix with different colours based on likelihood and severity.

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| Likelihood ↑ | Severity → | | |
|--------------|------------------|-------|----------|
| | Residual impacts | Minor | Moderate |
| Likely | 3 | 6 | 9 |
| Possible | 2 | 4 | 6 |
| Unlikely | 1 | 2 | 3 |

Figure 8.13. Residual Risk Assessment Matrix (3 X 3)

8.3.5.10. Climate Risk Adaptation Measures of BSRP

The Bengaluru Suburban Rail Project (BSRP) comprises many different interacting infrastructures including earthworks and civil structures, rapid rail track structure, signalling, and many interconnected installations. After understanding the climate change vulnerability of location of BSRP as discussed in previous sections, it is known that BSRP assets are sensitive and vulnerable to critical climate risks. The project specific potential risks by identified significant long term impacts and its management through proper care, concern and pro-actions or potential Adaptation measures are comprehensively assessed and presented in **Table 8.13**.

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Table 8.13. Climate Risk Assessment and Adaptation Plan for Construction and Operation Phase including Maintenance of BSRP

| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency |
|---------|---------------------------|--------------------|---|---|------------|----------|------------|--|---------------------|---|-------------------------------|---|--|
| 1 | Precipitation / Rain fall | | | | | | | | | | | | |
| A | Low / Medium Rainfall | Medium to Moderate | - | Increased risk of earthwork failures due to desiccation. | 4 | 3 | 12 | De-vegetation programme, Re-ballasting and tamping interventions | 1 to 2 | Section-8B: Technical Specifications. Chapter-2 Suitability of Subsoil & Ground Improvement Techniques Section-8B: Technical Specifications. Clause 3.4 Cross Slope of Formation Section-8B: Technical Specifications. Clause 4.3.1 Geotextile Clause 4.3.2 Geogrid | 570 – 578 580 595 - 597 | The cost of work is included in the respective construction activity. | Implemented during the construction stage/ Implemented by the Contractor/ Monitored by GC to BSRP & K RIDE |
| B | High Rainfall | Major | Flooding (surface water, fluvial, groundwater); infiltration and Landslides | Increased risk of earthwork failure and groundwater content in low-lying areas; landslides in wet weather landslide. Infrastructure slope failure; bridge scour; | 4 | 4 | 16 | Construction Phase : (i) Usage of Protection boxes to shield equipment that can't be moved or require protection and ventilation. (ii) Adopting Equipment protection systems safeguard essential equipment and items that cannot be | 3 to 4 | Section-8A Employer's Requirement Clause 14 Turfing/ Planting Clause 15 Provision of Jute Geo Textile | 277 277 | The cost of work is included in the respective construction activity. | Implemented during the construction stage/ Implemented by the Contractor/ Monitored by GC to BSRP & K RIDE |

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| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency | |
|---------|---------------------------|-------|-------------------|---|------------|----------|------------|---|---------------------|--|----------|--------------------------|--|--|
| | | | | <p>flooding of track, depots, buildings; water damage to electronic equipment.</p> <p>Track buckling/washout line closure</p> <p>Reduced operating speeds</p> | | | | <p>relocated from flood-prone areas.</p> <p>(iii) Flood panels serve as door barriers during hurricanes, offering excellent defense against flooding and water damage and for protection of construction materials.</p> <p>(iv) Usage of Compression panels for glass during emergency, to create a sealed flood protection barrier around openings, preventing water entry.</p> <p>(v) Flood barriers offer a strong, long-term solution to protect buildings.</p> <p>(vi) Conducting Awareness programs for working staff and local Community.</p> | | | | | | |

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| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency |
|---------|---------------------------|-------|-------------------|---|------------|----------|------------|---|---------------------|--|----------|--------------------------|--|
| | | | | | | | | <p>Flood Preventive and Control Measures shall be in compliance with IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020.</p> <p>Operation Phase : Planting of 'protection Trees' Slope stabilisation programmes including installation of retaining walls, soil nails and sheet piles Counterfort retaining drains in slopes and crest drain refurbishment..</p> <p>Regular monitoring during rainy season.</p> <p>Review and update Asset Risk Assessment and Action Plan in line with implementation timetable with identification of standards to be updated to take account of climate change.</p> | | | | | |

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| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency |
|---------|---------------------------|----------|-------------------|--|------------|----------|------------|---|---------------------|--|-----------|---|--|
| | | | | | | | | <p>Conducting Awareness programs for working staff and local Community.</p> <p>Flood Preventive and Control Measures shall be in compliance with IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020.</p> | | | | | |
| | | Moderate | Inland erosion | <p>Over flow from Culverts and Cross Drainages</p> <p>Disruptions from blockages affecting track stability</p> | 3 | 4 | 12 | <p>Applicable Measures for High Flood Control as provided above shall be followed during construction and operation phases.</p> <p>Periodic cleaning of drainages with the cooperation of BBMP and Local Authorities.</p> | 1 to 2 | <p>Section-8B: Technical Specifications.</p> <p>Chapter 8: Erosion Control of Slopes</p> | 641 - 649 | The cost of work is included in the respective construction activity. | Implemented during the construction stage/ Implemented by the Contractor/ Monitored by GC to BSRP & K RIDE |
| | | Moderate | | Increased risk of bridge scour arising from flood events. | 4 | 3 | 12 | Bridge scour protection programmes shall be followed. | 3 to 4 | Drainage Arrangement Drawing | - | The cost of work is included in the respective construction activity. | Implemented during the construction stage/ Implemented by the Contractor/ Monitored by GC to BSRP & K RIDE |

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| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency |
|---------|---------------------------|----------|-------------------|---|------------|----------|------------|--|---------------------|---|---------------------------|---|--|
| | | Minor | Flooding | Infrastructure slope failure; track misalignment; misalignment of poles supporting overhead lines Reduced operating speeds | 2 | 5 | 10 | Increase capacity of spillways and culverts. Embankment protection through tree plantings, Vegetation. Improvement of longitudinal ditches and drains Green planning. Increasing height of Station Entrances. Increase road embankment level to at least 0.5 m over the maximum flood level | 1 to 2 | Section-8B: Technical Specifications. Chapter 1: Soil Exploration & Survey Section-8B: Technical Specifications. Clause 3.11 Height of Embankment and Formation Layer Thickness Section-8B: Technical Specifications. Chapter 8: Erosion Control of Slopes | 564 592 642 | The cost of work is included in the respective construction activity. | Implemented during the construction stage/ Implemented by the Contractor/ Monitored by GC to BSRP & K RIDE |
| | | Moderate | | Failure of other structure supports due to increased risk of scour Standing water fouling track ballast. | 3 | 4 | 12 | Applicable Measures for High Flood Control as provided above shall be followed during construction and operation phases. Expanding drainage capacity , Discharge | 1 to 2 | Section-8B: Technical Specifications. Clause 6.2.5 Drainage Arrangements in Embankments and Cuttings | 628 - 631 | | |

| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency |
|---------|---------------------------|--------|----------------------------------|--|------------|----------|------------|--|---------------------|---|----------|---|--|
| | | | | Reduced operating speeds | | | | Capacity for infrastructure including culvert size, design for new flood event thresholds, Increasing maintenance including clearing debris from culverts to reduce flooding Installation of emergency culvert etc., Installation of pumped drainage solutions. Double twisted hexagonal woven steel wire mesh | | Section-8A Employer's Requirement Clause 44: RoB Drainage | 277 | | |
| | | Minor | | Voluminous Mud flow causing structural damage to infrastructure. Reduced operating speeds | 2 | 5 | 10 | Installation of containment channels and dikes, Revetments using riprap, gabion mattresses and concrete facings Anchors, geo-grids and micro-piles | 1 to 2 | Section-8B: Technical Specifications. Chapter 8: Erosion Control of Slopes | 642 | The cost of work is included in the respective construction activity. | Implemented during the construction stage/ Implemented by the Contractor/ Monitored by GC to BSRP & K RIDE |
| 2 | Temperature | | | | | | | | | | | | |
| A | High Temperature | Medium | Heat waves; wildfire (very rare) | Track buckling line closure; thermal expansion in structures and/or | 3 | 4 | 12 | Construction Measures : Change Rail installation procedure to increase temperature threshold for thermal expansion. | 1 to 2 | Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020) | | | |

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| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency |
|---------|---------------------------|-------|-------------------|---|------------|----------|------------|---|---------------------|--|----------|--------------------------|--|
| | | | | <p>associated misalignment problems.</p> <ul style="list-style-type: none"> Track stability may be affected. Disposition of high-risk track segments may lead to incidences of high temperatures. Reduced operating Speeds. | | | | <p>During extreme winter and summer, ambient temperature should be monitored and necessary steps shall be taken to cold/hot weather concreting as applicable.</p> <p>Using measures such as preventive grinding and milling to minimize the effects of temperature variation.</p> <p>Measures during Concreting in Hot Weather:</p> <p>DOs:</p> <ul style="list-style-type: none"> Depute competent inspection personnel at site to anticipate the need for requirements during hot weather concreting and ensure them. <p>When temperature conditions are critical, carry out concreting during evening or night.</p> <ul style="list-style-type: none"> If ambient temperature is likely to exceed 40 degree Celsius during period of concreting, start | | | | | |

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| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency | |
|---------|---------------------------|-------|-------------------|---|------------|----------|------------|---|---------------------|--|----------|--------------------------|--|--|
| | | | | | | | | concreting only if arrangements for hot weather concreting are in place. <ul style="list-style-type: none"> • Plan the locations of construction joints ahead of time with hot weather contingencies in mind. • Do not add water to pre-mixed concrete at the job site unless it is part of the amount required initially for the specified maximum water-cement ratio and the specified slump. • Use all available means to maintain the materials at as low temperatures as practicable. • Provide shades on stockpiles to protect them from direct rays of the sun. • Sprinkle water on the coarse aggregate piles & apply moisture correction accordingly. • Use cold water in concrete and keep it cold by protecting pipes, water storage tanks, etc. | | | | | | |

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| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency |
|---------|---------------------------|-------|-------------------|---|------------|----------|------------|---|---------------------|--|----------|--------------------------|--|
| | | | | | | | | <ul style="list-style-type: none"> • Mix ice directly into the concrete as part of the mixing water. • Design the mix with minimum cement content consistent with other functional requirements. • Use lower heat of hydration cements instead of that with greater fineness and high heat of hydration. • Check concrete temperature frequently using a metal clad thermometer by embedding it in concrete. • Keep the mixing time to the minimum as required to ensure adequate quality and uniformity. • Paint the exposed mixer surface yellow or white, cover it with hessian cloth and spray cool water. • Keep the period between mixing and delivery to an absolute minimum. | | | | | |

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| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency |
|---------|---------------------------|-------|-------------------|---|------------|----------|------------|--|---------------------|--|----------|--------------------------|--|
| | | | | | | | | <ul style="list-style-type: none"> • Coordinate the delivery of concrete with the rate of placement to avoid delays in delivery. • Sprinkle forms, reinforcement, and subgrade with cool water just prior to placement of concrete. • Wet the area around the work to cool the Surrounding air and increase its humidity. • Deploy ample personnel to place concrete immediately on delivery to minimise the delay losses. • Place concrete in thin layers and small areas to reduce time interval between consecutive placements. • Moist fresh the concrete by means of fog sprays, wet hessian cloth, cotton mats, or other means if cold joints or cracks tend to form, especially shortly after placement and before finishing. | | | | | |

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| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency |
|---------|---------------------------|-------|-------------------|---|------------|----------|------------|---|---------------------|--|----------|--------------------------|--|
| | | | | | | | | <ul style="list-style-type: none"> • Protect the concrete from evaporation of moisture, preventing ingress of external water, by means of wet (not dripping) gunny bags, hessian cloth, etc., immediately after consolidation and surface finish. • Commence the moist curing once the concrete has attained some degree of hardening sufficient to withstand surface damage (approximately 12 hour after mixing). • Sprinkle water on formed surface while forms are still in place. Keep the vertical and steeply sloping formed surfaces moist by applying water to the top surfaces prior to and during form removal. • Keep the exposed surfaces moist by wet curing & Provide wind breaker wherever possible. | | | | | |

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| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency |
|---------|---------------------------|-------|-------------------|---|------------|----------|------------|---|---------------------|--|----------|--------------------------|--|
| | | | | | | | | <ul style="list-style-type: none"> • Spray the covering material with water to keep them soaked. • Heavily reinforced area should be given special attention. <p>DONTs:</p> <ul style="list-style-type: none"> • Use such large chunks of ice that do not melt down completely before mixing is completed. • Use concrete if its temperature is above 40 degree Celsius • Rely on the protection afforded by forms for curing in hot weather. • In initial stages of hardening, temp of curing water should be approximately equal to that of concrete. • Remove wet covers until they are completely dry. • Delay in finishing air entrained concrete in hot weather. • Let the concrete surface dry during curing causing | | | | | |

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| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency |
|---------|---------------------------|-------|-------------------|---|------------|----------|------------|---|---------------------|--|----------|--------------------------|--|
| | | | | | | | | alternate drying and wetting conditions. <ul style="list-style-type: none"> • Prolong mixing. • Finish slabs prematurely, e.g. While bleed water is still on the surface. <p>Operation Measures : Change Rail installation procedure to increase temperature threshold for thermal expansion. Replacement of jointed track with continuously welded Rail.</p> <p>Painting Rails white in areas of known high risk to thermal expansion by direct sunlight.</p> <ul style="list-style-type: none"> • Regular monitoring during summer season at extreme temperatures. • Review and update Asset Risk Assessment and Action Plan in line with implementation timetable | | | | | |

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| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency |
|---------|---------------------------|-------|-------------------|---|------------|----------|------------|---|---------------------|---|----------|--------------------------|--|
| | | | | | | | | with identification of standards to be updated to take account of climate change To overcome the same, provision of thermal joint/ expansion joint is required to be provided. Eventually, sensors may be installed directly on the tracks to monitor rail stresses in real time and implement an early warning system. | | | | | |
| | | Minor | | Expansion of moveable assets such as swing bridges hindering operation. Reduced operating speeds | 2 | 4 | 8 | Sprinkler systems Replacement of bridges with heat resistant materials with lower thermal expansion coefficients | 1 to 2 | Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020) | | | |
| | | Low | | General increase in failure rate of assets in high temperatures. | 3 | 2 | 6 | Use of coolers, fans and air conditioning to improve tolerance of signaling equipment. Double-skinned | 1 to 2 | Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020) | | | |

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| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency |
|---------|-------------------------------|----------|-------------------------------|--|------------|----------|------------|---|---------------------|---|----------|--------------------------|--|
| | | | | Reduced operating speeds | | | | equipment casing to assist cooling | | | | | |
| | | Low | | Sagging of the overhead line equipment. Reduced operating speeds | 2 | 3 | 6 | Removal of fixed termination overhead line equipment Improved balance weight and head span technologies. Provision of Counter weights | 1 to 2 | Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020) | | | |
| | | Low | | Increased fire risk. Reduced operating speeds | 2 | 4 | 8 | Vegetation management along tracks | 1 to 2 | Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020) | | | |
| B | Low Temperatures | Low | - | Rail fracture, weld failure, cracks and/or associated misalignment problems. Reduced operating speeds | 1 | 2 | 2 | Proper Supervisions and Inspections Only ornamental trees will be planted at embankments, slope etc. | 1 | Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020) | | | |
| 3 | High Wind Speed – Wind Storms | Moderate | Tree fall; wind-blown objects | Increased risk of leaf fall leading to low track adhesion Rolling stock instability | 3 | 4 | 12 | Leaf Removal and partly de - vegetation programmes. During Operation & Maintenance Stage, | 3 to 4 | Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020) | | | |

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| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency |
|---------|---------------------------|----------|---|--|------------|----------|------------|--|---------------------|---|----------|--------------------------|--|
| | | | Severity of gusts at higher wind location | | | | | periodic cleaning will be carried out. | | | | | |
| | | Moderate | Tree fall; wind-blown objects | Damaged trees and debris falling onto track Downed power lines; structural damage and/or track misalignment by fallen trees/wind-blown objects. Reduced operating speeds | 3 | 4 | 12 | De-vegetation programmes Establishment of tree-free zones in Rail corridor and control measures to avoid debris falling. | 3 to 4 | Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020) | | | |
| | | Major | Tree fall; wind-blown objects | Excessive wind loading on structures such as masts and towers. Reduced operating speeds | 3 | 5 | 15 | Strengthening of existing equipment, build in resilience to design of new equipment. Improved overhead wire tensioning systems. | 3 to 4 | Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020) | | | |
| | | Moderate | Tree fall; wind-blown objects | Increased risk of damage to | 2 | 5 | 10 | Install damping devices | 1 to 2 | Measure considered under good engineering practice (Ref. : IRBM : 1998 and | | | |

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| Sl. No. | Climate Change Phenomenon | Scale | Predicted hazards | Predicted Risks/Impacts on Vulnerable Asset or Activity | Likelihood | Severity | Risk Level | Potential Adaptation Measures/ Activities | Residual Risk Level | Section/ Clause in Tender Document (Annexure enclosed) | Page No. | Budget Considered in INR | Implementation Stage/ Implementing agency/ monitoring Agency |
|--|--|-------|--|---|------------|----------|------------|---|---------------------|---|----------|---|--|
| | | | | bridges in high winds. Equipment destruction Reduced operating speeds | | | | | | Handbook on Railway Construction, Second Edition, June 2020) | | | |
| 4 | Lightning and electrical storms | Minor | Risk to line workers Outages of power | Damage to buildings and structures from lightning strikes | 2 | 4 | 8 | Install lightning conductors / arresters. Fitment of surge protection. | 1 to 2 | Station tender: SECTION-8A-Part-2- Employers-Requirements Clause 12.1. (h) | 396 | The cost of work is included in the respective construction activity. | Implemented during the construction stage/ Implemented by the Contractor/ Monitored by GC to BSRP & K RIDE |
| *Management (or non-structural) adaptation measures: e.g., changing the timing of maintenance to account for changing patterns of energy demand and supply, investment in early warning systems or purchasing insurance to address financial consequences of climate variability. These measures can also include enhanced monitoring of existing assets to reduce the risk of failure as climate conditions change. Adaptive management approaches also include provisions to include flexibility from the outset to monitor and adjust to changing circumstances over the assets lifetime. | | | | | | | | | | | | | |
| Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020 and other relevant Indian Railway guidelines | | | | | | | | | | | | | |

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In addition to the above Adaptation Measures towards Climate Risks, the following are the essential measures to be considered to protect railway assets against specific weather hazard events :

- switch protection,
- pile construction for buildings with technical equipment,
- cooling of signals and installation of fans to keep electronic equipment functional during periods of extreme heat,
- increased (preventive) maintenance activities (infrastructure and existing protection systems),
- vegetation clearance and land use regulations along rail tracks,
- installation of (automatic) monitoring systems such as anemometer, water and rain gauge, rail temperature gauge, landslide detectors.
- Boost energy-efficiency programmes – such as efficient provision for natural lighting and Solar lighting (at least one-third of all lightings)
- Adopt efficient lighting such as usage of LED based lighting
- Adopting to updated communication technology for Management of Emergency situations or any other risky situations during operation
- Awareness and Orientation Training to government and local authorities and public

Other asset infrastructures, such as drainage systems, catenary systems, and vegetation management shall be maintained by K RIDE, to reduce their impact due to climate change. Further, K RIDE will follow the guidelines and Preventive measures as per Indian Railway Manual to handle Monsoon Preparedness, Flood events, regular checking of Retaining walls, Rail affecting Tanks, drain cleaning and slope stability in BSRP.

8.3.5.11. Climate Adaptation /Mitigation Plan and Budget

Climate Adaptation Plan for BSRP includes Adaptation measures as follows:

- 1) implementation of Head-hardened 1080 grade steel rails, 60 UIC (at Design Stage itself) to overcome high temperature risks,
- 2) Elevated Rails avoid the impact of Floods on Rail network assets,
- 3) Utilization of Concrete mix materials increased durability, high strength and resistance to overcome flood and erosion impacts.
- 4) Installation of Rainwater harvesting systems at all stations in the viaduct sections of Corridors to overcome high rainfall run-offs and flood
- 5) Construction of Central Water Board approved recharge pits along the median at each pier location to facilitate percolation of runoff into the ground
- 6) Installation of Standby diesel generator sets in case of emergencies, including flooding in BSRP stations
- 7) Provision of Support equipment and plant necessary for maintenance to carry out preventive, restorative, and adaptive maintenance

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- 8) Construction of at-grade and elevated medium capacity rail lines in BSRP with implementation of Specific Environmental Management Action Plan (EMAP) to mitigate impact of pollutants on Climate.

As per estimate, the Cost of Rainwater harvesting/Construction of Recharge Pits is ₹ 312.9 Lakhs. Other costs are included under civil works cost. The main mitigation activity includes Construction of at-grade and elevated medium capacity rail lines in BSRP along with implementation of mitigation measures to reduce CO2 emission during construction stage of the BSRP. Estimated cost is included in the EMP budget. Estimated Savings in GHG Emissions of the project is 7,104.52 tCO2e/year and overall estimated mitigation cost is \$ 19,450.52 million. Out of \$ 19450.52 Million total cost of the project the KfW-EIB is financing 60% of the total civil works cost equivalent to \$11,670.31 million. K-RIDE, a special purpose vehicle formed by the Union Ministry and Gov. of Karnataka is executing authority. Gov. of Karnataka and Union Ministry will bear 20% (i.e. \$ 3,890.10 Million) each of the project cost.

8.3.6. Risks & Impacts on Utility/Drainage System

Risks and Impacts : The proposed Suburban Railway Corridors are planned to run through the urban area at grade (at ground level) in less densely populated and along the existing Railway corridors and above the ground (elevated) in populated and sensitive areas.

As per the Field Study of the proposed project, a large number of sub-surface, surface and Overhead Utility services viz. sewers, water mains, storm water drains, gas pipe lines, telephone/ communication cables, overhead power transmission lines, power cables, traffic signals, etc. exist all along the proposed alignment. Apart from these utilities, South Western Railway's huge network of Traction Power cables, Traction Power Installations, DC and AC traction substations, SPs and SSPs, Signal & Telecommunication cables, traction OHE masts and structures, Signal posts, power supply cubicles, location boxes etc. are spread along and across the entire alignment.

The proposed corridor has been planned to the maximum within Railway's ROW and the some of the utility services and Railways vital installations are encountered at number of locations.

These utility services are very essential and need to be maintained in working condition during different stages of construction, by either temporary or permanent diversions and relocation or by supporting in position. Any interruption to these will have serious repercussions on sensitive Suburban services and direct impact on the commuters, besides setback in construction and project implementation schedule. Meticulous planning, therefore, will be necessary in tackling the issue of.

Mitigation Measures : Since these impact on project implementation and completion time and cost, instigation of required meticulous pre-planning/ action shall be taken for the protection / diversion of these utility services and as well as Railway's vital installations, prior to the commencement of the project activities.

Drains running parallel/across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location. Sewer lines running parallel/across the alignment are not proposed for diversion. But due care will be taken to avoid any damage to above lines. The related Plans and cost of such shifting/diversions are covered in the section on Civil Engineering aspects of Design in DPR.

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All community utilities and properties i.e. hand pumps, open wells, water supply lines, sewer lines, telephone cables, buildings and health centers shall be relocated before only when construction of corridor activities commence. This will be in line with ESS 10 of World Bank & EIB ESS 2.

Residual Impacts: Not applicable.

8.3.7. Potential Social Impacts

8.3.7.1. Risks and Impacts : The following are the risks and impacts on socio-economic environment at the project area.

(i) *Loss of Land*

The proposed Suburban Rail Project shall require land for different purposes. Land is mainly required for stations, running section and depot. Acquisition of land shall make affected families landless, houseless, and jobless in most of the cases.

The data collection in the affected slum could not be completed, due to the reason of non-disclosure of Compensation and Resettlement and Rehabilitation Entitlements related information, as it was not ready and approved by then. The people demanded to disclose the entitlement ma-trix prior to the census and socio-economic survey. However, the Socio-Economic Survey will be done before the timeline provided in RAP Implementation Schedule.

Table 8.14. Overall Social Impacts of the Project

| S. No. | Impact | Corridor-1 | Corridor-2 | Corridor-3 | Corridor-4 | Total |
|--------|---|---------------------------|----------------------------|------------|------------|------------|
| 1 | Land Requirements | | | | | |
| A | Private Land (in Sqm) | 9.06 (including Depot) | 23.12 (including Depot) | 8.39 | 16.31 | 56.88 |
| 2 | Total Structures/buildings Affected | | | | | |
| A | Affected structures/buildings – details received/provided | 51 | 274 | 66 | 66 | 457 |
| B | Affected Common Property Resources | 1 | 15 | 6 | 5 | 27 |
| C | Affected structures/buildings – details not received/ provided* | 33 | 0 | 63 | 69 | 165 |
| | Total | 85 | 289 | 135 | 140 | 649 |
| 3 | Project Affected Households | | | | | |
| A | Affected PAH – Titleholders Owners | 94 | 267 | 106 | 150 | 617 |
| B | Affected PAHs- non Title holders -squatters | 34 | 44 | 43 | 26 | 147 |
| C | Affected PAHs- non title holders -Slum dwellers | 0 | 109 | 0 | 0 | 109 |
| D | Affected PAH - Tenants (These are tenants living in | 11 | 156 | 31 | 30 | 228 |

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| S. No. | Impact | Corridor-1 | Corridor-2 | Corridor-3 | Corridor-4 | Total |
|--------|---|------------|------------|------------|------------|-------------|
| | the properties of titleholders) | | | | | |
| E | Affected Households, details not received/ provided | 33 | 0 | 63 | 69 | 165 |
| F | Affected Workers | 0 | 2 | 0 | 0 | 2 |
| | Total | 172 | 578 | 243 | 275 | 1268 |
| 4 | Number of displaced employees | 9 | 11 | 27 | 17 | 64 |
| 5 | Affected buildings of Titleholder | 44 | 196 | 65 | 66 | 371 |
| 6 | Affected Residential Buildings | 46 | 177 | 48 | 61 | 332 |
| 7 | Affected Commercial Buildings | 4 | 54 | 14 | 5 | 77 |
| 8 | Affected Resi/Comm Buildings | 1 | 43 | 4 | 0 | 48 |
| 9 | Affected Vulnerable PAHs | 47 | 116 | 46 | 8 | 217 |

*Details not available due to House closed, Owner not willing to provide to provide, Owner not available.

Source: iDeCK survey Feb – July 2022

Mitigation Measures : Every effort has been made to keep land requirements to the barest minimum by realigning the alignments away from private property / human habitation. After planning, the land requirement is kept at minimum and particularly, acquisition of private land was avoided. The total land requirement for the project is 233.09 Ha in which 56.88 Ha are private land.

8.3.7.2. Number of Affected Structures

Out of the total 649 affected structures identified; 332 are residential, 77 are commercial, 48 residential cum commercial buildings and 27 are Common Property Resources (CPRs); while 165 have not responded. The table below indicates the impact of project on the different types of structures i.e. residential, commercial, residential cum commercial and other minor structures, such as portion of boundary wall, toilet, car shed, lean to roof etc. Out of these, 282 structures are fully affected and 202 are partially affected.

A total of 85 structures are affected in Corridor-1, 289 structures are affected in Corridor-2, 135 structures are affected in Corridor-3 and 140 structures are affected in Corridor 4. In all the corridors the majority of affected structures are the residential, i.e., 51.16%. The ownership status would be known only after the joint measurement is conducted by the land acquisition team of BSRP and Joint Measurement Certificate is issued.

Photographs of the major structures (Residential, and residential cum commercial) and CPRs are attached as Annexure C (Except for Corridor 2, as it is resurveyed and photographs are yet to be taken). The identification of structures for Corridor-2 is based on available design, which is under finalization, while for other corridors the alignments/ designs are yet to be finalized, and therefore results presented in the table should be considered preliminary for all corridors.

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Table 8.15. Number of Affected Structures

| Partially & fully affected structures | C1 | C2 | C3 | C4 | Total | Percentage |
|---------------------------------------|-----------|------------|------------|------------|------------|----------------|
| Residential | 46 | 177 | 48 | 61 | 332 | 51.16% |
| Commercial | 4 | 54 | 14 | 5 | 77 | 11.86% |
| Resi cum commercial | 1 | 43 | 4 | 0 | 48 | 7.40% |
| CPRs | 1 | 15 | 6 | 5 | 27 | 4.16% |
| Non – responded | 33 | 0 | 63 | 69 | 165 | 25.42% |
| Total | 85 | 289 | 135 | 140 | 649 | 100.00% |

Note: Number of affected structures presented in this table is preliminary. The results of final census for all corridors will be available at a later stage (see Section 1.18).

Table 8.16. Extent of Impact of Affected Structures

| Name of the corridor | Number of Structures | | | | | |
|----------------------|----------------------|--------------|------------|--------------|------------|------------|
| | Fully | Percentage | Partially | Percentage | Total | Percentage |
| Corridor 1 | 43 | 82.69% | 9 | 17.31% | 52 | 100 |
| Corridor 2 | 135 | 46.71% | 154 | 53.29% | 289 | 100 |
| Corridor 3 | 64 | 88.89% | 8 | 11.11% | 72 | 100 |
| Corridor 4 | 40 | 56.34% | 31 | 43.66% | 71 | 100 |
| Total | 282 | 58.26 | 202 | 41.74 | 484 | 100 |

In case of partially affected buildings, a stability assessment would be done by a qualified engineer during the valuation of the structure in consultation with the project affected family, to assess if the remaining part of the building is safe after repairs and renovations. As of now, no preventive demolition, due to structural damage caused by vibration is expected. The exact number of displaced and affected will be finalized after the verification by the engineer. Category wise preliminary impacts are discussed under chapter 7 of this report.

8.3.7.3. Number of Project Affected Tenants and Employees Households

Apart from the structures affected households 228 tenants and 64 employees would also be affected. Tenants are found in both titleholder's and non-titleholders' buildings. The corridor wise affected tenants and employees is presented in below table. The number of open land (land only) affected households would be identified during joint measurement survey and the RAPPIC would do the socio-economic survey during RAP development phase. As mentioned in previous sections, the surveys are yet to be concluded; these surveys will be updated once the designs are finalized and Joint Measurement Certificate (JMC) is issued. The Joint Measurement Surveys for Corridor 2 are in progress.

Table 8.17. Corridor Wise Number of Affected Tenants and Employees Households

| Corridor | Number of Tenants | | | Employees |
|--------------|-------------------|------------|------------|-----------|
| | Residential | Commercial | Total | |
| C 1 | 7 | 4 | 11 | 9 |
| C 2 | 109 | 47 | 156 | 11 |
| C 3 | 24 | 7 | 31 | 27 |
| C 4 | 26 | 4 | 30 | 17 |
| Total | 166 | 62 | 228 | 64 |

Note: (165 to be surveyed structures are not considered for this assessment)

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8.3.7.4. Vulnerable Households

As regards vulnerability among surveyed (excluding the 165 to be surveyed HHs) PAHs, there are 217 PAHs belonging to vulnerable category out of 845 (please see below table). Out of these 59 PAHs are women headed households, 68 PAHs are below poverty line, 21 PAHs having disability and old age persons. Apart from that, 54 and 15 PAHs belong to Scheduled Caste and Scheduled Tribes respectively. Both Scheduled Castes and Scheduled Tribes are considered as vulnerable groups because the Scheduled castes (SCs) and Scheduled Tribes (STs) falls under the provisions of Constitution of India and get preferential treatment in the government benefits because these people are traditionally vulnerable.

Table 8.18. Corridor Wise Affected Vulnerable Households

| Vulnerability | Number of Households | | | | | |
|-----------------------------------|----------------------|-----|----|----|----------|------------|
| | C1 | C2 | C3 | C4 | Total HH | Percentage |
| Women Headed Household | 0 | 54 | 3 | 2 | 59 | 27.19% |
| Below Poverty Line | 7 | 47 | 13 | 1 | 68 | 31.34% |
| Family with disability or old age | 7 | 12 | 1 | 1 | 21 | 9.68% |
| Scheduled Castes | 23 | 70 | 29 | 2 | 54 | 24.88% |
| Scheduled Tribes | 10 | 3 | 0 | 2 | 15 | 6.91% |
| Total | 47 | 116 | 46 | 8 | 217 | 100.00% |

Note: (165 to be surveyed structures are not considered for this assessment)

8.3.7.5. Number of Affected Community Property Resources

Corridor wise details of the affected common property resource are listed shown in below table. No heritage building is affected due to development of BSRP. Majority (66.7%) of the affected CPRs are religious structures.

Table 8.19. Corridor Wise Affected CPRs

| Description | CPRs | | | | | |
|--|------|----|----|----|-------|------------|
| | C1 | C2 | C3 | C4 | Total | Percentage |
| School & Collage (private) | 0 | 2 | 0 | 0 | 2 | 7.41 |
| Community Toilet | 0 | 0 | 0 | 0 | 0 | 0.00 |
| Religious centers (shrines and small temples, boundary wall of the religious centers, etc) | 1 | 11 | 4 | 2 | 18 | 66.67 |
| Railway Gate, Water Tank, CW, Shed/ Building | 0 | 2 | 2 | 3 | 7 | 25.93 |
| Total | 1 | 15 | 6 | 5 | 27 | 100 |

Note: (165 to be surveyed structures are not considered for this assessment)

8.3.7.6. Displacement

Those households who are fully affected due to land acquisition for the project and they are considered for relocation can be referred as Project Displaced Households (PDHs). Out of the total displaced 457 (Residence, commercial and residential cum commercial) households 332 households would be displaced physically (loss of residence), and 77 PAHs would be displaced economically (Source of livelihood), and 48 households will lose their both residence and livelihood due to proposed suburban rail project.

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8.3.7.7. Impacts from Loss of Access to Forest/Agricultural areas

The SIA study reveals that there are no impacts such as loss of access to forest resources or to agricultural areas. The Depot 1 at Akkupete requires 18.62 Ha of forest land. The Forest land to be acquired is within the city (Akkupete). This area does not offer any ecosystem services to nearby communities. This area was used for compensatory afforestation plantation; mostly dominated by Eucalyptus fibrosa and Acacia mangium tree species. No firewood collection, wild fruit collection or any other timber or non-timber forest produce is taking place as this is mostly social forestry; and does not impact any livelihoods. However, no agricultural activity takes place in any of the corridors.

8.3.7.8. Temporary Impacts Because of Construction Disturbance

The SIA study has not identified any temporary impact in relation to loss of income or livelihood due to the construction activities.. There will be temporary impacts due to construction, such as impacts on the Mathikere slum. The EPC contractor will identify temporary land requirements for workers camps, stores, yards, etc. and enter into rental/ lease agreements with land owners. These lease agreements will be submitted to the promotor. Presently, the designs are under process, once these are approved, temporary land requirement for working space will be assessed, impacts due to such temporary land requirement will be included in the corridor wise RAPs to be developed.

8.3.7.9. Impacts on Mobile and Semi-mobile Vendors

The SIA study has not identified any mobile/ semi-mobile vendors at any informal markets crossed by the alignment or stations or depots. However, when the surveys are updated by the RAPPIC, if any such impacts are identified, then they will be included in the corridor wise RAPs to be developed. These are eligible for relocation assistance.

8.3.8. Risks & Impacts on Religious Structures /Archaeological / Historical and Cultural Monuments/ Heritage Sites

Impact on religious structures present along the project corridors were assessed. As mentioned in the **Table 8.18**, there are few religious structures such as temple, shrine, tree shrine, church, mosques, etc., directly affected either a portion of the structure or entire structure. In corridor 1 – 1 structure, in Corridor 2 – 11 structures, Corridor 3 – 4 structures and Corridor 4 – 2 structures are affected due to proposed project improvements. Most of these structures such as tree shrines, shrines, few minor temples are encroachments falling within Indian Railway RoW. However, the affected structures shall be translocated to nearby locations in consultation with local community and Urban Local Body. There are no impacts on burial ground present along the project corridors.

In accordance with the Ancient Monuments and Archaeological Sites and Remains (Amendment) Bill, 2017, the proposed development project under infrastructure projects can be implemented within prohibited areas around protected monuments. As per the field study and assessment, two legally protected Archaeological Monuments / Heritage structures near Corridor 1 – KSR to Devanahalli (Devanahalli Fort - at 228m from the Project Site and Tippu's Birth Place, Devanahalli - at 271m from the Project site) were noticed to be affected (within in 300ms from the archaeological Sites) due to the proposed Suburban Rail project. There will be no construction within the radius of 100m from the above said monuments/heritage centres. Other than these no other archaeological/ historical/ cultural monuments or heritage centres are in the vicinity of the project corridors.

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Risks and Impacts on Tangible and Intangible Cultural Heritage Assets : There is no risk and impact on tangible cultural heritage assets such as visual art, food, clothing, and styles of architecture along and intangible assets such as legends, music, and values like generosity or respect. However, access shall be restricted to the Archaeological heritages at Corridor 1 during construction and operational phases of the project. Alternative access to local community shall be provided to make it convenient to reach to their residence or market or work place, etc.

Mitigation Measures :

Archaeological and Historical/Cultural Properties

As per the base line study and impact analysis, no damage to Archeological Monuments is predicted. However, during construction, archaeological or historical structures may get affected by direct or indirect construction activity. It shall be ensured that no impact is predicted on the ASI Monuments due to project activities.

A prior survey shall also be conducted before construction to identify if there is any historical structure nearby construction sites, which may get impacted. Necessary measures shall be undertaken accordingly, if any. Devanahalli Fort and Tippu Sultan birth Place at Devanahalli are the Archaeological Survey of India Protected monuments located at 228m and 271m respectively to the alignment – Corridor 1, for which necessary procedure will be followed to obtain the necessary construction permit from ASI. Prior to the initiation of construction, K RIDE will inform the ASI authority. The management plan will include ground vibration monitoring during construction and operation of project.

It is therefore specifically mentioned that the proposed project shall be executed with all required mitigation measures with utmost care and concern and particularly, in accordance with the stipulated guidelines of ESS 8 of World Bank; & EIB's ESS 10 and the Ancient Monuments and Archaeological sites and Remains Act, 1958 amended in 2010 and the Ancient Monuments and Archaeological Sites and Remains (Amendment) Bill, 2017.

Corridor 1: Measures shall be implemented to avoid any risks and impacts on legally protected Archaeological Monuments (Devanahalli Fort and Tippu Sultan's Birth Place at Devanahalli) in line with The Ancient Monuments and Archaeological sites and Remains Act, 1958 amended in 2010 (as per the stipulated conditions of ASI) and WB ESS 8 & EIB's ESS 10.

ASI Stipulations to be followed are as follows -

1. Interpretation panels/signage must be provided for the monument.
2. Drainage system should be checked so that the corridor level should not be higher than the monument and water should not enter inside the monument complex.
3. Prior intimation should be given to ASI authority to monitor the site and also to check the impact on monument during /post digging (excavation) process.
4. Prior permission must be obtained from the Competent Authority for any construction or increase in height.
5. A certificate should be furnished to the Competent Authority on completion of proposed construction to effect that it has complied with all conditions of the permission.
6. The compliance must be with the heritage bye-laws of the protected monument concerned as and when the bye-laws are approved.

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Residual Impacts and Measures: No residual impacts are anticipated because it will be ensured by the Contractor during construction stage to follow diligently the guidelines of The Ancient Monuments and Archaeological sites and Remains Act, 1958 amended in 2010 (as per the stipulated conditions of ASI); and in line with WB ESS 8 and EIB Standard 10.

Chance Find Procedures

All fossils, coins, articles of value of antiquity, structures and other remains of archaeological interest discovered on the sites shall be the property of the Government and shall be dealt with as per provisions of the relevant legislation - The Ancient Monuments and Archaeological sites and Remains Act, 1958 amended in 2010 (as per the stipulated conditions of ASI) and in line WB ESS 8 & EIB's ESS 10.

The Contractor shall take reasonable precautions to prevent his workmen or any other persons from removing and damaging any such article or thing. He shall, immediately upon discovery thereof and before removal acquaint the Environmental Specialist of GC of such discovery and carry out the GC's instructions for dealing with the same. Works shall be resumed once approval is obtained from the GC and K RIDE. The GC shall seek direction from the Archaeological Survey of India (ASI) before instructing the Contractor to recommence the work in the site. The Archaeological structures/ materials identified along the project corridors, if any, shall be protected/ preserved or enhanced and handed over to ASI as per the law. The details regarding Chance Find procedure is given in **Annexure 10.5**.

Residual Impacts: No residual impacts are anticipated. The project will be implemented with these above mentioned measures related to Archaeological and Cultural Heritages; and thus, comply with the Indian regulations and WB's guidelines ESS 8 and EIB Standards 10.

8.3.9. Risks & Impacts on Environmental Sensitive Receptors

As mentioned in the **Table 8.18**, there are no direct impact on environmental sensitive features such as educational institutes, Health Centers and court premises except one Health center in Corridor no. 2. There are about 67 environmental sensitive receptors present along the BSRP Corridors. Out of 67 receptors, Corridor 1 is having 8 receptors, Corridor 2 – 24 receptors, Corridor 3 – 23 receptors and Corridor 4 – 12 receptors. Corridor wise detailed list of Environmental Sensitive receptors present along the project is presented in **Table 5.48**. As per the social impact assessment study, there are no affected due to proposed project improvements.

8.3.10. Risks & Impacts on Local Transport Facilities

Risks and Impacts : The proposed project BSRP has been proposed only to gratify the surplus demand of present and future traffic requirement and for the access to essential destinations and metro stations. Therefore, there is no prediction of loss of either facilities or employment to the existing transport facilities and the people concerned. Instead, it supports the additional local transport facilities to cater to the requirement of transport to and fro work place/residence to Suburban stations and vice-versa. As a supplementary impact employment opportunities are predicted due to the proposed project.

Mitigation Measures : Not applicable here as the project has positive/beneficial impacts on local transport facilities.

Residual Impacts and Measures : Not applicable here as the project has positive/beneficial impacts on local transport facilities.

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8.4. Risks & Impacts Due to Project Design & its Mitigation Measures

The potential impacts enlisted due to project design are as given below :

The above issues are highlighted in the following sub-sections.

- Platform Inlets and Outlets
- Risks & Impacts of Noise and Vibration
- Right of Way, Alignment, Track design and Architecture
- Spatial Planning of Stations and Inter Modal Integration
- Consumption of Energy for Illumination, Ventilation and Water at Stations and Depots
- Risks due to Natural Hazards
- Robust Design with Provisions for Green Buildings
- Efficient Material Re-use and Conservation
- Conservation of Flora/Preservation of Trees
- Utility Plan
- Design Improvement to Minimise the Vibration

8.4.1. Risks & Impact of Noise and Vibration

Noise impact at grade line is anticipated in trade off with visual intrusion resulting from elevated line.

Necessary mitigation measures shall be employed during project construction and operation phases. Details are provided under section 8.6.5 and 8.6.6 for construction phase and section 8.7.1 & 8.7.2 for operation phase.

Residual Impacts : There will be insignificant residual impact on the environment. No adverse impact on the ecosystem is anticipated.

The project will be implemented with the above mentioned measures related to avoid impact of noise and vibration; and thus, comply with the Indian regulations and WB's guidelines ESS 8 and EIB Standard 3.

8.4.2. Consumption of Energy for Illumination, Ventilation and Water at Stations and Depots

The proposed project impacts on the Energy consumption as it is required for illumination/lighting and ventilation and water for drinking, sanitation and cleaning purposes, which will affect climate change, if due care is not provided.

Mitigation Measures : The illumination and ventilation system shall be adopted at Suburban Railway Stations and Depots as per the stipulated norms and guidelines of Manual for Standards and Specifications for Railway Stations, June 2009. Proper illumination and aeration/ventilation shall be implemented at required locations at Suburban Railway Stations and Corridors to ease out the public congestion.

As per Indian Green Building Council (IGBC) Standards, BSRP stations / Depots are proposed to be designed and constructed with all possible energy/ resource efficient measures. As per contract in an

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EPC bares, all the sustainable issues, energy conservation requirements are the requirements of design & construction contracts & proper tender conditions are included.

Natural source of energy such as solar energy and natural ventilation or open aeration shall be aimed as prime concern while considering the provision for proper natural lighting and ventilation at Suburban Stations and Depots. Required electricity shall be harnessed with natural source for lighting and ventilation facilities and Power Utilities such as HVAC, Lifts and Escalators etc. The electricity is sourced from existing BESCO / KPTCL.

As per the DPR estimate, Total power demand in BSRP project is estimated as 50 MVA. Detailed Power supply study is being taken up through simulation study of the project to optimize the power consumption and detailed design shall be carried out. The power consumption is also proposed to be augmented through non-renewable energy sources viz. solar energy. The Rolling stock specification is proposed to be with energy regenerating braking system.

The bulk power supply is proposed to be taken from the state power grid in coordination with the state authorities at one or two project locations and distributed through various sub stations to ensure reliable and uninterrupted power supply. K RIDE also intends to follow up with the concerned authorities, regulatory commissions to provide concessional power tariffs as BSRP is a public project.

The project envisages to generate solar energy to the maximum extent as per the Govt. of India policy published by Ministry of Non – Conventional energy. The depots & Station roof design are being proposed with proper orientation / inclination to harness maximum Solar energy. The exact quantum of energy depends once the detailed design is finalised along the corridor.

Resource efficiency measures such as LED lighting, timer for high mast lamps at depots, minimum lightings at stations and parking areas, out operation of water pumps, use of Resistance Temperature Detector (RTD) sensors in axial fans, use of split AC, etc.,

Additionally, consumption of water for drinking and sanitary facilities is significantly attained by proper design of passenger flow inside stations, space & facilities inside stations and multimodal integration facilities outside stations and by required measures and maintenance. The main source of water utilization shall be from Water supply.

Residual Impacts: There will be no residual impact on the environment.

8.4.3. Robust Design with Provisions for Green Buildings

Engineering design of BSRP is as per codal provisions. Application of green concepts during design, construction, operation, maintenance, renovation and demolition enhances to reduce or eliminate negative impacts on environment and creates positive impacts on environment. The “green Building” which is also referred as “Sustainable building” preserves precious natural resources; and improves total quality of life.

Green Building concept is adopted in K RIDE’s Bengaluru Suburban Railway Project in terms of structural design and provisions for better saving of energy and water; and reduction in emission of CO₂. All stations and Depots are designed as green buildings.

The Indian Green Building Council (IGBC), part of the Confederation of Indian Industry (CII) was formed to enable a sustainable built environment for all and facilitate India to be one of the global leaders in

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the sustainable built environment by 2025. IGBC has launched green Mass Rapid Transit System (MRTS) rating system for all stations and green Factory Building rating system for Depots. These rating systems are tools to enable new rail based MRTS to apply green concepts during design & construction, so as to further reduce environmental impacts that are measurable.

The proposed Bengaluru Suburban Railway Project addresses green building features in the following categories Design and Construction - Site selection, Planning and Maintenance, Energy Efficiency, Water Efficiency, Material Conservation and Indoor Environment and comfort. Design and Construction - Site selection, Planning and Maintenance Energy and water efficiency are discussed below. Material conservations during project execution are dealt under the sub-section Mitigation Measures during construction stage. Indoor Environment and Comfort will be considered while providing aesthetics to the Stations. All required care and measures shall be taken while providing comfortable Indoor Environment at Stations during operation, as well as Technical rooms and laboratories at Base Camp and plant sites during construction.

Residual Impacts: No residual impact is anticipated and there will be no impact on ecosystem. Positive impact on environment is predicted.

The project will be implemented with the above mentioned measures and thus, comply with the Indian regulations and WB's guidelines ESS 1 and EIB Standard 1, 3, 4 and 5.

8.4.3.1. Design and Construction Stage

The proposed project requires storage yard, casting yard, assembly yard for building and storage of materials and equipment required temporarily during construction and will be removed or cleared after construction stage, but before operation stage. The site selection and planning during design and construction has a major role in contributing for Green Building features. In this line the criteria to be followed are as follows :

- 500m away from the right of way of National Highway
- 500 m away from habitat and settlements
- 250 m away from flood plains, water bodies and State Highways

Away from the Notified Areas- Reserved Forests, Nature Protection, Sanctuary, Wildlife Sanctuary, Eco-sensitive zones, Historical Monuments, places of tourist interest, etc.

Maintenance of the yards is an important aspect to avoid emission of dust and other particulates into the ambient atmosphere.

Residual Impacts: Insignificant residual impact is anticipated and there will be no impact on ecosystem.

The project will be implemented with the above mentioned measures and thus, comply with the Indian regulations and WB's guidelines ESS 1 and EIB Standard 1, 3, 4, 5 and 10.

8.4.3.2. Utilization of Solar Power

Utilization of Solar power through Solar panels for lighting and aeration at Stations and Depots will not create harmful greenhouse gas emissions. The carbon foot print of solar panels is already quite

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small, as they last for 25 years plus with no loss in efficiency. Also the materials used in the panels are increasingly recycled. Hence, carbon foot print will continue to reduce.

For the utilization of renewable energy, wherever feasible, installations for solar power can be implemented on the roof of elevated stations and in Depots. It is assumed that 75% of roof area of each station can be considered for solar power generation. Energy potential and cost for installations in Depots has not been estimated in this report because amount of land/structure surface area available for this purpose can be estimated up on evaluation of the Depots layouts. However cost of this is not included in estimated cost of EMP since installation and maintenance of solar power infrastructure is proposed here and it shall be taken up only after the project is awarded to developer along with Power Purchase Agreement.

The project envisages to generate solar energy to the maximum extent as per the Govt. of India policy published by Ministry of Non – Conventional energy. The depots & Station roof design are being proposed with proper orientation / inclination to harness maximum Solar energy.

The exact quantum of energy depends once the detailed design is finalised for the project.

Residual Impacts: No significant impact of residues on the environment is anticipated.

8.4.3.3. Energy and Water Efficiency

The maximum utilization of natural day light and design of passenger flow inside railway stations and on roads outside stations and optimal utilization of electrical energy, climate control, lighting and other facilities at stations will enhance energy efficiency. For this purpose installations for solar power can be implemented at stations and Depots where feasible.

Water supply in stations for air conditioning, cleaning and use of staff and passengers will be procured from municipal supply. Water for Depots will be sourced from municipal supply: this will be supplemented by re-use of used water from coach wash.

8.4.4. Efficient Material Re-use and Conservation

Construction and demolition (C&D) waste includes building materials such as insulation, concrete, wood, gypsum wall board, PVC, steel, bricks, etc. and some hazardous materials such as asbestos, lead, mercury, and arsenic treated lumber contained in building related debris.

Mitigation Measures : The hazardous materials are not generally considered with the C&D waste and must be disposed of according to regulations and practices.

Proper storage, avoidance of spillage, re-use as far as possible and proper maintenance shall be carried out to conserve materials of use in construction. There are several strategies that can be employed to insure less Construction waste, and consequently less disposal-off materials in landfills.

Residual Impacts: No significant impact of residues on the environment is anticipated. The project will be implemented with the above mentioned measures and thus, comply with the Indian regulations and WB's guidelines ESS 1 and EIB Standard 1, 3 and 4.

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8.4.5. Conservation of Flora/Preservation of Trees

Conservation of flora during Suburban Rail Network Development at regional scale is a key to avoid exploitation or degradation of natural resources. Moreover, conservation of Flora with longer time horizons is intrinsically valued as beneficial tool for society and source of national pride.

Mitigation Measures : Maximum efforts were made to save and preserve trees at the project area during study. The alignment is designed in such a way that realignment and elevated corridor option were considered during design to preserve and save existing trees along the proposed alignment. It is ensured that only those trees which seem to affect project with no other alternative are proposed to be cut.

All efforts shall be made to preserve/save trees. Specific attention shall be given for protecting large trees, green tunnels and locally important trees (religiously important etc.). Details of the trees affected due to the proposed project corridors are given in (Section 5.9.2 of EIA Report) Tree cutting shall be proceeded only after all the legal requirements including attaining of In-principle and Formal Clearances from the Forest Dept. are completed and subsequently a written order is issued to the Implementing Agency. Tree preservation will be line with Karnataka Preservation of Trees Act, 1976, Forest Conservation Act 1980 and ESS 6 of World Bank & EIB's ESS 4. A Tree Management Plan is prepared in line with the State's Tree Act and World banks guidelines and is attached as **Annexure 10.44**.

Residual Impacts: No significant impact of residues on the environment is anticipated. The project will be implemented with the above mentioned measures and thus, comply with the Indian regulations and WB's guidelines ESS 1 and EIB Standard 1, 3 and 4.

8.4.6. Utility Plan

The proposed Bengaluru Suburban Railway Project alignment passes along major roads of the city and it is required to shift the sub-surface, surface and overhead utility services prior to construction. A detailed investigation of all utilities is undertaken and proper strategic plans shall be prepared for their retention *in-situ* or for temporary or permanent diversions with required precautions and approval shall be obtained in advance from concerned authority/organization before project construction. The stakeholder engagement and information disclosure for shifting of utilities should be planned in line with ESS 10 of World Bank to maintain the constructive relationship throughout the project construction stage. By implementing these measures, the project is expected to comply with the WBESF guidelines.

Table 8.20. Organizations Responsible for Utilities and their Services

| Sl. No. | Organization/Department | Utility/Services |
|---------|--|--|
| 1. | BBMP/PWD/NHAI | Roads |
| 2. | BWSSB | Sewerage and drainage lines. Water mains and their service lines Water treatment plants, pumping stations, Roads, surface water drains, nallahs, sewer lines, |
| 3. | Telephone Operating Agencies – State Govt. and Private | Telecables, junction boxes, telephone posts, O.H lines |

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| Sl. No. | Organization/Department | Utility/Services |
|---------|--------------------------------------|---|
| 4. | Power Grid Corporation of India Ltd. | HT towers, cables |
| 5. | Irrigation Dept. | Canal |
| 6. | Oil Corporations | Gas pipelines |
| 7. | BESCOM | HT/other overhead Power lines Street lights, high mast lights etc. |

8.4.7. Design Improvement to Minimise the Vibration

In order to suppress and/or reduce the negative effects of ground-borne noise and vibration, different mitigation measures were tested in the past years. To reduce the ground borne vibrations, design level changes are being practiced rather than typical operational level arrangements. Engineering control measures are in place to limit the vibration levels to the acceptable minimum.

These improvements can be applied to new infrastructure and/or existing ones. Different methodologies are to be compared both with their feasibility and the costs to be able to use them most conveniently. In this section, the major available technologies will be illustrated and discussed exhaustively.

The mitigation systems can be applied in all three parts of the railway system, on the vehicle, on the track and on the transmission path (that is generally soil). It is also possible to make improvements directly at the receivers (i.e., buildings). The parts of the railway environment (where the mitigation measure are possible) are subdivided into four main subsystems: vehicle, track, transmission path, and receiver. Based on the different rail systems, the characteristics of the components change from one to another.

8.4.7.1. Improvement in the Vehicle

The vehicle dynamics play a crucial role in the generation of the ground-borne effects, principally when irregularities are present at the wheel-rail contact. Rail vehicles are constructed using bogie system technology, with a single and double suspension, for the freight and passenger trains, respectively. Primary suspensions connecting the wheelsets to the bogie frame and are made with coil or rubber springs. Secondary suspension systems, located between the bogie and the car body, consist of elastomer elements, air spring or metal spring, a proper design of the bogie suspension can significantly reduce the levels of ground vibration. In general, vehicles with soft primary suspension produce lower levels of vibration than vehicles equipped with stiff suspensions. It is also important to highlight that the way in which the vehicle affects the generation of the vibrations depends on the type of train and the technology that is used. The importance of improvement of the vehicle is crucial for the ground-borne vibration since this effect is arising between the track and wheel contact, with the latter being a component of the train. The principal measures to control and/or mitigate the ground-borne vibration coming from the vehicles will be presented in the sub-section and are the following:

- Improving wheel roundness,
- Reduction of the unsprung mass,
- Reduction of speed,
- Resilient wheels.

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When the main contributor in the vehicle is identified, it is possible to design the vehicle so as the dynamic forces acting on the track are reduced. It should be noted that wheel out of roundness and the unsprung mass of a single wheel are often the dominant excitation mechanisms.

8.4.7.2. Improving Wheel Roundness

Wheels out of roundness are one of the main causes of excessive vibration. This can be the result of the manufacturing process or repeated loading at high frequencies.

The most common manifestation is the formation of wheel flats, caused primarily by train braking/deceleration. The most common manifestation is the formation of wheel flats, caused primarily by train braking/deceleration, and this results in high-frequency impact force whenever the corners of the wheel flat impact the rail during the rotation. **Figure 8.14** shows an example of wheel polygonization in the first-, second- and third-order.

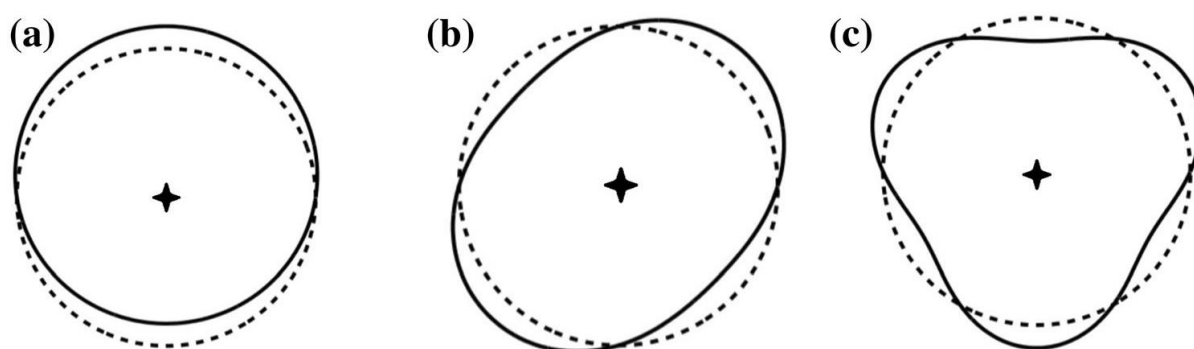


Figure 8.14. Wheel Polygonization to Mitigate Vibration

This can be achieved with good maintenance of the wheels, improvement of the sliding protection and steel quality. In particular, re-profiling, a high-quality wheel grinding program ensures the reduction of noise levels in the range of 5 to 10 dB.

8.4.7.3. Reduction of the Unsprung Mass

The unsprung mass is defined as the set of the loads generated by suspensions, wheels and bogies frames. This mass laying directly on the rail beams is the main cause of the damage to the tracks. Therefore, its reduction becomes relevant in terms of track and infrastructure damage and consequently with respect to the reduction of the vibrations level. However, the decrease of this mass is difficult to achieve due to safety criteria, wheels life and the vehicle dynamics design.

The wheel-set mass is generally in the range of 700–3500 kg, from small-diameter wheels on freight wagons to large diameter locomotive wheels. Its reduction can be obtained by the optimization of the cross-section in its shape and/or material and is generally limited to 5%– 10% of the nominal wheel mass, with which is possible to achieve a vibration reduction of 2–4 dB in the long-term. In addition, the reduction of the radial thickness would reduce wheel mass significantly but at the same time influence the number of re-profiling, wheel life and production costs.

8.4.7.4. Reduction of Speed

Vehicle speed plays central role in the generation of ground-borne noise and vibration. By reducing the train speed by a factor of two it is possible to reduce vibration levels approximately up to 6 dB.

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In general, when the train speed is approaching the Rayleigh wave speed of the transmission path it is possible to have considerable growth in the track vibration and consequently an increase in the ground-borne effects. In addition to the speed of the train, many other factors influence the vibration propagation, such as types of railway vehicles, transport type (passenger or freight), track type and others. In order to get advantages from the reduction of the speed, it would be necessary to find the less impacting speed during the motion, depending on the type of train, type of transmission path and other components. Even if vibration levels can be reduced up to 6 dB, speed reduction is not a favourite choice when developing mitigation systems. On the other hand, a disadvantage of this approach is that it has a high cost in a long time as the line capacity is reduced.

8.4.7.5. Resilient Wheels

Resilient wheels are more effective in eliminating wheel squeal on tight turns and is possible to have a reduction in vibration in the range of 3–6 dB.

With respect to the transmission of vibrations to the track, the use of resilient wheels significantly reduces the energy transmitted to the track.

With respect to the transmission of noise to the environment, the sound power emitted by the resilient wheels is clearly lower than that emitted by the monobloc wheel.

8.4.7.6. Improvement in the Track

Before introducing the improvements that can be applied to the track, it is worth to briefly present the track system and its components.

- Rail is the main part of railway track, acts as two parallel lines.
- Rail pad is designed between the sleeper plate and foot of the rail, generally made by an elastic polyurethane mat. Together with spikes and the fasteners joining the steel rails to the sleepers.
- Sleepers is laid perpendicular to steel rail. Railway sleeper can be properly deformed to trimmer pressure when the train passes through and are generally of three types (wooden, steel and concrete sleeper).
- Ballast bed is a layer of free-draining coarse aggregate used as a bed elastic support for sleepers.

An important factor for the ground-borne effects is the overall track stiffness. A low track stiffness can result in an increase in the deformation of the soil and ballast, while on the contrary when the stiffness is too high a corrugation is easier to be generated. Additionally, if the stiffness has radical fluctuations over the track section, track deterioration and vibration is resulted. The values of stiffness may change based on types of traffic that are expected (e.g., freight or passenger transport), consequently it is difficult to fix an ideal value of the stiffness since generally, the lines host various types of trains. Therefore, track imperfection and degradation (not only due to track stiffness) are crucial to the track vibrations.

Therefore, a correct selection of these elements (rail, fastening, sleepers, ballast) plays a central role in diminishing the formation and propagation of vibration. Increasing the flexibility of the

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superstructure components raises their ability to damp (dissipate) vibration generated at wheel-rail interface.

8.4.7.7. Rail Track Enhancements

The irregularity in the track and the ballast can be an important source of vibration. Indeed, a good track alignment can provide a 10 dB reduction for the ground-borne vibration, therefore, maintenance to the rail plays an important role in the vibration mitigation.

Embedded rail systems are also an alternative, typically used in urban lines. In these systems, the rail is embedded in a concrete slab which is then either filled by pouring out elastic embedding material (at the bridges steel moulds are applied) or by the installation of prefabricated rubber parts around the rail web, with a wedge on either side to keep the rail in place which showed that the elimination of metal-to-metal contact contributes to a reduction up to 8 dB in the frequency range 5–200 Hz;

Rail dampers can also be used for vibration mitigation. These are prefabricated passive elements in steel material, which are fixed to both sides of the rail web serve to reduce the vibration of the rails. Rail dampers are usually installed between every sleeper in problematic areas of the track. Studies conducted by German (DB) and French (SNCF) Railways, at the rail track sections with rail dampers installed, showed a reduction of vibration up to 9 dB.

8.4.7.8. Fasteners Enhancements

Use of rail fasteners can significantly reduce the vibration levels. Use of fasteners will help to reduce the vibration levels through the following enhancements.

- Hold rails securely in the rail seat.
- Limit the rotation of the rail about the outer edges of the rail foot.
- Minimise longitudinal movement of rails through creep and thermal forces.
- Assist in retention of track gauge.
- Not cause damage to the rail.

8.4.7.9. Sleepers and Ballast Enhancements

The sleeper can be installed in concrete or wood. Concrete sleepers are the most used type because of economic advantages (simpler installation, greater durability, lower maintenance, and operation costs). Wooden sleepers present a higher vibration damping capacity. The studies showed a vibration reduction by 5 dB when using wooden sleepers. At the same time, there are also other important improvements that can be done just under the track in order to achieve vibration attenuation, such as by placing the elastomeric pads between the sleepers and the ballast bed. This elastomeric pad is usually composed of two layers of different material, the upper made by viscoelastic rubber with high vibration damping ability and the lower layer is a coarse geotextile that serves to prevent possible upper layer damage from impressing of crushed ballast material. Elastomeric pads under the sleepers can provide a reduction of 8–20 dB. The ballast mats (that can be applied to both the surface and under-ground systems) offers a reduction of 3 to 15 dB. However, if a ballast mat is too soft there is a risk that the ballast layer becomes more feeble when solicited to the vibration produced by the passing train. Therefore, this could compromise the ride quality unless rigorous maintenance is performed (increase in costs).

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8.4.7.10. Alternative Track Technologies

In the track improvements, the technology of the track itself plays a crucial role and, in addition to the classical ballasted track, there are other approaches with different track design concepts projected to mitigate the ground-borne noise and vibration.

8.4.7.11. Ballast Bed with concrete slab

Track structures with ballast bed are better vibration reducers than the track structures on special reinforced concrete slabs. The main disadvantage of this type of track construction, compared with tracks laid in ballast bed, is its greater rigidity, which results in increased vibrations. Further reduction of the vibration propagation can be achieved by increasing the height of the ballast bed.

8.4.7.12. Floating-slab tracks.

Another alternative to ballasted tracks is the floating-slab tracks. These are special types of slab tracks with the so-called mass-spring systems principle, here the track is mounted on a thick concrete slab that rests on rubber bearings, glass fiber or steel springs. With such designs, the highest possible mass is added above the track spring to form a system with a very low resonance frequency. Floating-slab tracks are typically used to manage the vibration and ground-borne noise from underground trains where a large reduction is required.

8.4.7.13. Dynamic Vibration Absorber (DVAs)

An additional measure, that plays an important role when dealing with ground-borne vibration and noise mitigation, is the dynamic vibration absorber (DVAs). DVA is a vibration system that combines dampers and springs, to absorb and dissipate the vibration energy, the rubber layers bonded with the rail waist are mainly used to perform as the distributing elastic components of the DVA; the steel plates are used as the quality layer and the constraints layer to form the distributing power quality of DVA, together with the rubber damping layer. Then the distributing elastic components and distributing power quality can jointly constitute a set of distribution parameters of the dynamic vibration absorber. The DVA can absorb the vibration and prevent the noise radiation when the rail waist is vibrating. The DVA system can be an effective measure to address the ground-borne effects and can reduce between 5.3 and 6.6 dB depending on the type of soil and the train speed.

8.4.7.14. Improvement along the Path

Another important part of the rail environment, where it is possible to intervene in order to mitigate the effects of rail traffic, is the transmission path. Here, the elastic waves travel from the source to the receiver. In most cases, when referring to the transmission path the project has soil and/or rock materials.

Measures in the transmission path are typically applied in the surface train, where surface waves are the main contributor for the ground-borne effects, because for the P- and S-waves and the parts of the buildings those are below the ground level these measures would not be worthwhile. The aim of the measures insert between the track and the adjacent building is to act as a barrier, diverter or damper of the vibration waves that travel from the source with the scope of minimizing and/or cancel their effects at the receiver.

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8.4.7.15. Increasing the Distance

An obvious and effective way to reduce ground-borne noise and vibration is by augmenting the distance between the track and the receiver. However, this measure is applicable only in some cases when urbanization permits it, and the cost of the free land is cheaper than other mitigation measures. At a distance of 500 m from the rail track, people no longer perceive the rail traffic vibrations.

8.4.7.16. Embankment

Embankments are constructions that allow railway lines to pass at an acceptable level and gradient over low lying ground.

Placing rail tracks on an embankment, a reduction of vibration and noise at the point of emission for up to 5 dB(A) can be achieved if the height of the embankment is at least 3 m. Embankment with specific material stiffness can play the role of a waveguide by trapping energy within it.

8.4.7.17. Soil stiffening

Soil stiffening methods will mitigate the ground vibration. By reducing the coherence of the soil, it is possible to reduce the vibration by 14 dB within the frequency of 4–32 Hz. In addition to all the mitigation measures that can be applied within the transmission path, one should consider the exact soil characteristics since these have a direct relationship with the propagation of the waves.

Residual Impacts: By strictly adopting the aforesaid mitigation measures and regular and diligent monitoring during project implementation, residual impacts anticipated are insignificant.

The project will be implemented with the above mentioned measures and thus, comply with the Indian regulations and WB's guidelines ESS 1 and EIB Standard 1 and 3.

8.5. Risks Due to Natural Hazards

Mild Earthquakes / Tremors and Flood due to unprecedented rains are the two main natural disasters predicted for this BSRP.

Seismicity : The proposed project lies in Seismic Zone II (least active zone) as per revised Seismic Zoning Map of India corresponding to least seismic hazard or low-damage risks. Mild tremors are predicted once a while.

Mitigation Measures: Engineering construction shall be done in accordance with provisions specified in Code of Practice. K RIDE's Bengaluru Suburban Railway project area lies in Zone II as per revised seismic zone classification of India IS1893 (Part I):2002 corresponding to minimum seismic hazard. It is less prone to earthquakes. Engineering construction shall be as per codal provisions.

Flood: Causal factors include combinations of loss of pervious area in urbanising landscapes, inadequate drainage systems, blockade due to indiscriminate disposal of solid waste and building debris, encroachment of storm water drains, loss of inter connectivity among lakes, housing in floodplains and natural drainage and loss of natural flood-storage sites.

Mitigation Measures: This includes engineering measures and flood preparedness with the understanding of ecological and hydrological functions of the landscape.

Other than these, there is no other natural hazard due to climate change as per the forecast.

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Embankment Stability, Erosion control and Drainage: The formation work is proposed to be constructed as per RDSO (MoR) guidelines. All the precautions of slope stability, erosion control, drainage etc. are the tender conditions to be implemented by the EPC contractor. BSRP corridor predominantly runs parallel to the existing Railway line and there are no deep cuttings and high embankments along the corridor.

There are no reported cases of either of soil erosion, embankment settlement or slope failures in the cuttings along the existing Railway lines as per the records maintained by Indian Railways.

Residual Impacts: As there will be proper implementation and stringent monitoring by K RIDE, there will not be any residual impacts anticipated.

The project will be implemented with the above mentioned measures related to Natural Hazards; and thus, comply with the Indian regulations and WB's guidelines ESS 1 and EIB Standard 1.

8.6. Risks and Impacts Assessment during Project Construction & Mitigation Measures

Potential temporary negative environmental impacts have been foreseen during project construction. The required mitigation measures shall be adopted for the predicted impacts during project construction, which will reduce the overall magnitude of impacts on the environment and community. The potential negative Environmental impacts are discussed below:

- Preconstruction Activities, related issues and Mitigation Measures
- Construction Material Management and House Keeping
- Risks & Impacts on Land/Soil Quality
- Risks & Impacts on Air Quality
- Risks & Impacts on Noise Level
- Risks & Impacts on Vibration
- Risks & Impacts on Water Resources & its Quality
- Risks and Impacts on Flora & Fauna and their Protection
- Risks and Impacts due to Solid Waste
- Risks & Impacts on Traffic
- Energy Management
- Risks & Impacts due to Labour Camps
- Occupational Health Risks
- Occupational Safety Risks
- Community Health and Safety
- Risks and Impacts on Cultural Heritage and Archaeological and Historical/Cultural Properties
- Risks & Impacts of Plastics

Environmental mitigation measures during construction stage are provided here to mitigate observed potential negative impacts on environment. These mitigation measures shall be implemented by the Contractors in accordance with the approved Environmental Management Plan and monitored by the Environmental Consultant of Supervision Agency or the project Proponent. The cost of Environmental Management during construction is included in Cost Estimate/Budget provided at the end of this

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Chapter and it forms the part of Engineering Cost. The Sub-sections below will enlighten on the envisaged potential impacts along with necessitated appropriate mitigation measures.

8.6.1. Preconstruction Activities, related issues and Mitigation Measures

8.6.1.1. Establishment of Plants, Equipment and Machinery

All construction plants shall be sited sufficiently away (500ms) from settlements and agricultural operations or any commercial establishments. Such plants shall be located at least 100m - 500m away from the nearest dwelling preferably in the downwind direction.

The Contractor shall submit a detailed layout plan for all such sites and approval of Environmental Specialist of GC, prior to the establishment and obtain approval. Guidelines and reporting format for siting of Construction Camp is presented as **Annexure 10.2** and **Annexure 10.17** respectively. Specifications for crushers, hot mix plants and batching plants with required Equipment and Machinery shall comply with the requirements of the relevant emission control legislations. Consent for the Establishment and Operation from KSPCB shall be obtained before establishment.

Arrangements to control dust pollution through provision of windscreens, water sprinklers, and dust extraction systems shall have to be provided at all Plant work sites.

At present, contractor in place for Corridor 2 and he has identified the three camp sites near Benaganahalli Station, Hebbal Station and Jalahalli Station. These land are level land and free from vegetation and encroachment present within Indian Railway RoW. Hence, there is no impacts observed due to establishment of these camps.

8.6.1.2. Preparation for procurement/Supply of Construction Materials

Risks & Impacts : Construction materials such as quarry materials – aggregates; and borrow earth required for the project shall be procured from approved quarries and borrow areas, as per the guidelines stipulated by Dept. of Mining & Geology.

Mitigation Measures: Contractor shall finalize the quarry or borrow areas for procurement of construction materials after assessment of the availability of sufficient quantity of materials, quality and other logistic arrangements or he can directly procure crusher materials from the supplier.

The Sand shall be procured from approved sand mines. As a substitute, M-Sand may be used, wherever feasible. The Contractor shall obtain copy of the Lease Agreement of the supplier and submit to GC before procuring the sand. The Contractor shall obtain copy of the Lease Agreement of the supplier and submit to GC before procuring the sand. Contractor shall be solely responsible to obtain and maintain all the legal records of approvals, as per the Indian regulations. Procurement shall be in compliance with WB ESS 1, 3 & 6 and EIB ESS 1, 3 & 4.

8.6.1.3. Risks and Impacts due to Pre-casting yards and Material stockpiling

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

Mitigation measures : Mitigation measures include careful planning, timing of casting operations and storage in casting yards and camps. Pre-casts will be properly stock piled in Cast yards.

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Sites for casting of structural concrete elements and material stock piling and storage will be identified by the Contractor and decided by the K RIDE before start of construction. This helps to avoid any issues related to displacement of people, if any.

The Construction materials such as steel, bricks, concrete materials, etc. will be stock piled and stored properly in a fenced or closed Store yard. Precautionary measures shall be taken to reduce and mitigate dust generation at Store and Cast yards. The unwanted or unused balance materials will be removed for use, if required; if not will be disposed properly after the completion of works. The unwanted or unused balance materials, if suitable will be utilized for borrow areas or open pit or trench filling.

Residual Impacts: Residual impact to the environment is insignificant.

8.6.1.4. Labour Procurement and Protection of Work Force

Labour procurement shall be in accordance with labour laws and Contract Document - The Contract Labour (Regulation & Abolition) Act and Rules, 1970, The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 (BOCW Act, 1996), The Industrial Relations Code 2020, The Code on Social Security 2020, The Occupational Safety, Health and Working Conditions Code, 2020 and The Code on Wages 2019, The Minimum Wages Act, 1948, The Equal Remuneration Act, 1976, The Child Labour (Prohibition & Regulation) Act and Rules 1986, The Payment of Bonus Act, and Rules 1976, The Interstate Migrant Workmen (RE &CS) Act and Rules, 1979, The Payment of Wages Act, 1936, The Maternity Benefit Act, 1961, Labour Law (Exemption From Furnishing Returns & Maintaining Registers by Certain Establishments) Act, 1988, The Factories Act, 1948 and other related regulated.

The project workers may be direct, contracted or community workers. The Contractor shall preferably use unskilled labour drawn from local communities to give maximum benefits to the local community.

A. Working conditions and management of primary supply chain and contract workers relationships

Labour management procedure will be developed by the Contractor and approved by K RIDE in due course when once the Contract is signed.

(i) Terms and conditions of employment

The project workers will be with information and documentation that is clear and understandable regarding their terms and conditions of employment. This will be in line with worker's rights related to hours of work, wages, overtime, compensation and benefits, as per applicable regulations.

(ii) Non-discrimination and Equal Opportunity for Workers

There shall be no discrimination among project workers based on personal characteristics unrelated to inherent job requirements. The employment of project workers will be based on the principle of equal opportunity and fair treatment and there will be no discrimination with respect to any aspects of employment relationship.

(iii) Worker's organizations

The project will not require a separate worker's organization during project implementation.

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B. Protecting Work Force

(i) Protection to Female Workers

Protection shall be provided for women workers of project against sexual harassment and grievance shall be redressed with necessary actions, in accordance with the Act - Sexual Harassment at the Workplace (Prevention, Prohibition and Redressal) Act, 2013 and amendments.

(ii) Child labour and minimum age

The Child Labour is totally prohibited in the project. No child under the age of 18 shall be employed or permitted to work in any sort of works related to project, as per the Child Labour (Prohibition and Regulation) Act, 1986. Whoever employs any child or permits any child to work in contravention of the provisions of section 3 shall be punishable with imprisonment for a term which shall not be less than three months but which may extend to one year or with fine which shall not be less than ten thousand rupees but which may extend to twenty thousand rupees or with both, as per Section 14 of the Child Labour (Prohibition and Regulation) Act, 1986. If the Contractor is found guilty of breaching the Act, he shall be treated as per the Child Labour (Prohibition and Regulation) Act, 1986 and the relevant procedure shall be followed by the K RIDE.

(iii) Forced Labour

Labours engaged or inducted either through contract basis or through paper notifications complying local labour law. Further, there is no scarcity of skilled and unskilled man power in project district. Hence, forced labour issue will not be raised in the project.

C. Grievance mechanism pertaining to project labour

A grievance mechanism will be in place during project construction stage for all types of workers such as direct workers and contracted workers to raise work place concerns and grievances. Workers will be informed regarding grievance mechanism at the time of their recruitment. Measures will be taken to make the grievance mechanism easily accessible to all project workers. The grievance mechanism will be proportionate to the nature and scale and the potential risks and impacts of the project. It will be an easily understandable and transparent process.

Based on the above labour aspects and in compliance with ESS 2 of World Bank's Guidelines & EIB's ESS 8 the Contractor will prepare Labour procurement procedure and Management Plan for the Approval from Sr. Environmental Specialist/Sr. Social Specialist and K RIDE, prior to labour procurement and commencement of Construction activities. Overall labour procurement will be in line with ESS 2 of World Bank's Guidelines & EIB's ESS 8.

8.6.1.5. Obtaining of Temporary Land for borrow Areas and temporary camps at work sites

The Contractor as per prevalent rules shall carry out negotiations with the landowners for obtaining their consent for temporary use of lands for construction camp at work sites and borrow areas, etc. in line with Occupational Safety and Health Standards, Part 1910.142, WB ESS 6 and EIB Standards 1 and 3.

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8.6.1.6. Procurement of Construction Materials

The procurement of qualitative construction materials by the Contractor shall be from the licensed supplier. This will be decided by the Contractor with the approval from the Supervision Consultant/General Consultant or the Project Proponent.

Quarry materials – Quarry materials shall be procured by Contractors from approved and licensed Quarries. Contractor shall finalize the quarry for procurement of construction materials after assessment of the availability of sufficient quantity of materials, quality and other logistic arrangements. Contractor shall be solely responsible to obtain and maintain all the legal records of approvals, as per the regulations and WB ESS 1 & 3 & EIB's ESS 3. Contractor shall also work out haul road network and report to Environmental Specialist of GC/IE and GC/IE shall inspect and in turn report to K RIDE, before approval. In case, if approved quarry is owned or leased by the Contractor, following are the measures to be undertaken during Blasting operations :

- Except as provided in the contract or ordered or authorized by the Engineer, the Contractor shall not use explosives. In case, explosives are the dire requirement for the construction purpose, it shall be procured by the Contractor from the authorized agencies by complying with the requirements of the Explosives Act, 1884 and Explosives Rules, 1983 and in line with WB ESS 2 and 4 and EIB Standards 8 and 9.
- The Contractor shall at all times take every possible precaution and shall comply with appropriate laws and regulations relating to the importation, handling, transportation, storage and use of explosives. The contractor shall at all times when engaged in blasting operations, post sufficient warning flagmen, to the full satisfaction of the Engineer.
- The Contractor shall at all times make full liaison with and inform well in advance and obtain such permission as is required from all Government Authorities, public bodies and private parties whomsoever concerned or affected or likely to be concerned or affected by blasting operations.
- Blasting shall be carried out only with permission of the Engineer. All the statutory laws, regulations, rules etc., pertaining to acquisition, transport, storage, handling and use of explosives shall be strictly followed.
- Controlled Blasting shall be carried out during fixed hours (preferably during mid- day) or as permitted by the Engineer. The timing should be made known to all the people within 1000m (200m for pre-splitting) from the blasting site in all directions.

Contractor shall also work out haul road network and report to Environmental Specialist of GC and GC shall inspect and in turn report to K RIDE before approval.

Borrow Earth – Finalisation and procurement of Borrow earth from approved borrow areas and all logistic arrangements as well as compliance to environmental requirements, as applicable, shall be the sole responsibility of the Contractor and shall be in line with EPA 1986 and ESS 1 & 3 of World Bank and EIB Standards 1 and 3.

The Contractor shall not start borrowing earth from selected borrow area until the formal agreement is signed between landowner and Contractor and a copy is submitted to the GC.

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Locations finalized by the Contractor shall be reported to the Environmental Specialist of GC for approval and he/she shall report to K RIDE.

Planning of haul roads for accessing borrows areas shall be undertaken during this stage. The haul roads shall be routed to avoid agricultural areas as far as possible and shall use the existing village roads wherever available.

The environmental personnel of the GC shall be required to inspect every borrow area location prior to approval. The GC should include the Request for Inspection form for borrow area approval from the environmental point of view. Guidelines and reporting format for siting, operation and re-development of borrow area is presented as **Annexure 10.4**. Reporting format for borrow area management plan is presented as **Annexure 10.19**.

Sand / M-Sand - The Sand / M – Sand shall be procured from approved sand mines. The Contractor shall obtain copy of the Lease Agreement of the supplier and submit to GC before procuring the sand. Contractor shall be solely responsible to obtain and maintain all the legal records of approvals, as per the amended Sand Mining regulations and WB ESS 1 & 3 and EIB Standards 1 & 3.

As a substitute, M-Sand may be used, wherever feasible. The Contractor shall obtain copy of the Lease Agreement of the supplier and submit to GC before procuring the sand.

Risks and Impacts of Construction Materials : During construction dust generations, noise pollution, loss of natural resources and personal safety issues are the major hazards in operational quarry and borrow regions which lack necessary mitigation measures. Improper or negligent management of unwanted or surplus construction materials and waste materials at Construction camps cause the dumped and left over waste materials to enter in to nearby/adjoining water courses. Approximately 10-15% of the construction materials will be left over at Construction camps as construction waste/spoils. Dumping of construction waste/spoil in haphazard manner at construction sites or camps may cause surface and ground water pollution near the construction sites.

Mitigation Measures during Construction : All required environmental and safety mitigation measures such as sprinkling of water to control dust emission, cordoning of work area, provision of dust screens, etc., need to be adopted during construction to minimize or avoid dust particles and other emissions due to operation of equipment and entry of waste materials into nearby natural resources. Contractor shall be solely responsible to obtain and maintain all the legal records of approvals, as per the amended regulations and WB ESS 1 & 3 and EIB Standards 1 & 3.

8.6.1.7. Procurement of Water for Construction

The contractor shall use ground/surface water as a source of water for the construction and may set up own bore well facility for construction work. If construction water is procured from common or public source, it may lead to disruption/disturbance to other water users in the nearby locality.

Mitigation Measures : The Contractor shall need to comply with the requirements of the State Ground Water Department for the extraction of Water for Construction and shall follow stipulations as per the contract document and EPA, 1986 and in line with ESS 1 & 3 of World Bank and EIB Standards 1 & 3.

To avoid disruption/disturbance to other water users, the Contractor shall extract water from fixed locations and consult Environmental Specialist of GC before finalizing the locations. The Contractor

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shall provide a list of locations and type of sources from where water for construction shall be extracted.

8.6.2. Construction Material Management and House Keeping

The project related construction materials include coarse aggregates, cement, coarse sand, reinforced steel, structural steel, water supply, drainage and sanitary fittings, etc. The loading and unloading activities involve labourers employed by the Contractor at Material site/s and construction sites.

Mitigation Measures The Contractor shall be solely responsible for regular management of Construction Materials from storage to loading, unloading, usage and maintenance to ensure to maintain quality and quantity of materials and stringently follow approved Environment, Health and Safety (EHS) guidelines. Procedures for storage, handling and transport of construction materials and their reuse shall be prescribed in EHS guidelines. The EHS guidelines shall be prepared in line with World Bank ESS guidelines and National regulations.

House Keeping : Housekeeping at Base Camp, Storage Yards, Plant sites and Construction sites is to maintain cleanliness and hygiene at working areas. This keeps the working environment cleared of all unnecessary waste, thereby providing a first-line of defense against accidents and injuries. It is the responsibility of Contractor and all site personnel.

Mitigation Measures : Some of the preventive and mitigation measures are listed below:

- Full height fences, barriers, barricades etc. shall be erected around the site in order to prevent the surrounding area from excavated soil, rubbish etc, which may cause inconvenience to and endanger the public.
- All stairways, passageways and gangways shall be maintained without any blockages or obstructions. All emergency exits passageways, exits fire doors, break-glass alarm points, fire-fighting equipment, first aid stations, and other emergency stations shall be kept clean, unobstructed and in good working order.
- All surplus earth and debris shall be removed/disposed-off from the working areas to officially designated dumpsites. Trucks carrying sand, earth and any pulverized materials, etc. shall be covered while moving.
- Unused/surplus cables, steel items and steel scrap within the working areas shall be removed to pre-identified locations.
- All wooden scrap, empty wooden cable drums and other combustible packing materials shall be removed from workplace to identified locations.
- Empty cement bags and other packaging materials shall be properly stacked and removed.
- Proper and safe stacking of material is of paramount importance at yards, stores and such locations for future use. The storage area shall be well laid out with easy access and material stored / stacked in an orderly and safe manner.

Following of EHS Guidelines during Construction till handing of the project to the project proponent, is the sole responsibility of the contractor, which should be clearly mentioned in the contractor's agreement.

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By implementing these EHS guidelines, the project is expected to comply with the Indian Standards and WBESF guidelines – WB's ESS 1, 2 & 4 and EIB Standards 1 & 9.

8.6.3. Risks & Impact on Land / Soil Quality

8.6.3.1. Soil Erosion, Fugitive dust generation and Land Subsidence

The fugitive dust generation due to clearing of land, cutting of trees, excavation of borrow areas are likely to trigger soil erosion. The movement of vehicles/machinery/equipment and work forces is also likely to cause soil erosion. Loosening of top soil and loss of vegetative cover from the ROW along the detour and parallel section due to excavation, land cut and back filling could lead to soil erosion.

There will be minor impact on soil causing erosion due to run-off from unprotected excavated areas which can result in soil erosion, especially when erodibility of soil is high. The clearing of land, cutting of trees, excavation of borrow areas are likely to trigger soil erosion. The movement of vehicles/machinery/equipment and work forces is also likely to cause soil erosion. Loosening of top soil and loss of vegetative cover from the ROW along the detour and parallel section due to excavation, land cut and back filling could lead to soil erosion. Denudation of vegetation from soil slopes or the lack of vegetative cover on embankment slopes is often responsible for formation of rills and rain-cuts, eventually leading to a surficial slide or to an undermining of the edges of the railway structure.

The problems anticipated include mainly the Surface and ground water pollution due to dumping of unwanted or surplus construction soils (concrete and bricks), waste materials (from Contractor's Camp), etc.

The borrow areas are likely to cause soil erosion and affect agricultural areas. Loss of productive soil may result from uncontrolled opening up of borrow pits. However, embankment slopes made from earthen material as well as exposed surfaces of hills will be protected for preventing soil erosion in areas which have high soil erodability or high intensity rainfall.

Land subsidence is not predicted as there is no underground construction. The construction of stations is at grade only.

Mitigation Measures : Measures to mitigate the Soil Erosion and dust generation include careful planning, timing of cut and fill operations and re-vegetation in accordance with Water (Prevention and Control of Pollution) Act, 1974 & its amendments and ESS 1, 3 and 6 of World Bank. In general, construction works shall be stopped during monsoon season.

As far as practicable, top soil removed from the construction sites will be used for construction of embankment to enhance growth of vegetation on the embankment surface and its consolidation. Besides, adequate temporary or permanent drainages are planned to be provided before slope construction begins with lagoons to allow silt to settle out. As for the borrow areas, appropriate measures for the management of borrow areas will be taken. Top soils of the borrow pit sites will be conserved and restored after excavation is over.

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. It is suggested to utilize Ready Mix Concrete (RMC) at site directly from batching plant to avoid spillage. The Construction materials such as steel, bricks, etc. will be stored in a fenced stored yard. The unwanted

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or unused balance materials will be removed for use, if required; if not will be disposed after the completion of works.

The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. Works such as construction of temporary berms, temporary mulches, seeding or other methods as necessary to control erosion shall be implemented.

The pre-identified disposal location shall be part of Comprehensive Waste Disposal Plan Solid Waste Management Plan to be prepared by the Contractor in consultation and with approval of Environmental Specialist of GC.

Guidelines for preparation of Comprehensive Waste Management Plan are provided in **Annexure 10.9**. Guidelines on topsoil conservation and reuse and slope stabilization measures are provided in **Annexure 10.1** and **Annexure 10.3**.

Cumulative Impacts on Soil erosion : Soil erosion may take place near cutting areas, at steep and uncompact embankment slope, and wherever vegetation is cleared. Soil erosion may have cumulative effect viz. siltation, embankment damage, drainage problem etc. Loss of soil due to run off from earth stock-piles may also lead to siltation. The consequences of soil erosions are far wider than repair and maintenance of the project corridor. Along the project corridor 1, the inflow of water into lake during rains causes erosion of the embankment besides seepage of water into embankment and subgrade resulting in softening of the subgrade. This may also increase siltation in water bodies.

Mitigation Measures : Project corridors are with elevated stretches near the lakes. Project design includes provisions of retaining walls/retaining walls for the protection. Regular checks shall be made to ensure its effectiveness.

Following are the some of the important control measures considered during project implementation:

- Bank protection measures shall be taken at erosion prone areas.
- Provision of side drain shall be provided to guide the water to natural outfalls.
- When soil is spread on slopes for permanent disposal, it shall be buttressed at the toe by retaining walls.
- Side slopes of the embankment shall not be steeper than 2H: 1V. Turfing of embankment slopes shall be done along the at grade stretches.
- IRC: 56 -1974 recommended practice for treatment of embankment slopes for erosion control shall be taken into consideration for this suburban Rail project also.

The project will implement these above mentioned vegetation protection measures and thus, comply with the Indian regulations and WB ESS 1, 3 & 6 and EIB Standards 1 & 3.

8.6.3.2. Preservation of Top Soil

The topsoil from all areas of cutting and all areas to be permanently covered shall be stripped off to a specified depth of 150 mm and stored in stockpiles. A portion of the temporarily acquired area and/or Right of Way shall be earmarked for storing topsoil. The locations for stock piling shall be pre-identified in consultation and with approval of Environmental Specialist of GC. Topsoil is rich in organic content and is essential to establish new vegetation. The stored topsoil may be used as finished grade for planting areas or to rehabilitate borrow areas.

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Mitigation Measures : The preservation of Top soil shall be in accordance with EPA 1986 and ESS 1 & 3 of World Bank & EIB's ESS 3. The following precautionary measures shall be taken to preserve them till they are used:

Stockpile shall be designed such that the slope does not exceed 1:2 (Vertical to horizontal), and height of the pile is restricted to 2 m. To retain soil and to allow percolation of water, silt fencing shall protect the edges of the pile.

Stockpiles shall not be surcharged or otherwise loaded and multiple handling shall be kept to a minimum to ensure that no compaction shall occur. The stockpiles shall be covered with gunny bags or vegetation.

It shall be ensured by the Contractor that the topsoil shall not be unnecessarily trafficked either before stripping or when in stockpiles. Such stockpiled topsoil shall be utilized for –

- Covering all disturbed areas including borrow areas, only in case where they are to be rehabilitated.
- Dressing of slopes of embankment/agricultural fields of farmers acquired temporarily land.

Guidelines on topsoil conservation and reuse and slope stabilization measures are presented in **Annexure 10.1** and **Annexure 10.3** respectively.

8.6.3.3. Embankment or Slope Protection Measures

All temporary sedimentation control works and maintenance thereof shall be deemed as incidental to the earth work or other items of work and as such no separate payment shall be made for them in compliance with WB ESS 3 & EIB's ESS 3.

Mitigation Measures : Contractor shall ensure the following measures :

- After construction of railway embankment, the side slopes shall be covered with grass and shrubs (refer **Annexure 10.3** and **Annexure 10.25**) as per design specifications.
- Turfing works shall be taken up as soon as possible provided the season is favorable for the establishment of grass sods. Other measures of slope stabilization shall include mulching netting and seeding of batters and drains immediately on completion of earthworks.
- In borrow pits, the depth shall be so regulated that the sides of the excavation shall have a slope no steeper than 1 vertical to 2 horizontal, from the edge of the final section of the bank.
- Along sections abutting water bodies, pitching as per design specification shall protect slopes.
- The formation work is proposed to be constructed as per RDSO (MoR) guidelines. All the precautions of slope stability, erosion control, green cover, drainage etc. are the tender conditions to be implemented by the EPC contractor. BSRP corridor predominantly runs parallel to the existing Railway line and there are no deep cuttings and high embankments along the corridor.
- There are no reported cases of either of soil erosion, embankment settlement or slope failures in the cuttings along the existing Railway lines as per the records maintained by Indian Railways.

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- As far as possible, cutting soil is proposed to be reused in the embankment in case the soil is found to be suitable for the Railway embankment. Alternatively, suitable blending materials, soil improvement techniques, blanketing materials for proper drainage, geo-grids are proposed to be used.

Guidelines on slope stabilization, sediment control and Embankment/slope protection measures are presented in **Annexure 10.3**, **Annexure 10.6** and **Annexure 10.25** respectively. Typical cross section of Silt trap is presented in **Annexure 10.31**.

8.6.4. Risks & Impacts on Air Quality

Respirable Particulate Matter (PM10) would be the predominant pollutant affecting air quality during the construction phase as it is likely to generate considerable quantities of dust, especially during dry conditions due to excavation, backfilling, concreting, hauling, dumping of earth materials, construction spoils and vehicular movement along unpaved routes. Deterioration of air quality due to gaseous emissions from construction equipment and vehicular traffic will also occur.

The assessment of air pollution during construction phase has been undertaken based on the principles of Air pollution Health Risk Assessments (AP-HRA). Construction and decommissioning activities may generate emission of fugitive dust caused by combination of on-site excavation and movement of earth materials, contact of construction machinery with bare soil and exposure of bare soil and soil piles to wind, during construction phase. A secondary source of emission includes exhaust from diesel engines of earth moving equipment and open burning of solid waste on-site. During operation of the proposed project ambient air quality gets affected only at Stations and Depots.

The Air quality gets affected due to the potential sources of emission of dust and particulates during overall project activities as mentioned below:

- Fugitive Dust emission during earth works – excavation during site preparation and loading and unloading of construction materials;
- Emissions from construction equipment, DG Sets and Machinery during their operation;
- Fugitive emissions from the vehicles plying on the road;
- Fugitive emissions during transport of construction materials;
- Dust, particulates and hydrocarbon pollutants due to combustion during the operation of RMC Plant and at casting yard;
- Dust and particulate emission due to traffic congestion at construction sites along the corridors
- Dust emission at muck disposal, debris disposal and pre-casting yards and
- Burning of garbage or solid waste materials

As mentioned above, the air emission will be mainly in the form of coarse and fine particulate matter at construction sites and will settle down in the close vicinity of active sites whilst the air emission at RMC Plant and casting yard sites during operation of equipment/plants/machinery dust and particulate matters, NO_x and SO_x. This air emission with pollutants as specified, will affect the ambient air quality in the vicinity of the construction activities. Discharge from low stack height may also be one of the main causes for air pollution. As per KSPCB Standards stack height should be 30m from the ground. However, with all the above facts it is required to mention here that the air pollution

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temporary and localized around stations and construction sites which can be mitigated by adopting proper measures diligently.

The quantification of generated Air pollutants due to transportation of construction material and excavated/fill material has been attempted considering the BS III vehicles in usage by the Contractors. Trucks and Backhoe loaders/excavators are direly required to transport civil construction material from pre-cast yards and batching plants to construction sites and between construction sites and soil disposal sites.

The particulate matter 10 (PM₁₀) and 2.5 (PM_{2.5}) generated from excavation activities particularly and from other construction activities, are considered as critical pollutants. In this situation, the pollution emission sources shall be distributed throughout the project site and shall be considered under the category of area source.

The impact of project on air quality during the construction period will be mainly due to increase in Suspended Particulate Matter (SPM) along haul roads and emission from vehicles and construction machinery. The mitigation measures proposed for air pollution reduction are in line with Air (Prevention and Control of Pollution) Act, 1981 & its amendments and ESS 3 of World Bank and EIB Standards 1 & 3.

Mitigation Measures : The land for the proposed project construction is relatively more level plateau (plain terrain) with rare and minor undulations in east portion of Bengaluru. Therefore, extensive earth work activities are not anticipated during this phase. Moreover, as far as possible, environment friendly and technologically upgraded construction equipment/vehicles of BS V norms shall be preferred.

Mitigation measures which shall be adopted to reduce the air pollution are highlighted below:

Control of Dust Pollution :

- The Contractor shall take every precaution to reduce the level of dust from construction plants, construction sites involving earthwork by sprinkling of water, encapsulation of dust source.
- The Contractor shall take all mandatory precautions to minimise fugitive dust emissions from operations involving excavation, grading, and clearing of land and disposal of waste and from processes such as pneumatic filling of silos, transportation by road, drilling and blasting, crushing, screening, bulk/bag unloading, etc.
- The Contractor shall not allow emissions of fugitive dust from any transport during handling of materials, construction or storage activity. The emission should not remain visible in atmosphere beyond the property line of emission source for any prolonged period of time.
- The Contractor shall use cover for materials of dust generating like debris and soil being transported from construction sites. All trucks carrying loose material should be covered and loaded with sufficient free-board to reduce spills and avoid fugitive dust.
- Contractor shall install barriers around the open construction sites before commencing the work.

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- The temporary dumping areas shall be maintained by the Contractor at all times until excavated materials are reutilized for backfilling wherever necessary 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 wetted each day, to minimize dust production. During dry weather, dust control measures must be used daily especially on windy, dry days to prevent any dust from blowing across the site perimeter.
- The Contractor shall sprinkle water at construction sites 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.
- In case of water scarcity in certain areas or periods, Contractor may limit water sprinkling once in the early morning hours and should erect warning boards on dust nuisance to the road users and limit the dust emanating activities.
- Contractor shall carry out periodic check of machinery and vehicles; dust collectors and physical barriers at bulk.
- The concentration of suspended particulate matter at a distance of 40m from a construction plant located in a cluster of industries should be less than 500 µg. The environmental monitoring is to be conducted as per the monitoring plan.

Control of Emission from Construction Vehicles, Equipment and Machinery :

- The Contractor shall procure the construction plants, equipment and machinery, which shall conform to the pollution control norms specified by MoEFCC/CPCB/KSPCB. This will control air pollution.
- He shall maintain evidence of design and equipment to make these available for inspection by Employer.
- Contractor shall ensure that all vehicles, equipment and machinery procured for construction are regularly maintained and confirm that pollution emission standards and comply with the relevant statutory requirements of CPCB such as The Air (prevention and control of pollution) Act, 1981 and EPA, 1986 and/Motor Vehicles Rules 2000 with amendments and WB ESS 3 and EIB Standards 3.
- The Contractor shall properly maintain and periodically check all construction / haulage vehicles, machinery and Equipment so as to comply emission in accordance with National Ambient Air Quality Standards stipulated by Statutory Agencies of Government of India or the State Government from time to time.
- Stack height of equipment/ Plants and D. G. sets at plant site should conform to KSPCB Standards – minimum 30 meters from the ground level.
- The Contractor shall carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.

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

Summarizing the above mitigation measures, it can be the following techniques considered for the reduction and control of air emissions from construction and decommissioning sites :

- Minimizing dust from material handling sources, such as conveyors and bins, by using covers and /or control equipment (Water suppression, bag house or cyclone)
- Minimizing dust from open area sources, including storage piles, by using control measures such as installing enclosures and covers, and increasing the moisture contents
- Dust suppression by water sprinkling to minimize dust emission from vehicular movements
- Managing emissions from mobile sources
- Avoiding open burning of solid wastes such as waste papers, clothes, tyres, etc.

The project will implement above mentioned Air Control Measures proposed comply with the Indian regulations and WBESF and EIB E&S guidelines.

Residual Impact: After implementation of the mitigation measures described above residual impacts are expected to be minor and no significant impact is anticipated on the ecosystem.

8.6.5. Risks & Impacts on Noise Level

A significant impact of Noise pollution from the proposed project is mainly on public health. Noise is a contributing factor to the degradation of human health. The effects may be due to direct or indirect impacts of Noise. The most common health issue in persons exposed to noise pollution is Noise Induced Hearing Loss (NIHL) such as abnormal loudness perception, tinnitus (high pitched ringing in ears) and paracusis in very rare cases (distorted hearing leading to hallucination). Other potential mental health impacts of noise pollution include increased stress/tension levels, sleep disturbances, etc. leading to uncontrolled emotions and mood shifts, lack of concentration, dizziness and loss of balance, and in extreme cases nervous disorders; and potential physical health impacts include high blood pressure, heart disease, increased respiration rates, fatigue, etc.

Source: Noise pollution during construction is mainly due to movements of construction vehicles for transportation of material and equipment. The impact of noise on surrounding community is assessed considering the following factors :

In order to mitigate noise pollution with necessitated measures Noise level has been assessed based on the following criteria and factors :

Criteria for noise level assessment :-

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- The existing ambient noise levels;
- The expected construction noise levels;
- The criteria relating the existing noise environment and the predicted construction noise levels to human responses and
- Mitigation strategies that can be used to control the construction noise.
- Factors considered for assessment include the following :-
- Characteristics of noise source (instantaneous, intermittent, or continuous in nature)
- The difference between the existing noise level and the anticipated construction noise levels;
- The absolute level of expected construction noise;
- The adjacent land uses;
- The time and duration of construction;
- Location of noise source with respect to noise receptor

Day time Noise Levels : Ambient Noise levels during day time were found to be in the average range of 48.8 to 60.8 dB (A). The maximum noise level was observed as 60.8 dB (A) at Yeshwanthapur RS and a minimum of 48.8 dB (A) was observed at Nirmithi Kendra near Akkupete Depot.

Night time Noise Levels : Ambient Noise levels observed to fall in the range 37.6 to 48.2 dB (A) during the night time. A maximum of 48.2 dB (A) was observed at Yeshwanthapur RS and a minimum of 37.6 dB (A) was observed at Nirmithi Kendra near Akkupete Depot.

The forecast of the at source noise levels at varied distances are presented in **Table 8.21**.

Table 8.21. Noise Level Prediction For Construction Equipment

| S. No. | Machine | Noise Levels in dB(A) without Noise Controls | | |
|--------|-------------------------------------|--|----------|-----------|
| | | At Source** | At 15 m* | At 45 m** |
| 1 | 1.5 cum capacity Excavator / Loader | 109 | 85 | 65 |
| 2 | 8.33 cum capacity rear end dumper | 108 | 84 | 64 |
| 3 | Crawler Dozer | 109 | 85 | 65 |
| 4 | Heavy Duty jack Hammer | 109 | 85 | 65 |
| 5 | Compressor | 104 | 80 | 60 |
| 6 | Crane | 107 | 83 | 63 |
| 7 | Generator | 105 | 81 | 61 |
| 8 | Rock Drill | 122 | 98 | 78 |

Source : FHWA – Noise Hand Book - * Data taken from “construction equipment noise levels and ranges report” of Federal Highway Administration, ** Calculated using logarithmic equation.

It is understood from the above table that construction activities are expected to produce noise levels in the range of 104-109 dB (A) at source which decreases with increase in distance.

Whilst predicting noise emissions due to proposed project the sources of noise generation have been examined for construction phase.

The proposed Suburban Rail construction project would involve placing ballast, and installation of new tracks and establishment of stations. Construction period may be for 2 -3 years. The construction will take place at different distinct locations at different period. It will not be continuous throughout the entire alignment a time. And employment of vehicles vary based the type of construction

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activities. The production of noise varies with the type of construction vehicle/s operated for a particular activity.

The construction activities of the proposed project will be associated with Maximum Environmental Noise Levels (MENL) applicable to Construction Noise. Construction noise is temporary, intermittent and localized; vary extensively both spatially and in time/duration; and with location and distance of the equipment/machinery from sensitive receptors.

The construction activities which emit highest construction noise levels include pile driving activities, in association with construction of walls and bridges. The most prevalent noise source at Project construction sites would be internal combustion engines. Earth-moving equipment, material-handling equipment, and stationary equipment are all engine-powered. Mobile equipment operates in a cyclical fashion, but stationary equipment (e.g. generators and compressors) operate at sound levels that are legitimately constant over time. Because the trucks cannot be confined to a particular Project site and their movement will be there during most of the time for transportation of construction materials, thereby leading to noise generation and may impact sensitive receptors nearby. Other noise sources may be impact equipment and tools such as pile drivers for pile foundations. Impact tools could be pneumatically powered, hydraulic, or electric.

The analysis and assessment of construction noise is dependent on above mentioned criteria and factors; and typical activities with types of equipment used for demolition, excavation, erection works and other related activities. The **Table 8.22** highlights assessed typical values of noise level generated from major noise generating sources – Vehicles and Equipment/Machinery envisaged during construction phase.

Table 8.22. Average Noise Levels Generated from Construction Equipment

| Sl. No. | Name of Source | Noise Level at in dB (A) L _{max} @ 15m(DBA, Slow) |
|---------|--------------------------|---|
| 1 | Batching Plant | 83 |
| 2 | Concrete Pump Truck | 82 |
| 3 | Dumpers | 84 |
| 4 | Cranes | 85 |
| 5 | Dozer | 85 |
| 6 | Generators | 82 |
| 7 | Excavator | 85 |
| 8 | Trailer | 84 |
| 9 | Jackhammer | 85 |
| 10 | Hydraulic Hammer | 90 |
| 11 | Compactor (ground) | 83 |
| 12 | Compressor (air) | 78 |
| 14 | Impact Pile Driver | 95 |
| 14 | Vibratory Concrete Mixer | 80 |
| 15 | Auger Drill Rig | 85 |

Source: Federal Highway Administration's (FHWA), national model for the prediction of construction noise.

The Construction activities shall be between the hours of 7:00 a.m. to 10:00 p.m. near sensitive locations, residential areas and other restricted areas, as instructed by the Railway authority. Construction of noise barriers, such as temporary walls between noisy activities and receivers reduces

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noise by up to 15 dB (A). Vegetation cover act as noise pollution shields and supports to reduce the noise level.

Careful planning with proper maintenance of machinery and their operation and scheduling of operations can however reduce noise levels. The overall noise during construction will be for short-term (for day time only) and can be mitigated.

For modeling purpose, terrain is considered to be plain and there are no sound absorptive materials present in the direction of the sound wave propagation so as to formulate the worst-case scenario.

8.6.5.1. Noise Modeling During Construction Phase

To estimate the typical noise generated during the construction process, model studies was done considering one piling rig, one construction crane and one concrete mixer truck. This setup will give a typical noise generation during piling and concreting activities. From the study it was observed that, 70 dB(A) noise was observed up to a distance of 80 m from the source. As the noise level beyond he permissible limit, EMP measures will be strictly followed in piling activity. The construction phase noise plot is shown in **Figure 8.15**.

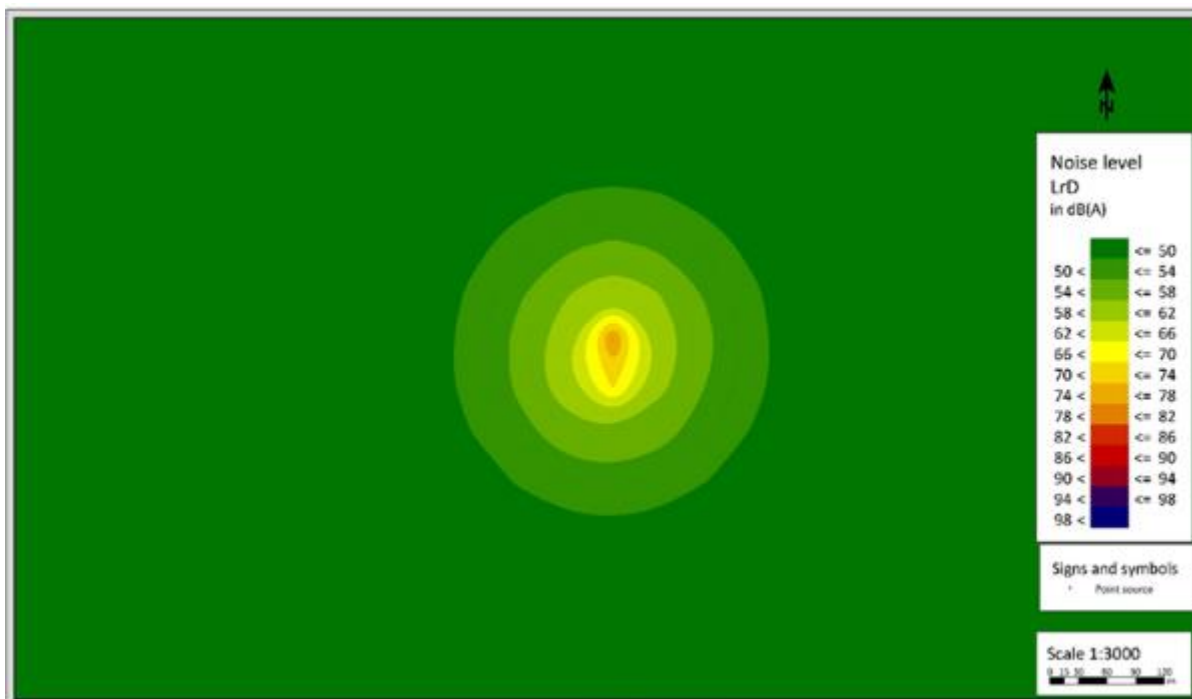


Figure 8.15. Prediction of Construction Noise

8.6.6. Risks & Impacts on Vibration

Significant impacts due to vibration are predicted during project construction and operation. Required mitigation measures will be implemented as per the requirement to control impact of vibration on structures, sensitive receptors and human beings.

8.6.6.1. Vibration Impacts and Risk to Existing Buildings

Significant impacts due to vibration are anticipated from the project construction activity. Mitigation measures will be implemented. Prior to this building condition survey will be conducted before, during

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and after construction. Transportation and Construction Vibration Guidance Manual, Caltrans, September 2013, specified threshold criteria for various structures are listed in **Table 8.23**. These criteria for monuments are more stringent than those prescribed in UK, Germany, Switzerland and Japan. Vibration source levels for typical construction equipment are listed in **Table 8.24**.

Table 8.23. Guideline Vibration Damage Threshold Criteria

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

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

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

Table 8.24. Vibration Source levels for Construction Equipment

| Equipment | | PPV at 7.6m (in/sec) | Approximate L # at 7.6m v |
|--|-------------|----------------------|---------------------------|
| Pile Driver (impact) | Upper range | 1.518 | 112 |
| | Typical | 0.644 | 104 |
| Pile Driver (sonic) | Upper range | 0.734 | 105 |
| | Typical | 0.170 | 93 |
| Large bulldozer | | 0.089 | 87 |
| Caisson drilling | | 0.089 | 87 |
| Loaded trucks | | 0.076 | 85 |
| Jackhammer | | 0.0345 | 79 |
| Small bulldozer | | 0.003 | 58 |
| # RMS velocity in decibels (VdB) re 1 μ inch/sec | | | |

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

Construction activities involve various sources of vibrations such as blasting, pile driving, dynamic compaction of weak soils, and operating heavy machines. Dynamic effects of these sources may create substantial vibration problems for surrounding buildings influencing structures, sensitive devices, and people. The level of structural vibrations caused by construction work depends mostly on interaction of three major factors: dynamic sources, geology, and structures. Each of them affects structural vibrations. Only dynamic sources can be modified in certain degree to comply with vibration limits. The rest of the two cannot be changed. Operating frequencies are typically between 25 and 50Hz.

Based on the baseline vibration monitoring performed, except for Corridor 1 V3 location – NITTE Global Institute, Yalahanka where the Peak Particle Velocity (PPV) is 0.128 mm/s which is less the threshold trigger level (05mm/s). Rest all of the locations the PPV is higher than the threshold triggering level. The maximum was recorded at Corridor 3 V-3 location, Karnataka Welfare Association for the Blind, Sheshadripuram which showed a PPV of 8.636 mm/s. The second highest was recorded

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at Corridor 3 V-1 location, Suhasini Hospital Kengeri, which recorded a PPV of 6.171 mm/s. These two areas fall under the Corridor 3 and proper action has to be taken to reduce the baseline vibration levels. Corridor 1 V-1 location recorded a PPV of 1.107 mm/s and Corridor 4 V-2 location recorded a PPV of 1.313 mm/s, which is the third highest value and proper remedial action, has to be taken to bring down the vibration level below the threshold trigger level. All other locations indicated less than 1.00 mm/s but higher than 0.5mm/s threshold trigger level. Hence, the construction team must give priority and take proper corrective and preventive action to mitigate and reduce the vibration level. Threshold limit (upper Limit) of the vibration monitors were set to 0.5 mm/s limit. The construction team must give priority and take additional care with proper corrective and preventive action to mitigate and reduce the vibration level at these above mentioned 2 locations of sensitive receptors.

The factors which affect the level of vibration at in the ground, arising from any activity, are: the amount of energy transmitted into the ground by the source; the rate of attenuation of the energy as it propagates through the ground; and the distance of the observation point from the location at which the energy enters the ground. Piling methods differ from many other vibration sources in that the position of the source which transfers energy into the ground continually changes as piling progresses, since the tip gets progressively deeper and encounters different soil and the length of the pile shaft in contact with the ground increases as driving progresses. A further difference is that the actual energy source does not come into direct contact with the ground, except in the case of end-driven piles. Therefore, factors which may need to be considered are the details of the pile and piling hammer or driver, the nature of the ground into which the pile is being driven and the distance from the pile to the measurement location.

Based on the summary of the baseline vibration monitoring performed, it was observed that, the Peak Particle Velocity (PPV) is higher than the threshold trigger level except for V-3 location of Corridor 1 (NITTE Global Institute).

The maximum PPV was recorded at Corridor 3 V-3 location, Karnataka Welfare Association for the Blind School, Sheshadripuram which showed a PPV of 8.636 mm/s. The second highest was recorded at Corridor 3 V-1 location, Suhasini Hospital, Kengeri, which recorded a PPV of 6.171 mm/s. These two areas fall under the corridor 3.

Corridor 1 V-1 and Corridor 4 V-2 locations recorded a PPV of more than 1 mm/s. PPV recorded for all other location is < 1.00 mm/s, but > 0.5mm/s the threshold trigger level.

The proposed rail corridors do not pose any serious risk to existing buildings as the corridors pass almost within the existing ROW and already there are existing functional/operative railway corridors however, minor risks of vibration in association with noise have been predicted which can be resolved by adopting specified mitigation measures during construction. The ground stability and settlement analysis is a mandatory activity prior to the commencement of construction activities at designated site locations.

8.6.6.2. Risks and Impacts of Vibration on Sensitive Receptors

The major impacts to the sensitive receptors are due to vibration. Vibration levels are assessed at the sensitive receptors identified along all the corridors as given at **Table 5.48**. The analysis of the results indicates the following:

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Impact piles shall be used only when any structure comes under older Residential and Historic old Buildings located at a distance of more than 50 m.

- Vibration levels generated are exceeding at 01 no. educational institute along Corridor 1.
- Vibration levels generated are exceeding at 01 no. educational and 01 no. Hospital along Corridor 3.
- Vibration levels generated are exceeding at 01 no. educational institute along Corridor 4.

As discussed in Section 5.8.2, there are 12 numbers of sensitive receptors identified within 100 m on either side of the alignment for Vibration study. The nearest receptor is 30 meters away from the centre line of suburban rail alignment. Disturbance to facilities such as Schools, Hospitals and Parks are anticipated as proposed alignments are at grade and elevated levels. None of the Station locations lies in any park area. The major construction activities causing vibration and noise pollution include excavation, loading, transportation of materials and operation of construction equipment and DG sets etc.

The potential impact of vibration due to Construction activities is mainly annoying public nearby. The typical levels of vibration for construction equipment as recommended by Federal Transit Administration (FTA) are briefed in **Table 8.25**. In the table the values at 25 feet are based on the FTA 1995. On the basis of reference values of vibration at 7.6m, an impact at 22.8m, 30m and 45m are calculated. The ground borne vibration impacts may be somewhat perceptible to people who are outdoors, it is almost never annoying and does not cause a strong adverse human reaction. According to the California Department of Transportation, (2004), the threshold of perception, or roughly 0.25 mm/s (108 VdB) may be considered annoying to people and the architectural damage criterion for continuous vibrations is 5 mm/s (134 VdB).

Table 8.25. Typical Levels of Vibration for Construction Equipment

| Sl. No. | Construction Equipment | VdB at 7.6m | VdB at 22.8m | VdB at 30m | VdB at 45m |
|---------|---------------------------|-------------|--------------|------------|------------|
| 1 | Rock drilling (Rig Pile) | 115.9 | 101.6 | 97.9 | 94.3 |
| 2 | Dump trucks | 122.7 | 108.3 | 104.6 | 99.3 |
| 3 | Bulldozer | 124.0 | 109.7 | 106.0 | 100.7 |
| 4 | Excavator 0.089, 106 | 124.0 | 109.7 | 106.0 | 100.7 |
| 5 | Hydraulic Crane 0.808, 87 | 143.2 | 128.9 | 125.1 | 119.8 |

Source: Transit Noise and Vibration Impact Assessment, Federal Transit Administration (FTA).

There are no adverse vibrations risks & impacts predicted on environment or buildings nearby from construction activities that will be carried out for at grade sections. Vibration impacts on environment are anticipated during construction of elevated sections. Pile-driving is one of the major sources of vibration during project construction. Continuous operation of Vibratory piles at a fixed frequency may be more noticeable to nearby residents, even at lower vibration levels. The steady-state excitation of the ground may induce a growth in the resonant response of building components.

Mitigation Measures : The mitigation measures to reduce the construction vibration are:

- Routing heavily-loaded trucks away from residential and sensitive areas,
- Operation of earth-moving equipment on the construction site as far away from vibration - sensitive sites as possible,

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- Phase demolition, earth-moving and ground-impacting operations so as not to occur in the same time period. The total vibration level produced could be significantly less when each vibration source operates separately,
- Avoidance of night time construction activities near residential and sensitive areas,
- Avoidance of impact pile-driving where possible in vibration-sensitive areas,
- Avoidance of vibratory rollers near sensitive areas.

Preparation and implementation of a Vibration mitigation plan will be done by the contractor incorporating all required above mitigation measures and as per codes of practice during construction phase of the project. This scheme of the Vibration Mitigation Plan shall include:

- Monitoring of requirements for vibrations at regular intervals throughout the construction period.
- Pre-construction structural integrity inspections of protected monuments, heritage assets or other sensitive structures.
- Information dissemination about the construction method, probable effects, quality control measures and precautions to be used.
- Vibration monitoring plan during final design and the implementation of a compliance monitoring program during construction
- Proper scheduling of construction activities producing vibration shall be taken, such that demolition, earth moving and ground-impacting operations to not to take place at the same time. Unlike noise, the total vibration produced may be significantly less when vibration sources operate separately.
- Construction activities shall be avoided during night hours when people are more aware of vibration.
- Press piling shall be adopted by the contractor to minimise vibration levels during piling along the path in conjunction with pre-auguring and jetting dependent on ground conditions. Vibration levels at properties due to press piling including pre auguring are predicted to be less than 0.2mm/s at 23m.
- Piling programmes should be arranged to control the amount of disturbance in noise and vibration sensitive areas at times that are considered of greatest sensitivity. If piling works are in progress on a site at the same time as other works of construction or demolition that themselves may generate significant noise and vibration, the working programme should be phased so as to prevent unacceptable disturbance at any time.
- Maintain the setback distances for construction equipment.
- Site-specific mitigation will be determined prior to the start of construction based on selected means and methods.
- Develop a communications protocol for providing advanced notice of construction work and addressing public complaints in a timely manner.

The project will implement above mentioned Vibration Mitigation Measures and thus, comply with the Indian regulations and WBESF guidelines.

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Residual impact: With proper execution of the proposed mitigation measures the residual impact is expected to be negligible. If any damage is caused and proven to be valid then it will be incumbent on the contractor to pay compensation.

The project will implement above mentioned Vibration Mitigation Measures and thus, comply with the Indian regulations and WBESF guidelines and EIB Standards 1 & 3.

8.6.7. Risks & Impacts on Water Resources and its Quality

8.6.7.1. Impact on Drainage and Hydrological Flow

The project road runs through plain terrain. There is no river crossing in the project stretch but the project road abut water bodies - lakes at 8 locations and natural drainage channels /nala /streams at two locations. During heavy rainfall these natural drainage channels carry swift flow. As the existing CD structures and bridges will be suitably supporting the water flow, there is no obstruction or disturbance to the water bodies. Therefore, no impact on drainage is envisaged.

During Construction there may be risks and Risks and Impacts of the following nature :

- Chances of filling of existing drainage courses during earth filling.
- There may be potential drainage Risks and Impacts relating to the establishments of construction camps and various plants such as batching etc. drainage Risks and Impacts at these locations may result in loss of top soil.

Mitigation Measures : Measures to avoid risks and impacts on Drainage and Hydrological Flow include the following :

- Adequate side drains will be provided along the corridor to facilitate its better maintenance and to avoid soil erosion and land degradation due to water stagnation.
- Filling of existing drainage courses will be strictly avoided
- Construction works of cross drainage structures, if any, are taken up during the lean flow periods in summer to minimize the impacts on drainage.
- Construction work near natural drainage channels / low lying areas shall be carried out in such a way that flow of water is not blocked and even if it has to be blocked then the contractor must ensure that the local communities are informed about the same in advance
- Suitable drainage at construction site & camp will be provided to eliminate the chances of formation of stagnant water pools that leads to soil erosion & breeding of mosquitoes.

The proposed project activities may impact Water sources and Water bodies as mentioned below :

8.6.7.2. Impact on Water Sources

The Water sources along the proposed suburban rail corridors are listed below :

Table 8.26. Water Sources along the Suburban Rail Corridors

| Corridor 1 | Corridor 2 | Corridor 3 | Corridor 4 |
|-------------------------------------|--------------------------------------|--|-------------------------------------|
| Streams at RHS Km 2/610 and 11/850; | No Lakes or Streams. Open Wells at 4 | No Lakes or Streams. Bore well at RHS Km | Lakes along the existing corridor - |

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| | | | |
|--|---|--|---|
| Gantigunahalli Lake at LHS Km 4/200 and Nellukunte Lake at Km 6/300 and at RHS Km 1/350 Yelahanka Lake and Open Well at Km LHS 12/000. | locations - RHS at km 216/830, Km 217/450, Km 217/600 & Km 218/100 and at LHS Km 217/550 and Bore well with Pump at RHS Km 216/625. | 6/820 and Open Well at RHS Km 349/860. | Huskur Lake at LHS Km 188/600, Panathur Lake at LHS Km 185/800 and Doddanekundi Lake at LHS Km 202/050; Jakkur Lake at RHS Km 12/880 and Yelahanka Lake at RHS Km 17/600. |
|--|---|--|---|

Mitigation Measures : Proper care and measures shall be undertaken as mentioned above and in line with Water (Prevention and Control of Pollution) Act, 1974 & its amendments and ESS 3 of World Bank. Measures to avoid risks and impacts on Water Sources include the following :

- Affected hand pump, bore well and open well shall be relocated in such a manner that it should not hamper the access to drinking water.
- Construction will not be started until all drinking water sources are replaced with new ones.
- Supply water is the main sources of drinking water in the project area. Therefore, no major impact is envisaged on the user.

8.6.7.3. Water Usage/consumption for Construction

During construction period Water is required for compaction of embankment, dust suppression, concrete making and domestic use in construction camp. Water use balance for the project during construction is presented in below table.

Table 8.27. Water Use Balance for the Project during construction

| Sl. No. | Water requiring Activities | Quantity of Water Consumption (KL) | | | Water for Recycling (KL) | Water usage for Project (KL) | Reuse of recycled Water |
|--------------|-----------------------------|------------------------------------|-----------------------|------------------|--------------------------|------------------------------|---|
| | | Corridor 2 | Remaining 3 Corridors | Total Project | | | |
| 1 | Operation of Batching Plant | 44200 | 221000 | 265200 | - | 265200 | - |
| 2 | Washing of TM | 2600 | 13000 | 15600 | 15600 | - | Used for flushing of toilets at labour camp, office and gardening |
| 3 | Curing | 520000 | 2600000 | 3120000 | 624000 | 2496000 | - |
| 4 | Labour/Base Camp | 109350 | 546750 | 656100 | 557685 | 98415 | Used for flushing of toilets at labour camp, office and gardening |
| Total | | 6,76,150 | 33,80,750 | 40,56,900 | 11,97,285 | 28,59,615 | |

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Mitigation Measures: Measures to avoid risks and impacts on Water usage for Construction include the following :

- Minimum use of water from existing sources for construction purpose will be ensured to minimize likely risks and impacts on other users.
- The contractor will arrange water required for construction in such a way that the water availability and supply to nearby communities remain unaffected.
- If new tube-wells are to be bored, due to the non-availability of water required for construction, prior sanctions and approvals by the Ground Water Department has to be obtained by the Contractor.
- Wastage of water during the construction shall be minimized.

Residual Impact: After implementation of the mitigation measures described above residual impacts are expected to be minor.

8.6.7.4. Risks and Impacts on Water Quality

During construction phase, leakage of Petroleum, Oil and Lubricants (POL) could lead to an increase in water pollution level of the region. Anticipated potential Risks and Impacts are due to spillage of construction materials, such as, cement, Petroleum, Oil and Lubricants (POL), etc. discharged in to the drainage channels from workshops, construction camps, and quarry / borrow areas, etc. of the Contractor.

- Accident involving hazardous materials may cause pollution but the occurrence of large scale spillage of is extremely rare.
- Increase of sediment load in the run off from construction sites and increase in turbidity in receiving streams/water bodies
- Water pollution due to sewage from construction camps

Mitigation Measures: Control Measures to avoid risks and impacts on Water Quality (Water Pollution Control Measures) are as follows :

Waste water will be generated from construction activities and labour activities at base camp due to cleaning, washing, etc. Waste water generated from the site during the construction contains suspended materials, spillage and washings which can pollute surface and ground water. Such washings/waste water shall be led through separate drains in to precipitation chambers before their discharge into the sewage drain, in accordance to the standards prescribed for disposal and Water (Prevention and Control of Pollution) Act, 1974 & its amendments and ESS 3 of World Bank & EIB's ESS 3.

Measures to avoid risks and impacts of water pollution due to project activities during construction are as given below :

Control Measures for Water Pollution from Construction Wastes :

- The Contractor shall take all precautionary measures to prevent entering of wastewater into streams, water bodies or the irrigation system during construction.
- Contractor shall avoid construction works close to the water bodies during monsoon.

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- Contractor shall not wash his vehicles in water body and shall not enter the water body for any purpose.
- Measures such as sedimentation tanks on site for batching plants shall be implemented.
- Contractor shall try and reduce the water consumption through use of energy efficient water fixtures at sites and project offices.
- Leakage of water should not be allowed through pipes and valves.
- Reuse of water used for curing and for other uses shall be planned.
- Proper sanitation facilities (mobile toilets) may be provided at the construction site to prevent health related problems due water contamination
- An effective traffic management plan is to be implemented to avoid any accidental spillage of risky materials.
- All the construction and preparatory activities including construction of CD structures will be carried out during dry seasons only.
- The CD structures should not be drained to the agricultural and horticultural farms or to the immediate vicinity of houses of the locales.
- The unlined roadside drains in rural stretches carrying storm water will be connected to the nearest natural drainage channel, water bodies with silt traps.

Control Measures for Water Pollution from Fuel and Lubricants :

- The Contractor shall ensure that all construction vehicle parking locations, fuel/lubricants storage sites, vehicle, machinery and equipment maintenance and refueling sites shall be located at least 500 m away from rivers and irrigation canal/ponds.
- The Contractor shall submit all locations and layout plans of such sites prior to their establishment and shall be approved by the Environmental Specialist of GC.
- Contractor shall ensure that all vehicle/machinery and equipment operation, maintenance and refueling shall be carried out in such a manner that spillage of fuels and lubricants does not contaminate the ground.
- Provision for oil interceptors shall be made at all the construction camps / workshop areas to separate the oil and grease waste generated from servicing of equipment and vehicles used in the construction. Wastewater from vehicle parking, fuel storage areas, workshops, wash down and refueling areas shall be treated in an oil interceptor before discharging it on land or into surface water bodies or into other treatment system.
- Overall fuel storage and refueling areas, if located on agricultural land or areas supporting vegetation, the topsoil shall be stripped, stockpiled and returned after cessation of such storage.
- Contractor shall arrange for collection, storing and disposal of oily wastes to the pre-identified disposal sites (list to be submitted to GC and K RIDE) and approved by the Environmental Specialist of GC. All spills and collected petroleum wastes shall be disposed-off in accordance with Petroleum Rules and PCB guidelines.

Residual Impact: After implementation of the mitigation measures described above residual impacts are expected to be minor.

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8.6.7.5. Impact from Siltation and Sedimentation

Silt Run off during earth activities due to unmanaged construction materials and excavated earth materials lead to siltation and sedimentation of water bodies and thereby reducing the water storage capacity of Water Bodies.

Mitigation Measures : The Contractor shall not excavate beds of any stream/canals/any other water body for borrowing earth for embankment construction in compliance with WB ESS 3 and EIB Standards 1 & 3..

Contractor shall construct silt fencing at the base of the embankment construction for the entire perimeter of any water body adjacent to the project corridor and around the stockpiles at the construction sites including ancillary sites close to water bodies. The fencing shall be provided prior to commencement of earthwork and continue till the stabilization of the embankment slopes, on the particular section of the project corridor.

A temporary basin at the lowest point of the site has to be constructed for collecting, trapping and storing sediment produced by the construction activities, together with a flow detention facility for reducing peak runoff rates. This would allow most of the sediments to settle before the runoff is directed towards the outfall.

Typical cross section of Silt trap is presented in **Annexure 10.31**. Contractor shall ensure that construction materials containing fine particles are stored in an enclosure such that sediment-laden water does not drain into nearby watercourse. Guidelines on sediment control measures are presented in **Annexure 10.6**.

8.6.7.6. Drain choking and Flood Control

The large-scale choking of the storm water drains due to construction waste and debris such as bricks, aggregates, cement, etc. during rainy season cause flooding in the surrounding area.

Mitigation Measures : Contractor shall ensure that no construction materials like earth, stone, or appendage disposed-off in a manner that block the flow of water of any water course and cross drainage channels in compliance with WB ESS 3 and EIB Standards 1 & 3..

Contractor shall take all necessary measures to prevent any blockage to the water flow. In addition to the design requirements, the Contractor shall take all required measures as directed by the Environmental Specialist of GC to prevent temporary or permanent flooding of the site or any adjacent area.

8.6.7.7. Risks and Impacts on Ground and Surface Water Quality

Risks and Impacts : Impact on Ground water is anticipated if sewage is not treated properly and disposed. Ground water contamination is predicted if sewage at labour camps or chemical substances from construction site or dumped muck or construction/demolition waste or used water from the RMC plant are not treated properly; they get leached by precipitation of water and percolate to the ground water table.

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Mitigation Measures : The construction activities shall be planned in such a way that the water resources will not be affected in accordance with Water (Prevention and Control of Pollution) Act, 1974 & its amendments and ESS 3 of World Bank & EIB's ESS 3.

Waste water shall be treated by appropriate sedimentation/ETP facilities to a conforming standard before its release. Part of the treated wastewater is also recycled to minimize the quantum of release of wastewater into the water body. Treated water shall be reused for construction activities.

Ground Water Pollution Control Measures:

The measures proposed to prevent ingress of toxic / heavy metals shall be implemented. By implementing the proposed measures, the project is expected to comply with Water (Prevention and Control of Pollution) Act, 1974 & its amendments and ESS 3 of World Bank & EIB's ESS 3.

Suitable storage area for such materials shall be prepared and equipment shall be made available for handling of these materials.

Contractor shall take all necessary precautions such that construction material, diesel, grease, waste oil, chemicals etc. does not spill on ground.

Regular monitoring of groundwater and soil leachate shall be conducted at muck disposal areas where possibility of ground water contamination is anticipated. Reporting format for pollution monitoring is presented in **Annexure 10.34**.

Water Quality Monitoring: Apart from provision of the mitigation measures, water quality shall be monitored to understand the effectiveness and further improvement in designs in reducing the concentration of pollutants. The monitoring plan shall be functional in construction as well as in operation stages. The frequency, duration and responsibility will be as per the Environmental Monitoring Plan (Section 10.10 of Chapter-10). The maximum desirable limits as per the water quality standards are given in **Annexure 8.3** and the monitored values should correspond with the table. All deviated results shall be reported to Sr. Environmental Specialist of the General Consultant for remedial measures. It should be ensured that no construction camps or stockyards are set up near rivers, irrigation canals and water bodies to prevent oil spills.

Silt Fencing: Silt fencing will be provided to prevent sediments from the construction site entering into the nearby watercourses. The silt fencing consists of geo textile with extremely small size supported by a wire mesh mounted on a panel made up of angle / wooden frame and post. The frame will be installed at the edge of the water body along which construction is in progress. It is proposed to install silt trap at the edge of all water bodies located along the project road, major and minor bridge locations. Further, silt fence will be mounted in guiding drains at a distance of 3 to 5 m in the upstream direction depending on the gradient of the guiding drains. However location of silt traps will depend on contractor's proposal for site facilities and work sites and should be provided in the contractor's proposals. This will be checked by Sr. Environmental Specialist of the General Consultant and monitored by PIA. Drawing of typical silt trap is given in **Annexure 10.31**.

Oil Interceptors: Oil and grease from road run-off is another major concern during construction as well as operation. During construction, discharge of oil and grease is most likely from workshops, oil and waste oil storage locations, and vehicle parking areas of the contractor camp. Therefore, location of Oil Interceptors has been considered such that each construction camp having refuelling stations, oil and lubricants storage places will have one oil interceptor to stop & separate the floating oils. The arrested products shall be disposed as per MoEF&CC and CPCB guidelines. However, the number of

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interceptors shall increase as the situation demands or during the accidental spillages. Actual number will be decided by the Contractor with the consent of Sr. Environmental Specialist of the General Consultant. Drawing of typical Oil Interceptor is given in **Annexure 10.33**.

Ground Water Recharge Pit/ Rainwater Harvesting Structures with silt fences have been proposed near water bodies and local stream crossings to improve the water table in this region and conserve water bodies. It has been observed from the past meteorological data of IMD, total number of rainy days in Bengaluru is 58.5 rainfall days and average 974.5mm (38.37") of precipitation.

The project will implement these above mentioned water pollution control measures and thus, comply with the Indian regulations and WBESF guidelines.

Residual impact: After implementation of the mitigation measures described above residual impacts are expected to be minor.

8.6.7.8. Increased Water supply and Demand

There will be increased water demand during construction phase. Total water demand is 40,56,900 KL during construction stage, out of which, 34,00,800 KL for construction activities and 6,56,100 KL for Labour camp. Sufficient water for construction will be made available by digging bore hole/bore well within the project site vicinity or by public water supply.

Therefore, proper care shall be administered while deciding the location of these activities or drawing water from public facilities.

8.6.8. Risks & Impacts on Flora & Fauna and their Protection

8.6.8.1. Risks and Impacts on Flora

Clearing and Grubbing (C & G) activities for Vegetation clearance at work sites may affect the adjacent or nearby flora by damaging and disruption to their growth. There are no threatened tree species falling within the ROW along the project corridors.

Mitigation Measures: Vegetation shall be removed from the construction zone before commencement of construction. All works shall be carried out such that the damage or disruption of flora other than those identified for cutting is minimal.

Only ground cover/shrubs that impinge directly on the permanent works or necessary temporary works shall be removed with prior approval from the Sr. Environmental Specialist of GC.

The Contractor, under any circumstances shall not cut or damage trees and forest reserves. Trees identified under the project shall be cut only after receiving clearance from the BBMP Forest Wing/Forest Dept./DoEF/MoEFCC (as applicable) and after the receipt of K RIDE's written permission in this regard. This will be in line with ESS 1 & 6 of World Bank and EIB Standards 1 & 3.

Vegetation only with girth size of over 30 cm shall be considered as trees and shall be compensated, in the event of K RIDE's instruction to undertake tree cutting.

Translocation of trees less than 30cm and trees as suggested by BBMP Forest Wing/Forest Dept. shall be carried out adequately.

Compensatory afforestation for the tree cut and translocated trees shall be carried out by BBMP forest Wing/ Forest Dept. in coordination with K RIDE as per the Tree Management Plan.

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The tree protection/preservation, cutting and disposal shall be planned in line with The Karnataka Tree Preservation Act, 1976 & amendment Rule 2008, Tree Management Plan, Forest Conservation Act 1980 and ESS 6 of World Bank & EIB's ESS 4.

- The Contractor, under any circumstances shall not cut or damage trees and forest reserves. Trees identified under the project shall be cut only after receiving clearance from the BBMP Forest Wing/Forest Dept./DoEF/MoEFCC (as applicable) and after the receipt of K RIDE's written permission in this regard. This will be in line with ESS 1 & 6 of World Bank & EIB's ESS 1 & 4.
- Deposition of fugitive dust on pubescent leaves of nearby vegetation may lead to temporary reduction of photosynthesis. Such impacts will, however, be confined mostly to the initial periods of the construction phase and in the immediate vicinity of the construction area.
- Biomass shall not be stored at site for more than 15 days.
- The Contractor shall do turfing on embankment slopes, plantation of shrubs as specified in the Contract.

8.6.8.2. Risks and Impacts on Fauna

Except the domestic fauna such as dogs, cows, Oxen, hens, buffaloes, snakes, monkeys, donkeys, etc. and birds such as crows, parrots, pigeons, etc., there are no wild or endangered animals or birds noticed in the vicinity of all the corridors of the project. Therefore, no risks or impacts on wildlife or domestic fauna are anticipated due to the proposed BSR Project.

8.6.8.3. Protection of Chance found Wild Flora and Fauna

The Contractor shall take reasonable precaution to prevent his workmen or any other persons from removing and damaging any flora (plant/vegetation) and fauna (animal) including fishing in any water body and hunting of any animal, nearby. If any wild animal is found in the vicinity of construction sites by chance, at any point of time, the contractor shall immediately upon discovery thereof acquaint in the Environmental Specialist of GC and carry out his instructions for dealing with the same. The related procedure shall be followed and records shall be maintained.

Residual Impact: No residual impact is expected on ecologically important areas as long as resource materials are sourced from approved legitimate suppliers.

8.6.9. Risks and Impacts Due to Solid Waste

8.6.9.1. Construction /Demolition Waste Materials

Surplus or unused materials and Construction Wastes with Debris will be generated from dismantling structures and from activities at work zones along the corridors. During rainy season this may leach out along with run off in to nearby low lying areas or water bodies.

Mitigation Measures: Construction Waste and Debris shall be disposed as per Guidelines provided in EMP and complying with the Solid Waste Management Rules, 2016, amended in 2018 and Regulations of PCB and ESS 1 & 3 of World Bank and EIB Standards 1 & 3.

The pre-identified disposal site shall be a part of Comprehensive Waste Disposal Plan. Solid Waste Management Plan shall be prepared by the Contractor for disposal of debris in consultation and with

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approval of Environmental Specialist of GC. In the case of non-availability of disposal site, Solid Wastes shall be handed over to BBMP authority regularly, as per the Solid Waste Management Rules, 2016, amended in 2018 and Regulations of PCB.

Surplus materials and other debris generated due to dismantling of the existing structures along the corridors shall be suitably reused in the proposed construction zone, subjected to the structure suitability of the materials and approval of the Resident Engineer and Sr. Environmental Specialist of GC as follows:

- For filling and levelling of School grounds and proposed parking areas.
- Earth from cutting shall be used as embankment fill material.

Existing base and sub-base material shall be recycled as sub-base of the haul road or access roads.

The existing bitumen road shall be utilized as haulage routes for transportation of materials.

The Contractor shall suitably dispose-off unutilized debris materials either through filling up of borrows areas located in wasteland or at pre-designated disposal locations, subject to the approval of the Environmental Specialist of GC.

All arrangements for transportation during construction including provision, maintenance, dismantling and clearing debris, shall be considered incidental to the work and shall be planned and implemented by the Contractor as approved and directed by the Environmental Specialist of GC.

Reuse and Recycling of materials shall be carried out as follows :

- Segregation and temporary storage of reusable and recyclable materials at identified locations. Transportation of recyclable materials to construction sites.
- Sale of metal scrap and other saleable waste.
- Identification of intended transport means and route.
- Obtaining permission wherever required, for treatment of the hazardous component and its disposal.
- Concrete material shall be broken in to coarse size and reutilized in filling.

The pre-designed disposal locations shall be a part of Waste Disposal Plan in consultation and with approval of Environmental Specialist of GC. Debris generated from pile driving or other construction activities shall be disposed such that it does not flow into the nearby surface water bodies or for mud puddles in the area.

The Contractor shall identify dumping sites as per the Debris Disposal Plan prepared using the Guidelines provided in the **Annexure 10.8**; The identified locations shall be reported to the Environmental Specialist of GC. These locations shall be checked on site and accordingly approved by Environmental Specialist of GC prior to any disposal of waste materials. Reporting format for identification and site selection and management of Debris disposal site is presented in **Annexure 10.21** and **Annexure 10.22** respectively.

8.6.9.2. Risks and Impacts due to Construction/Demolition Waste Disposal

Risks and Impacts : Improper disposal or dumping of Construction /Demolition Wastes and other debris at construction sites result in air and water pollution, noise, diversion of green parks and

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temporary displacement. Approximately 26135 m³ of construction/ demolition was generated from the BSRP.

Table 8.28. Quantity of Construction/Demolition Waste Generated from BSRP

| BSRP Corridors | | Corridor 1 | Corridor 2 | Corridor 3 | Corridor 4 | Total Quantity in m ³ |
|---|--|------------|------------|------------|------------|----------------------------------|
| Quantity Construction/ Demolition waste generated in m ³ | | 8262.6424 | 4982.13 | 3679.32 | 9211.26 | 26135.35 |

About 10-15% of the C&D wastes are from the Contractor's Camp. Improper management of C & D waste and Quarry dust by dumping irregularly or haphazardly at construction sites or in labour camps may lead to surface and ground water pollution in nearby areas and may cause loss of natural resources.

During construction period the demolition waste materials and surplus or unwanted construction materials as wastes [Construction and Demolition (C&D) waste] are considered as the solid waste materials resulting from land clearing, excavation, construction, demolition, remodeling and repair of structures, roads and utilities. C&D waste has the potential to save natural resources (stone, rivers and soil, etc.) and energy, reduce transportation over long distances for dumping, and reduce space occupied at landfill sites.

C&D waste generated from Suburban Railway construction has potential reuse after processing, grading solid waste and recycling. The C&D waste generated will be reused and remaining will be disposed in a manner that will not affect the human health and environment in line with C&D Waste Management Rules, 2016 & its amendments, regulation of PCB and ESS 3 of World Bank and EIB Standards 1 & 3.

Mitigation Measures : Following are the measures to be followed by the Contractor during C & D Management:

- The pre-identified disposal site shall be a part of Comprehensive Waste Disposal Plan. Solid Waste Management Plan shall be prepared by the Contractor for disposal of debris in consultation and with approval of Environmental Specialist of GC. In the case of non-availability of disposal site, Solid Wastes shall be handed over to BBMP authority regularly, as per the Solid Waste Management Rules, 2016, amended in 2018 and Regulations of PCB.
- Surplus materials and other debris generated due to dismantling of the existing structures along the corridors shall be suitably reused in the proposed construction zone, subjected to the structure suitability of the materials and approval of the Resident Engineer and Sr. Environmental Specialist of GC as follows:
 - For filling and leveling of School grounds and proposed parking areas.
 - Earth from cutting shall be used as embankment fill material.
- Existing base and sub-base material shall be recycled as sub-base of the haul road or access roads.

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- The existing bitumen road shall be utilized as haulage routes for transportation of materials.
- The Contractor shall suitably dispose-off unutilized debris materials either through filling up of borrows areas located in wasteland or at pre-designated disposal locations, subject to the approval of the Environmental Specialist of GC.
- All arrangements for transportation during construction including provision, maintenance, dismantling and clearing debris, shall be considered incidental to the work and shall be planned and implemented by the Contractor as approved and directed by the Environmental Specialist of GC.
- Reuse and Recycling of materials :
 - Segregation and temporary storage of reusable and recyclable materials at identified locations. Transportation of recyclable materials to construction sites.
 - Sale of metal scrap and other saleable waste.
 - Identification of intended transport means and route.
 - Obtaining permission wherever required, for treatment of the hazardous component and its disposal.
 - Concrete material shall be broken in to coarse size and reutilized in filling.
- The treatment and disposal sites will be identified by K RIDE in consultation with KSPCB such that pollution of water bodies and green areas are not impacted and displacement of persons is not involved. Before dumping, recyclable material will be removed. The disposal sites will be cleaned and then treated so that leached water does not contaminate the ground water.
- The pre-designed disposal locations shall be a part of Waste Disposal Plan in consultation and with approval of Environmental Specialist of GC. Debris generated from pile driving or other construction activities shall be disposed such that it does not flow into the nearby surface water bodies or for mud puddles in the area.

The Contractor shall identify dumping sites as per the Debris Disposal Plan prepared using the Guidelines provided in the **Annexure 10.8**; The identified locations shall be reported to the Environmental Specialist of GC. These locations shall be checked on site and accordingly approved by Environmental Specialist of GC prior to any disposal of waste materials. Reporting format for identification and site selection and management of Debris disposal site is presented in **Annexure 10.21** and **Annexure 10.22** respectively.

By implementing these waste management measures, the project is expected to comply with the Indian Standards and WBESF guidelines.

Residual Impact: With proper implementation of the proposed mitigation measures the residual impact during construction will be minimal.

8.6.9.3. Risks and Impacts due to Muck Disposal

After the reuse of the graded excavated materials during construction, the left over materials form the muck for disposal. Prior cautions need to be taken by the Contractor by checking the quality of soil

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before excavation for presence of heavy metals in soil and the results will be compared with standards. If the soil is contaminated, disposal will be done with due treatment or isolation of such muck.

The muck generation is unavoidable from the proposed project activities. All the Suburban Rail Corridors are a mix of elevated and at grade right of way. The short term construction activity involves cut and cover, excavation and fills. All these activities will result in excavation of about 826688.4 m³ and fill of about 372009.8 m³ with net quantity to be disposed of about 454678.6 m³.

Corridor wise Muck generated for the BSRP corridor is presented in **Table 8.29**;

Table 8.29. Quantity of Muck Generated from BSRP

| BSRP Corridors | Corridor 1 | Corridor 2 | Corridor 3 | Corridor 4 | Total Quantity in m ³ |
|---|------------|------------|------------|------------|----------------------------------|
| Quantity Muck generated in m ³ | 261355.98 | 157589.88 | 116380.85 | 291361.70 | 826688.4 |

The location shall be identified in consultation / coordination with local authorities, Pollution control Board & all the Environmental safeguards by the contractor shall be ensured.

These details will be provided in due course of time and contractor shall require to submit the details in Monthly Environmental Report.

Risks and Impacts : Muck disposal if not properly done can result in environmental pollution. The impacts predicted are as follows:

8.6.9.4. Obstruction to Natural Watercourses

If muck materials are not disposed properly, this will enter into nearby water courses along with surface run-off and cause obstruction to the natural water courses – river, streams, etc. and lead to flooding affecting people residing at low lying areas.

8.6.9.5. Siltation in Surface Water Bodies

Muck materials along with run-off if enter into Surface Water bodies downstream, then deposit heavily and lead to high siltation, thereby substantially reducing the water holding capacity of the Water body in a very short span. Since De-siltation is expensive, the clearance of silt will be delayed by the authority.

8.6.9.6. Soil Erosion

If muck disposal is not proper at Disposal site, it will directly impact soil by eroding and thus, causing enormous soil erosion. The precipitation and the consequent run off will erode the loose materials by way of suspension and solution.

The total muck generation predicted is about 826688.4 m³.

Mitigation Measures : Due to the scarcity of land/space in busy city like Bengaluru, where elaborate measures are required for collection, storage, transfer and disposal, the generated waste muck will be reused to the maximum. This avoids dust generation during transportation of muck to the disposal site. If any balance muck, then it will be disposed in a manner that will not affect the human health and environment in line with ESS 3 of World Bank & EIB's ESS 3. For safe stacking or storage of dumped material, concrete reinforced retaining wall is proposed to be built before dumping of any material on

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the pre-identified muck dumping sites. The details will be provided by the Contractor once the muck disposal land is identified.

Disposal sites will be identified by K RIDE in consultation with Urban Local Body and KSPCB such that pollution of water bodies and green areas are not impacted and displacement of persons is not involved.

Location of disposal sites shall be finalized prior to initiation of the works on any particular section of the corridor. The Environmental Specialist of GC shall approve these disposal sites after conducting a joint inspection on the site with the Contractor.

The pre-identified Muck disposal site shall be a part of Comprehensive Waste Disposal Plan. Solid Waste Management Plan including Muck disposal shall be prepared by the Contractor in consultation and with approval of Environmental Specialist of GC. Muck disposal plan contain Dumping site selection criteria, precautions to be taken and actions to be implemented during muck disposal (**Annexure 10.7**) to avoid the negative impact on human health and environment as specified in ESS 3 of World Bank and ESS 3 of EIB. In the case of non-availability of disposal site, Solid Wastes shall be handed over to BBMP authority regularly, as per the Solid Waste Management Rules, 2016, amended in 2018 and Regulations of PCB, also in line with WB ESS 3 and EIB Standards 1 & 3.

The following are the mitigation measures which shall be taken up by the Contractor for Muck Disposal Management:

- Contractor shall ensure that any spoils or material unsuitable for embankment fill shall not be disposed-off near any water course or agricultural land, orchards and Natural Habitats like Grasslands. Such spoils from excavation can be used to reclaim borrow pits and low-lying areas located in barren lands along the project corridor (if it so desired by the owner/community and approved by the Environmental Specialist, GC).
- Non-bituminous wastes shall be dumped in borrow pits covered with a layer of 30cm soil to ensure that borrow pit is restored to original use. No new disposal site shall be created as part of the project, except with prior approval of the Environmental Specialist of GC.
- All waste materials shall be completely disposed and the site shall be completely cleaned and certified by Environmental Specialist of GC before handing over.
- Contractor shall carry out the reconciliation for the disposed soil and quantities shall submit to K RIDE on quarterly basis.
- Dry wheel wash facilities shall be provided at exit gate, from where soil disposal shall be carried.
- Sufficient staff shall be made available at site to control the disposal of muck/soil from site such as a supervisor, labors for wheel cleaning; brooms for wheel cleaning and concrete pad where wheels will be cleaned.
- The dumpers carrying the muck/dry soil has to be covered while plying on the roads on the way to disposal location.
- Contractor shall take due care that muck generated during piling works does not get contaminated with any contaminant.

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- The onsite muck shall be monitored quarterly at random location during piling works in progress. In case any polluted muck is produced; the muck shall be handled and disposed as per provisions of Hazardous and Other Wastes (Management and Trans boundary Movement) Rules, 2016 and its amendments and Control of Substances Hazardous to Health (COSHH)
- Construction and Demolition Waste shall be disposed in accordance with the provisions of C & D waste Handling Rules 2016 and its amendments.
- The Contractor at his own cost shall resolve any claim, arising out of waste disposal management.

The following activities are to be followed by the Contractor for Muck Disposal Site Management:

- Disposal sites shall be cleaned and then treated so that leached water does not contaminate the Ground Water.
- Material will be stock-piled with suitable slopes
- Material will be stabilised each day by watering or other accepted dust suppression techniques. The muck shall be filled in the dumping site in layers and compacted mechanically.
- Once the filling is complete, the entire muck disposal area shall be provided with a layer of good earth on the top and covered with vegetation.

Guidelines on muck and debris disposal and site management are provided in **Annexure 10.7** and **Annexure 10.8** respectively. Reporting format on muck and debris disposal and site selection and management are provided in **Annexure 10.22** and **Annexure 10.23**. Guidelines for storage, handling, use and emergency response for Hazardous substance are provided in **Annexure 10.12**.

The project will comply with the Indian regulations and WBESF guidelines by adopting the Dumping site selection criteria and precautions with necessary actions for muck disposal.

Residual Impact: After implementation of the mitigation measures described above residual impacts are expected to be minor.

8.6.9.7. Risks and Impacts due to Hazardous Waste

Risks and Impacts : Hazardous materials required to be used in the project includes the following :

Hazardous waste will mainly arise from the maintenance of equipment which may include used engine oils, hydraulic fluids, waste fuel, spent mineral oil/cleaning fluids from mechanical machinery, scrap batteries or spent acid/alkali, bulbs, air filters, spent solvents, paints, petroleum products (vehicular & Generator fuel), etc. Approved materials in accordance with the Control of Substances Hazardous to Health Support (COSHH) and MSDS will be used for the project. The following are the anticipated risks and impacts of mismanagement of hazardous materials :

- Accident involving hazardous materials may cause water pollution but the occurrence of large scale spillage of is extremely rare.

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- Dumping of hazardous materials on land without care will spoil the fertility of the soil and thereby leading to land degradation.
- Hazardous materials may lead to major accidents from injury to fatality of people during transportation
- Unsafe disposal can result in water and soil pollution, diversion of green parks and temporary displacement.

Mitigation Measures : The following measures are mandatory to be followed by the Contractor during Construction phase :

Hazardous material spill prevention and control plans shall be made,

- to clearly stating measures to stop the source of the spill,
- to contain the spill,
- to dispose the contaminated material and hazardous wastes, and
- stating designation of personnel trained to prevent and control spills.

EHS guidelines in line with Metro Rail projects is part of the EPC tender document of K Ride it is mandatory for Contractors to implement and manage accordingly. This EHS guidelines shall be formulated and redeveloped as per project activities and in accordance with all applicable legislation and Indian Statutory requirements listed as well as International Standards –IFC’s EHS Guidelines for Railways.

In addition, Hazardous Substance Management Plan shall be prepared by the Contractor prior to respective Construction activities in compliance with PCB’s guidelines of Hazardous and Other Wastes (Management and Trans boundary Movement) Rules, 2016 & its amendments. The storage, handling, utilization and disposal shall be carried out by the Contractor in line with PCB’s Hazardous Waste Management Rules, 2000.

The Hazardous waste management shall be handled diligently by authorized / licensed agent as per guidelines of Hazardous and Other Wastes (Management and Trans boundary Movement) Rules, 2016 & its amendments, Control of Substances Hazardous to Health (COSHH) and ESS 3 of World Bank and EIB Standards 1 & 3.

Residual Impact: With proper implementation of the proposed mitigation measures the residual impact during construction will be minimal.

8.6.9.8. *Municipal Solid Waste Management*

The pre-identified disposal site shall be a part of Comprehensive Waste Disposal Plan. Solid Waste Management Plan to be prepared by the Contractor in consultation and with approval of Environmental Specialist of GC. In case of non-availability of disposal site, Solid Wastes shall be handed over to BBMP authority regularly, as per the Solid Waste Management Rules, 2016, amended in 2018 and Regulations of PCB; and in line with WB ESS 3.

The Contractor shall provide with colour coded garbage bins for wet and dry wastes in the camps and ensure that these are regularly emptied and disposed-off in a hygienic manner as per the Comprehensive Solid Waste Management Plan approved by the Environmental Specialist of GC.

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Solid waste generated from labour camps shall be segregated and collected in separate Garbage bins for non-biodegradable and biodegradable waste and regularly emptied and the garbage shall be disposed-off in a hygienic manner. Biodegradable Municipal solid waste shall be collected by local BBMP and transported to local municipal bins for onward disposal to disposal site. Non-biodegradable waste shall be disposed by selling to scrap dealers (recyclable) and to existing authorized agency (inert and non-recyclables).

About 4,000 persons are likely to work during construction activity including skilled and unskilled workers. One fourth of persons involved in construction works are assumed as skilled workers. The skilled workers associated with fabrication and structure works are supposed to stay at labour camp while the local workers will be employed for other associated works like earthwork and concreting. About 400 skilled workers may stay at labour camps. Four labour camps may be proposed for 4 Corridors at appropriate and suitable locations. Considering that 80% of labourers are married, in 80% of married families both husband and wife will be working and taking average family size as 4, total workforce in the labour camps will be about 700 in numbers. It is estimated that about 300 Kg per day municipal solid waste may be generated from the 4 labour camps during construction. The collection, conveyance and disposal facilities shall be made available by providing 20 litres capacity bin with handle and cover for 8 workers. In addition, one community colour coded garbage bins for wet and dry wastes would be provided for effective collection of the waste. The disposal of the waste will be at municipal corporation landfill site.

Guidelines for preparation of Comprehensive Waste Management Plan are provided presented in **Annexure 10.9**. This Comprehensive Waste Disposal or Management Plan includes Solid Waste Management Plan for Management of Surplus materials which can be reusable or recyclable.

8.6.9.9. Risks & Impacts of Plastics

Plastic contributes to global warming. Almost all plastics are made from chemicals that come from the production of planet-warming fuels (gas, oil and even coal). Plastic pollution can alter habitats and natural processes, reducing ecosystems' ability to adapt to climate change, directly affecting millions of people's livelihoods, food production capabilities and social well-being.

There shall be total ban on usage of plastics and one time use plastic in accordance with the Plastic Waste Management Amendment Rules, 2021.

The usage of Paper or cotton bags shall be encouraged and shall be in practice, complying with WB ESS 1, 2, 3 & 4 and EIB Standards 1 & 3.

8.6.10. Risks & Impacts on Traffic

During construction period, complete/partial traffic diversions on road will be carried out based on the activity with strategic procedures. Proper entry and exits will be made along with required cautionary and information signage. Wherever the project alignment pass nearby roads it is advisable to allow for single lane traffic operation, during construction. Advance traffic updates/information on communication systems will be an advantage to affected road users.

The rail project will not pose any serious risks to existing buildings, as major parts of the project alignment lie at grade and elevated within the vicinity of existing rail corridors. However, works at corridors may get affected due to traffic issues and improper management. Also subsequently, it delays work completion.

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Mitigation Measures : To avoid work interruption and delay in work completion due to traffic and safety issues at construction sites, satisfactory traffic management shall be undertaken by the Contractor. This will help in easing out traffic flow during construction. The Contractor shall prepare Traffic Management Plan in accordance with codes of practice in advance and obtain approval from the Consultant or the project Authority prior to construction activities. Accordingly, the Traffic Management Plan should include provisions for provide the maximum safety to the population and project personnel and alternative access roads in coordination with local (transport) authorities. Following are the minimal measures:

- 20Km/h speed limit should be maintained for all the vehicles entering project site, construction camp and labour camps.
- The road users and residents should be very well notified and informed in advance to avoid problems and possible complaints.
- The prime measures include road widening, traffic segregation, one-way movements, traffic diversions, acquisition of service lanes, etc.
- All construction workers shall be provided with high visibility jackets
- All road users shall be warned in advance.
- All safe and clearly marked lanes, buffer and work zones shall be provided guiding road users.
- Various construction technologies like cut and cover can be employed to ensure that traffic impedance is minimized.

Residual Impacts: No impact on the ecosystem.

The project will implement these above mentioned Traffic Management measures and thus, comply with the Indian regulations and WB ESF guidelines and EIB Standards 1 & 9.

8.6.11. Energy Management

Energy is crucial to socio-economic and sustainable environmental development, as well as for improvement in the quality of life. Indirect methods may be adopted to achieve energy efficiency. Substandard and improper maintenance of construction vehicles, equipment and machinery lead to energy destruction or loss during construction period of the proposed project.

All necessary measures shall be taken by the contractor to use and maintain lighting, tools and equipment of appropriate specifications so as to conserve energy. Energy efficient construction vehicles should be used for construction activities. Fuel efficiency should be undertaken by the Contractor. An energy audit needs to be conducted to know the energy management during construction. Proper maintenance of Construction vehicles aid energy saving. More than technical measures organizational measures play vital role in the management of energy efficiency.

The project will implement these above mentioned Energy Efficiency measures and thus, comply with the Indian regulations and WB ESF guidelines ESS 1 & 3 and EIB Standards 1 & 3.

8.6.12. Risks & Impacts due to Labour Camps

Improper disposal of municipal solid waste generated by labour camps can pollute surface water bodies and groundwater. Burning of waste can cause air pollution. Construction workers are more

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prone to infectious diseases like HIV/AIDS due to unsafe sexual activity and lack of sanitation facilities (water supply and human waste disposal) and insect vectors. Problems could arise due to cultural differences between workers from outside and local residents. Approximately 1,000 persons are likely to work during peak construction activity in all the corridors. 04 numbers of labour camps will be proposed at appropriate locations.

The water requirement at all labour camps (for 4000 workers for all corridors) will be 6,56,100 KL, waste water generation 4,92,075 KL & Municipal solid waste generation 1600 Kg per day (400gm/capita waste generation). Waste water will be treated in accordance with CPHEEO, PCB Standards. And the recycled waste water will be used for toilet flushing, cleaning and washing. Septic tanks and soak pits will be provided at certain sites, if required and sewage will be connected to sewer line after septic tank. Municipal Solid Waste will be segregated and handed over to local body. Training and awareness programme will be conducted during construction to avoid the spread of infected diseases and maintain good sanitation in labour camp.

Selection of Location for Construction/Labour Camp

- Construction camps shall not be proposed at a distance of 500m from the nearest settlements to avoid conflicts and stress over the infrastructure facilities with the local community.
- Contractor's camps shall be identified at least 2km away from the Forest Reserves.
- Location for stockyards for construction materials shall be identified at least 300m away from watercourses.
- The Sewage Treatment Plant and solid waste treatment for the camp shall be designed, built and operated.
- Guidelines and layout for setting-up of Construction Camp is presented as **Annexure 10.2**. And Reporting format for identification and establishment of Construction camp is presented in **Annexure 10.16** and **Annexure 10.17** respectively.

During Construction Stage the Contractor will provide, erect and maintain necessary (temporary) living accommodation for construction workers at locations away from construction sites in line with National regulations, as per IFC's Workers accommodation procedures (as given **Annexure 10. 20.**) and World Bank ESS 2 guidelines and EIB Standard 8.

Welfare of Labour on Construction Sites

Labour camps will be setup by the contractor at suitable locations, in accordance with the stipulated guidelines. Siting of the construction camps shall be as per the guidelines and details of layout to be approved by GC Resident Engineer and Environment Specialist; complying with Occupational Safety and Health Standards, Part 1910.142 and in line with ESS 1, 2, 3 & 6 of World Bank and EIB Standards 1, 2, 3, 4, 5, 8 & 9.

Contractor shall follow all relevant provisions of the Building and Other Construction workers (Regulation of Employment and Conditions of Service) Act, 1996 (including Section 32) and Factories Act, 1948 and amended in 1987 and WB ESS 2 for construction and maintenance of labour camp. The location, layout and basic facility provision of each labour camp shall be submitted to GC and K RIDE prior to their construction. The Construction shall commence only upon the written approval of the

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Environmental Specialist of GC. The following welfare facilities should be provided by the Contractor for labourers/ Workers at Base Camp:

- **Shelter at Workplace:** At every workplace, shelter shall be provided free of cost, separately for use of men and women labourers. The height of shelter shall not be less than 3m from floor level to lowest part of the roof. Shelters shall be with adequate illumination and ventilation and the space provided shall be on the basis of at least 0.5m² per head. Sufficient number of mosquito nets shall be provided. Housekeeping and hygiene are monitored by the Contractor. The Contractor shall maintain necessary living accommodation and ancillary facilities in functional and hygienic manner and as approved by the Sr. Environmental Specialist, GC.
- **Canteen Facilities :** A cooked food canteen on a moderate scale shall be provided for the benefit of workers wherever it is considered necessary. Usage of Fire Wood for cooking or any other purpose shall be totally avoided to prevent CO₂ emission.
- **Conveyance :** Free and adequate transport facilities shall be provided for all workers employed by the Contractor and residing at base camp to construction sites and Back.
- **Water supply (Provision of drinking Water) :** The Contractor shall construct and maintain all labour accommodation in such a fashion that potable water is available for drinking, cooking, floor cleaning and washing. The Contractor shall also provide potable water facilities within the premises of every camp at an accessible place, as per standards set by the Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 & as per IFC's Workers accommodation procedures (**as given Annexure 10.20.**). The Contractor shall also guarantee the following:
 - Supply of sufficient quantity of Potable Water (as per IS) in every workplace/labour camp Site at suitable and easily accessible places and regular maintenance of such facilities.
 - If any water storage tank is provided that shall be kept such that the bottom of the tank at least 1 m above the surrounding ground level.
 - If water is drawn from any existing well, which is within 30 m proximity of any toilet, drain or other source of pollution, the well shall be disinfected before water is used for drinking.
 - All such wells shall be entirely covered and provided with a trap door, which shall be dust proof and water proof.
 - A reliable pump shall be fitted to each covered well. The trap door shall be kept locked and opened only for cleaning or inspection, which shall be done at least once in a month.
 - Analysis of water shall be done every month as per parameters prescribed in IS 10500-1991. Water quality testing shall be carried out as per the guidelines provided in Environmental Monitoring plan is presented in Chapter 10 and reporting format for recording results is given in **Annexure 10.40.**

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Sanitation Facilities and Waste Water treatment : The Contractor shall implement proper sanitation and sewage system in accordance with the Building and Other Construction workers (Regulation of Employment and Conditions of Service) Act, 1996 and Factories Act, 1948 and amended in 1987.

- The Sewage system for the camp are designed, built and operated in such a manner that no health hazards occurs and no pollution to the air, ground water or adjacent water courses take place.
- Separate and adequate toilets/urinals and wash room Facilities shall be provided at Base Camp for Workers, separate for men and women (marked in vernacular). Cleaning/washing and bathing places shall be provided. Separate and adequate toilets and bathrooms, wherever required, shall be provided for men and women.
- Adequate water supply shall be provided in all toilets and urinals; and wash rooms/bath rooms.
- Drains for waste water shall be provided for the flow of used water outside the camp. Drains and ditches shall be treated on a regular basis.
- Wastewater shall be discharged to the existing sewage network or will be disposed-off in septic tank and soak pit.
- Night soil can be disposed of with the help of local municipal extractor or disposed of by putting layer of it at the bottom of a permanent tank prepared for the purpose and covered with 15 cm layer of waste or refuse and then covered with a layer of earth for fortnight.
- Hygienic condition shall be maintained till the closure of labour camp. All septic tank/soak pits shall be regularly serviced and emptied to reduce the risk of surface or groundwater pollution.
- The contractor shall conform generally to sanitary requirements of local medical, health and municipal authorities and at all times adopt such precautions as may be necessary to prevent soil pollution of the site.

8.6.13. Occupational Health Risks

8.6.13.1. Occupational Health Risks of Workers

Health risks include accidents due to improper construction practice and hazard diseases due to lack of drinking water and sanitation facilities (i.e., water supply and human waste disposal). Implementation of good construction practice may reduce the chance of accident at work place.

8.6.13.2. Occupational Health Risks due to improper Construction Practices

Occupational Health risks for workers include accidents due to improper construction practice and hazard diseases due to lack of drinking water and sanitation facilities (i.e., water supply and human waste disposal). Occupational Health and Safety hazards that may result in a wide range of injuries from minor to fatal, including train/worker accidents, rotating and moving equipment, electrical hazards, fire and explosions, eye hazards, noise and vibration, and fatigue including struck by moving objects; and air or water borne diseases. Implementation of good construction practice may reduce the chance of accident at work place.

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8.6.13.3. Risks and Impacts of Air Pollution on Human Health

Air pollution is one of the major present day concerns of new civilized world, because it has a serious toxicological impact on human health and the environment. The proposed project contributes to air pollution.

According to the World Health Organization and CPCB regulations, major air pollutants include particulates, ground-level ozone, carbon monoxide, carbon dioxide, sulfur oxides, nitrogen oxides, Hydrocarbon, and lead. Long and short term exposure to air suspended toxicants has a different toxicological impact on human including respiratory and cardiovascular diseases, neuropsychiatric complications, the eyes irritation, skin diseases, and long-term chronic diseases such as cancer. Several reports have revealed the direct association between exposure to the poor air quality and increasing rate of morbidity and mortality mostly due to cardiovascular and respiratory diseases. By adopting proper mitigation measures health risk due to air pollution can be reduced during construction phase of the project.

8.6.13.4. Impacts of Water Pollution and Poor Sanitation on Human Health

Health risks include accidents due to improper construction practice and hazard diseases due to lack of drinking water and sanitation facilities (i.e., water supply and human waste disposal). Implementation of good construction practice may reduce the chance of accident at work place.

Mitigation measures should include proper water supply, sanitation, drainage, health care and human waste disposal facilities at construction site. In addition to these, efforts need to be made to avoid water spills, adopting disease control measures, awareness programmes etc.

8.6.13.5. Impacts of Noise and Vibration on Human Health

Impacts of noise and vibration on human health have been predicted, analysed and assessed. The modern development of technology, equipping enterprises with powerful and fast-moving machines and mechanisms leads to the fact that people are constantly exposed to noise of increasing intensity. Increasing noise and vibration in the workplace has a harmful effect on the human body. Long-term exposure to transport noise and vibration can have significant impacts on human health, primarily related to sleep disruption and stress, and the resulting health impacts. Other impacts may include speech interference, cognitive impacts, and psychological and behavioural impacts. As a result of prolonged exposure to noise, the normal activity of the cardiovascular and nervous systems, digestive and hematopoietic organs is disturbed, and professional hearing loss develops, the progression of which can lead to complete hearing loss. Elevated workplace or environmental noise can cause hearing impairment, tinnitus, hypertension, ischemic heart disease, annoyance, and sleep disturbance.

8.6.13.6. Occupational Health Risks due to communicable diseases

Occupational health Risks/hazards also include communicable diseases such as HIV/AIDS/COVID due to close interaction and working atmosphere among workers and accidents during working or operation of Plants & equipment. Construction workers are more prone to Infectious diseases such as HIV/AIDS/COVID.

Mitigation measures : Measures include proper water supply, sanitation, drainage, health care and human waste disposal facilities at construction site. In addition to these, efforts need to be made to

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avoid water spills, adopting disease control measures, awareness programmes etc. It should be prevented by following Counselling, community events, clinic and coordination with local health authority.

Health care facilities : The following health care facilities shall be provided by the Contractor for labourers/Workers at Base Camp :

- Medical Facilities on site: Occupational Health Centre, Ambulance van and clinical room to test HIV/ AIDS/COVID prevention and control with all requirements.
- First aid facilities: At every workplace, a readily available first-aid unit including an adequate supply of sterilized dressing materials and appliances will be provided. Suitable transport will be provided to facilitate taking injured and ill persons to the nearest hospital.
- A readily available first aid unit including an adequate supply of sterilized dressing materials and appliances as per the Factories Rules in every work zone and Labour Camp.
- Availability of suitable transport at all times to take injured or sick person(s) to the nearest hospital.
- Equipment and trained nursing staff at construction camp.
- Periodical health check-up for construction workers and their family and for the sick persons.
- Control of Occupational Health Hazards : Housekeeping and hygienic (cleanliness) conditions shall be well maintained at labour camps and construction sites to avoid any epidemics such as COVID, etc. among workers. Mosquito breeding shall be prevented by avoiding any stagnant water at base camps or at work sites. Mosquito control fogging shall be carried out in all sites as well as in labor camps for Malaria and Dengue control. Rest sheds shall be provided to workers working on sites to avoid humidity effects and rest during lunch hours. Provision of conditions in contract and good construction practices will take care of any occupational health hazard issues and provide environmentally safe work areas.
- Prevention of Infectious Diseases: Construction workers are more prone to Infectious diseases such as HIV/AIDS/COVID. It should be prevented by following actions as depicted below:
 - One-one interactions – helps to build confidence,
 - Counselling- addressing the myths and misconceptions,
 - Community events-street theatre, puppetry, cultural programs are proven communication tools to the illiterate community to message dissemination,
 - STD clinic - early identification through testing,
 - Condom promotion- encouraging condom usage, an accessible place, made available at all times and free distribution.
 - Advertisement board at appropriate location will be put to make aware about the infectious diseases.
 - Co-ordination with State Aids Control Society and Health Department

Residual Impacts: No impact on the ecosystem.

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The project will comply with the Indian regulations and WBESF guidelines (WB ESS 2) and EIB Standards 1 & 9 by implementing these labour welfare/health care facilities as proposed in the EHS guidelines (**Annexure 10.11**).

8.6.14. Occupational Safety Risks

Safety Management is a major and significant part during construction and operation stages of the proposed project. It is the prime responsibility of Contractor to take safety measures during Construction and Project authority during project operation.

Safety of primary supply chain workers: Workers' Safety during construction on elevated and at grade sections is a statutory requirement and also has impact on progress of work.

The Contractor shall make reasonable efforts to assess if there are significant health and safety risks associated with the workers of the primary supplier of the goods and materials central to the core functions of the project. Where there are significant health and safety risks related to supply chain workers, the Contractor shall resort to a primary supplier that can prove is compliant with this standard.

The Contractor shall require the relevant primary supplier to introduce procedures and mitigation measures to address such risks. The promoter shall periodically monitor and review the effectiveness of such procedures and mitigation measures.

If the health and safety risks are identified in relation to an existing primary supplier, the Contractor shall engage with the relevant primary supplier in order to take the appropriate steps to remediate and eliminate such practices in a satisfactory manner and within a reasonable time frame. In this process, the ability of the Contractor to get the primary supplier to address these risks depends on the level of influence and control of the Contractor over its primary suppliers. When remedy proves to be impossible, the K RIDE shall resort, within a reasonable timeframe agreed with the EIB in consideration of the existing contractual relations, to different primary suppliers that can prove to be compliant with the requirements set out in this Standard.

Mitigation Measures: The Contractors shall ensure system safety and integrity; safety and health management for workers, Technical Staff and public in the vicinity of the project construction sites, plant & Equipment sites and at labour camps.

A Safety Management shall be carried out during execution of construction activities as per Environment, Health and Safety (EHS) manual (**Annexure 10.11**) prepared in line with World Bank ESS guidelines and National regulations and guidelines-OHSAS 18001-2007: Occupational Health and Safety Management System and ISO 14001-2015: Environmental Management Systems. Prior approval of Safety Management shall be obtained from the Supervision Consultant/Project Authority for implementation. The Safety Management Plan includes identified safety hazards Emergency Response Plan, control measures, schedule and responsible personnel for safety management to prevent/control any untoward events/accidents during construction. Approved Safety Management Plan shall be executed at Construction sites/ work places for traffic diversion, personal safety, fire safety, electrical safety and chemical safety in accordance with safety rules, regulations and guidelines.

Work place safety : Work place safety shall be ensured with special focus on following key areas:

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- Housekeeping
- Working at Height and Falling objects and Danger areas
- Lifting Appliances
- Launching Operations
- Construction machinery, tools equipment – Safe worthiness
- Electrical Points, machinery/Equipment
- Lighting
- Exposure of worker to use of exhaust or harmful gases in confined locations
- Fire prevention, protection and fighting system
- Corrosive substances
- Demolition
- Excavation
- Traffic Management
- Personal Protective Equipment(PPE)

Following are the Safety Management Activities which will be carried out during construction at work sites:

- Safety Management at work sites :
- Traffic management with proper plan and prior approval from the Engineer –in- Charge.
- Personnel/Workers' Safety at work places –
- The construction personnel will wear protective headgear, mask, gloves, safety jacket, safety shoes/footwear, safety belt and other special garments designed for safety with applicable code practices.
- The specific high rise working areas during construction can have their own unique hazards that personnel requires to be made aware of by providing training and displaying the instruction wherever it requires.
- The weather proofed 'First aid boxes' will be made available at appropriate locations. Detailed instructions will be followed for handling and storage of explosives to be used in controlled blasting if any.

The Contractor shall comply with all the precautions as required for ensuring the safety of the workmen as per the International Labour Organization (ILO) Convention No. 62 as far as those are applicable to this contract. The Contractor shall make sure that during the construction work all relevant provisions of Building and other Construction Workers (regulation of Employment and Conditions of Services) Act, 1996 are adhered to. Contractor shall provide safety to working personnel complying with WB ESS 1 & 4 and EIB ESS 1 & 9.

The Contractor shall not employ any person below the age of 18 Years (18 years as per ILO stipulations for hazardous work) for any work and no woman shall be employed on the work of painting with products containing lead in any form. The Contractor shall also ensure that paint containing lead or lead products is used in the form of paste or readymade paint.

The Contractor shall confirm the following personnel safety during construction:

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- Protective footwear, protective goggles and nose masks to the workers employed in asphalt works, concrete works, crusher etc.
- Welder's protective eye-shields to workers who are engaged in welding works
- Earplugs to workers exposed to loud noise, and workers working in crushing or compaction
- The Contractor shall comply with all regulations regarding safe scaffolding, ladders, working platforms, gangway, stairwells, excavations, trenches and safe means of entry and egress.
- Contractor shall provide the adequate personal protection equipment such as belts, protective hats/helmets, jackets, shoes, gloves, welding shields, etc. for the workers working with height and heavy electric equipment.

The Contractor shall follow the Guidelines to ensure worker safety during construction as presented in **Annexure 10.11**. Periodically contractor should report the workers safety to GC Environmental Specialist using Reporting format for Safety checklist and project safety measure are presented in **Annexure 10.26** and **Annexure 10.27**.

Safety Precautions at Worksites Adjacent to Existing Railway Track :

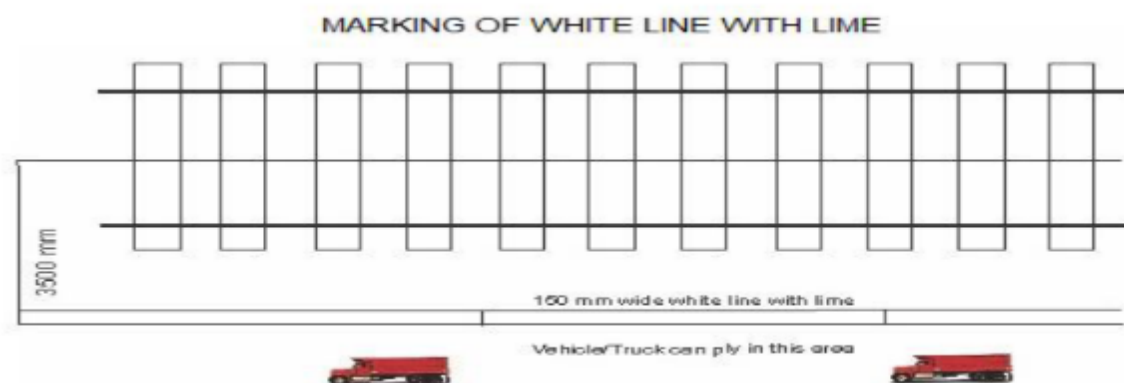
All works planned for execution close to the running lines and fixed structures, on bridges, inside cutting, constricted area etc. should be carried out only after preparation of detailed plans for the same and getting clearance from Engineering Department of open line and approval of competent authority to ensure that the execution of the work will not in any way infringe the prescribed schedule of dimension or aggravate existing permissible infringement.

Safety measures shall be carried out in accordance with Safety Precautions at Worksites Adjacent To existing Railway Track, Ministry of Railways, GOI, 2015. Before starting any track work the engineering in-charge of the section and Representative Engineers from Contractor shall ensure that he has complete knowledge of the following aspects;

- 1) Detailed planning of the work including protection of track and safety measures proposed to be adopted and precautions to be taken at site for working of trains including materials required for protection after joint survey of site by the supervisors of the contractor and Railway.
- 2) Railway supervisor at site will ensure safety precautions against any danger to safety of track and will accordingly educate the contractor's staff and take their acknowledgement before starting the work.
- 3) Before permitting the execution of certain works close vicinity of existing running line like earthwork, supply of ballast for new or existing rail line, gauge conversion or laying of concrete sleepers and rails etc. where it is necessary to use road vehicle/ machinery, Open lines Engineer-in-charge and K RIDE Engineers/Officials of the section shall ensure that he receives the prior intimation of the following aspects from Assistant Engineer/ Assistant Officer in charge of the work of the executing agency i.e. construction, electrification, S& T, etc.
- 4) Name and address of the contractor assigned to execute the work.
- 5) List of individual vehicle with numbers, name and licence particulars of the drivers, those are proposed to be used by contractor at work site.

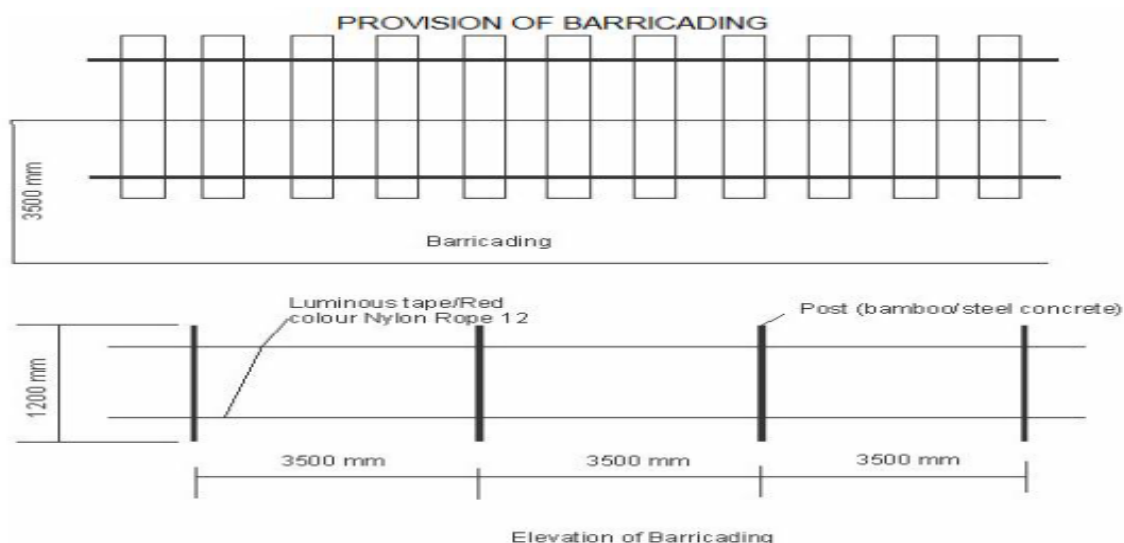
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- 6) Information regarding location, where the vehicles are planned to be plied.
- 7) The supervisor/workmen should be counselled about safety measures. The staff of the contractor should be fully trained for the work. List of contractor's supervisors who have been issued competency certificate with location and the nature of works they will supervise, shall be submitted to Engineer In-Charge.
- 8) The other organisations working in the section should submit to K RIDE the names of supervisors of construction organisations/other organisations who are going to be site in-charge / in-charge of work site.
- 9) Before the start of work, the land strip adjacent to running track where road vehicle machinery is to ply for the work shall be demarcated with lime in advance at the appropriate distance from the centre of existing track and acknowledged by contractor. Sketches showing the location of marking are as under;



Source: *Safety Precautions at Worksites Adjacent To existing Railway Track, Ministry of Railways, GOI, 2015*

- 10) Barricading as design given below shall be provided in full length of work area along the track at the specified distance;



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Source: Safety Precautions at Worksites Adjacent To existing Railway Track, Ministry of Railways, GOI, 2015

- 11) the worksite shall be suitably demarcated to keep public and passengers away from work area. Necessary signage boards such as 'Work in progress' etc. shall be provided at appropriate locations to warn the public/passengers.

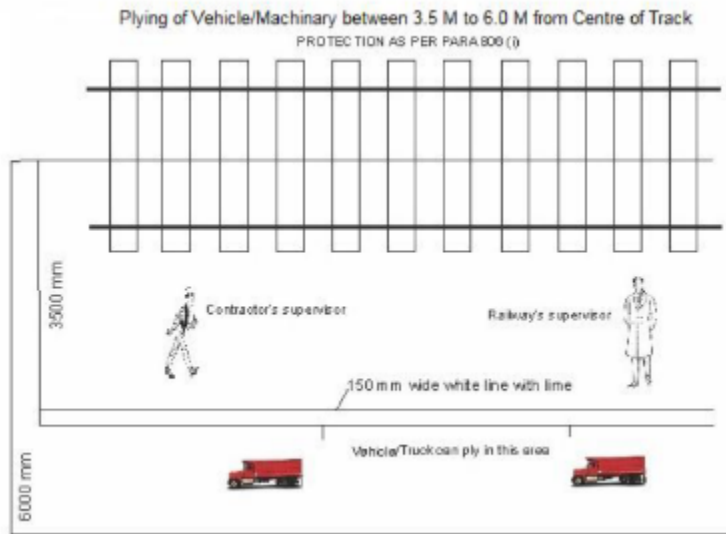
Safety Measures to be ensured during the Execution of the Work by Executing Agency and Engineer In-charge

The Engineer in-charge shall approve the methodology proposed to be adopted by the contractor, with a view to ensure safety of trains, passengers and workers and he shall also ensure that the methods and arrangements are actually available at site before start of the work and the contractor's supervisors and the workers have clearly understood the safety aspects and requirements to be adopted/followed while executing the work.

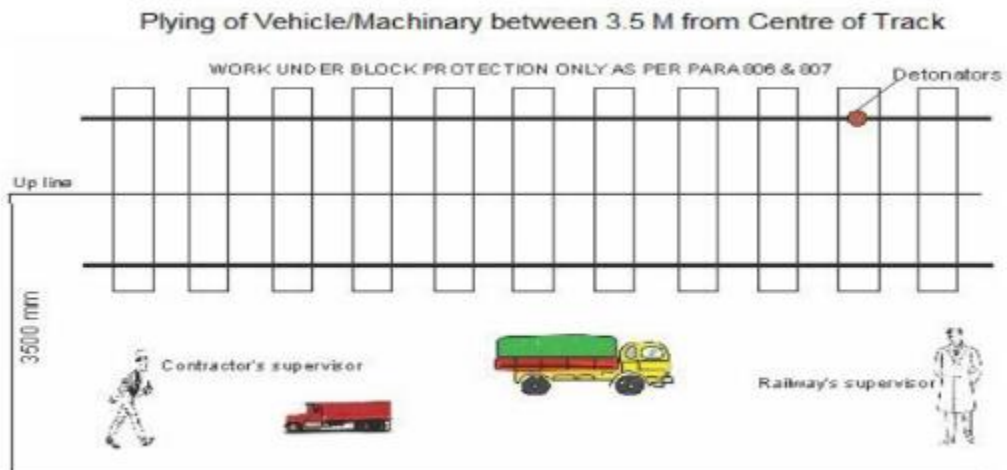
- i) There shall be an assurance register kept at each site, which will have to be signed by both, i.e. Railway Supervisor or his representative as well as the contractor's supervisor as a token of their having understood the safety precautions to be observed at site.
- ii) The contractor shall not start any work without the presence of railway supervisor or his representative and contractors supervisor at site.
- iii) Only trained supervisors have been deputed at work sites duly certified by K RIDE/in charge of the work.
- iv) Drivers of road vehicles / machinery have been briefed about the safety and precautions to be taken while moving / working close to traffic / track.
- v) The contractor shall not allow any road vehicle belonging to him or his suppliers etc. to ply within 6meters from centre of running line without presence of railway trained supervisor.
- vi) Contractor shall ply road vehicles only between sunrise and sunset. When vehicle is plied to work during night hours, sufficient lighting shall be ensured in the complete work area for the safety of public and passengers. Engineering indicator will be of luminous material. Also the luminous tapes should be used for demarcation of prohibited area. Additional staff shall be posted as necessary for night working.
- vii) The area of work should be demarcated by providing barricades and Sign Boards, which will enable the work-men posted at site and also the lorry drives to have clear guide lines of the movement on vehicles.
- viii) Contractor shall ensure that road vehicle / machinery ply in a way so that these do not infringe the line of demarcation.
- ix) The look out and whistle caution orders shall be issued to the trains and speed restrictions imposed where considered necessary. Suitable flagmen/detonators shall be provided where necessary for protection of trains.
- x) In unusual circumstances, where operator apprehends infringement to track while working truck/machinery near running track, following action shall be taken;
 - a) The track should be protected as per the provision of IRPWM laid in para 806(i) by the Railway staff.

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- b) Any emergency, if occurs, will be protected and attended by the Railway staff, contractor's staff may assist the Railway staff.
- xi) All temporary arrangements required to be made during execution of work shall be made in such a manner that moving dimensions are not infringe. Necessary checks shall be exercised by site in-charge from time to time.
- xii) In case, work has been planned to be done within 6m but beyond 3.5 m of centre of track, it shall be ensured that, necessary precautions for protection of track have been taken as per para 806(i) of IRPWM and look out man has been posted where necessary.



- xiii) In case work is planned within 3.5 m of centre line of adjacent track, it shall be ensured that the work is done under block protection only and necessary safety precautions for protection to track as per para no. 806 and 807 of IRPWM are taken.



- xiv) Proper communication system shall be available in form of Mobile phones or Walkie-Talkie sets, where necessary at works sites.
- xv) In one block section, Lorries should be permitted to work at not more than two locations at a time.

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- xvi) Where turnings of Lorries are found necessary in course of work, locations for reversing for the purpose of turning should be nominated and should be selected in such a way that there is no danger to the running train. At such locations, a Railway official not below the rank of Works / P-Way supervisor should be available with Hand Signal Flag to ensure that the Lorries do not infringe the Standard Dimension for the running lines. Sufficiently strong stoppers or rail barricades should be installed at such locations wherever required to ensure that even by carelessness or oversight the Lorries do not infringe the fixed dimensions. Wherever Lorries have to take turn, the reversing should be done in such a way the driver invariably faces the running lines at all time.
- xvii) The new embankment for doubling should be made extra wide at every 500m or so interval for permitting turning/crossing of vehicles/construction machinery. The extra earthwork involved in such widening of embankment, may be included in the schedule of quantities as a paid item.
- xviii) Engineering Supervisors and Contractor's representative should ensure the clearance of total infringements before they leave the work site.
- xix) Supplementary site specific instructions, wherever considered necessary, shall be issued by the Engineer in Charge.
- x) While inspecting the worksite check list given in Annexure -II shall be used to ensure that all the Requisites measures have been taken during the execution of the work.

Safety Measures While Undertaking Excavation & Trenching adjacent to Track

- i) Before taking up any digging activity on a particular work by any agency Sr. DSTE/DSTE or Sr. DEE/DEE of the section shall be approached in writing by the concerned Eng. or S&T or Electrical officer for permitting to undertake the work.
- ii) After getting the permission from S&T or Electrical Dept. as case may be the, relevant portion of the cable route plan shall be attached to the letter through which permission is issued to the contractor by concerned Eng. official for commencement of work and ensuring that the contractors has fully understood the cable rout plan and precautions to be taken to prevent damage to the underground cables. The contractor shall be asked to study the cable plan and follow it meticulously to ensure that the safety the cable is not endangered. Such a provision including any penalty for default should form part of agreement also. However, basic responsibility will be of the Department executing the work and the Contractor.
- iii) While digging in station area, if any cable is found, digging should be stopped and concerned signalling /electrical staff should be informed immediately.
- iv) No new OFC or Quad cable shall be laid close to the existing track. It shall be laid close to the Railway boundary to the extent possible to avoid any interference with the future work (doubling etc.). It shall be ensured in the new work of the cable laying that the cable route is properly identified with electronic or concrete markers.
- v) Trenches and foundation pits should be adequately and securely fenced, provided with proper caution signs and marked with red lights at suitable intervals during

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night to avoid accidents. Adequate protective measures should be taken to see that the excavation operations do not affect or damage adjoining existing buildings.

- vi) Position of all underground installations such as sewer, gas pipes, water pipes, electrical cables and other civic facilities that may cause danger during the work should be checked and proper precautions should be taken not to damage them.
- vii) Land should be cleared of trees, loose boulders and other obstructions before excavation commences so as to avoid accidents.
- viii) Where hard rock is found with and blasting operations are considered necessary, the contractor should obtain the permission of the Engineer-in-Charge in writing for resorting to blasting operation.
- ix) Proper precautions should be taken for safety of persons and adjacent track before undertaking any blasting operation. Red flags should be prominently displayed around the area to be blasted. All the people on the work except those who actually light the fuses should be withdrawn to a safe distance of not less than 300 metres from the blasting site.

Unloading and Stacking of Materials along the Railway Track

- i) The sites for material stacking shall be selected in advance ensuring that no part of the stacked material would infringe the standard moving dimensions or inconvenience to any worker or the public. Necessary fencing and lights are to be provided. Later on the material may be stacked to a place from where it may be conveniently disposed-off. A plan of proposed stacking locations be made and signed jointly by a competent Railway representative and authorized Contractor's representative, if stacking is done within 6 meters of track centre.
- ii) The selected locations within 6 meters shall be marked by lime in advance.
- iii) All unloading operations near the track should be undertaken under the supervision of a competent P.Way Supervisor.
- iv) The unloaded ballast/rails/sleepers/other P.Way materials after unloading along track should be kept clear off moving dimensions and stacked as per the specified heights and distance from the running track, which will not cause infringement to SOD in case of accidental roll off.
- v) After completion of work, the released sleepers and fittings shall be properly stacked away from the track clear of moving dimensions.
- vi) While inspecting the worksite, check list given In Annexure-II shall be used to ensure that all the requisite measures have been taken during the execution of work.

Precaution required to be taken during Execution of Work demanding Traffic Block

- i) Any work, which infringes moving dimension, shall be started only after the traffic blocks have been imposed and track protected.
- ii) At location where night working is unavoidable, proper lighting arrangement should be made.
- iii) Before closing the work, the track shall be left with the proper track geometry so that the trains run safely. After completion of work, the released sleepers and

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fittings should properly stacked away from the track to be kept clear of moving dimensions.

- iv) Block shall be removed only when all the temporary arrangements, machineries, tools, plants, etc. have been kept clear of moving dimensions.

Safety aspects to be observed while working in OHE area

- i) The risk of direct contact with live OHE is ever present while working in electrified sections such as for painting of steel work of through spans of bridges and platform cover.
- ii) The return current in the rails may cause dangerous voltages. During maintenance or renewal of track, continuity of the rails serving electrified tracks shall invariably be maintained. For bridging gaps which may be caused during removal of fish-plates or rails, temporary metallic jumpers of approved design shall be provided.
- iii) No electrical work close to running track shall be carried out without permission of Railway's representative.
- iv) No work shall be done within a distance of two meters from the live parts of the OHE without a 'permit-to-work'.
- v) While unloading rails from BFRs in an electrified section, it should be ensured that no metallic rod/ stick held by the workmen come in touch with the OHE. A minimum distance of 2 m has to be maintained between live OHE wire and body part of worker or tools or metallic supports, etc.
- vi) It is important to note that dangerous voltages may be induced in metallic masses such as fencing posts, continuous metallic mass (unloaded rails) of length greater than 300 metres in the vicinity of traction conductors. To avoid possibility of shock due to such voltages, the metallic structures are bonded together and earthed.
- vii) No electric connection etc. can be tapped from OHE.
- viii) Authorized OHE staff should invariably be present when the relaying work or any major work is carried out.
- ix) In the electrified territories, the cutting and day to day trimming of the trees, wherever required shall be done in the presence of authorized engineering and TRD staff to ensure safety and to maintain the 4 m safety clearances from OHE.
- x) Power block is correctly taken and 'Permit to work' is issued.
- xi) The structure bonds, track bonds, cross bonds, longitudinal rail bonds are not disturbed and if disconnected for the work, they are reconnected properly when the track work is completed.
- xii) The track level is not raised beyond the permissible limit during the work.
- xiii) The relative alignment of the centre line of the track with respect to the alignment of the contact wire must be maintained within the specified tolerances.
- xiv) No fallen wire or wires shall be touched unless the power has been switched off and the wire or wires have been suitably earthed.
- xv) In the electrified section, for carrying out repairs/ painting works etc. to bottom of elevated sections, top chords and bracing of trough type / semi through type girder bridges and other overhead structures over track, power block should be taken before commencing the work in consultation with SSE (Electrical). Staff working on station roofs and signal gantries and similar structures adjacent to Live Overhead

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Equipment shall not use any measuring tapes, tools and materials when there is a possibility of their being dropped or carried by wind on to the live overhead equipment.

- xvi) In AC traction areas, intimation should be given to the concerned officers of the Electrical General services and also S&T Department, since all the S&T and Electrical lines are cabled on account of Electrical Induction.
- xvii) During excavation, if workmen come across tiles or bricks in an arranged manner, they should at once report the matter to the higher officials. Any further excavation should be carried out only in the presence of the authorized staff of Electrical and or S&T department as the case may be.
- xviii) No crane shall be worked except on the authorised 'permit-to-work'.
- xix) For inspection of roofs and sides of a tunnel, the overhead equipment shall be rendered 'dead'.

Safety during working of Track Machines

Track machine working is likely to produce a dusty atmosphere and/or heavy noise pollution. Hence extra care is necessary at site to ensure safety of workers. For this, the following steps should be taken.

- i) Hooters should be provided on the track machines. These hooters should preferably have remove control operation so that the Lookout man standing around 150 m away from the track machine can operate the hooter to warn the staff working on/around the track machine about approaching train on adjoining track.
- ii) Temporary 'Whistle Board' should be fixed on the adjoining track, which can be moved along with track machine worksite.
- iii) It is necessary that all trains passing on the adjoining track should be issued a caution order "OBSERVE HAND SIGNAL, WHISTLE FREELY AND STOP, IF REQUIRED". Such caution order on the adjoining track is necessary due to high noise level caused by track machine and large concentration of staff working around it.

Precautions prior to Demolition of Structure near Running Track

- i) If the structure to be demolished is one which may have got hidden damages, caused by fire, flood or earthquake, measures necessary to prevent accidental collapse by way of bracing, shoring, etc., should be provided.
- ii) When demolition by explosives has to be resorted to, this should be done only after the approval of the Authority and after taking necessary precautions.
- iii) Prominent danger signs should be posted all around the property and all openings giving access to the structures should be kept barricaded or manned except during the actual passage of workmen or equipment. However, provision should be made for at least two independent exits for escape of workmen during any emergency. During night, warning lights should be placed on or above all barricades.
- iv) All gas, water, electricity, steam and other service lines should be shut off outside the property line after notifying the service companies and concerned authorities and obtaining their approval. Any temporary service connections required for the

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demolition work should be separately taken and arranged in such a manner as to afford safety to the workmen.

- v) When work is not in progress, watchmen should be provided to prevent unauthorised entry of the public in the danger zone.
- vi) All necessary safety appliances should be issued to the workers prior to starting of work.
- vii) Safety distances to ensure safety of the public should be clearly marked and prominent sign boards posted. Every sidewalk or road adjacent to the work should be closed or protected.

Dos and Don'ts during Construction for Safety

- a. Boulders including CST-9 plate, rail pieces etc., should not be left unguarded in the mid-section to facilitate miscreants for their unauthorized placing on the track particularly in areas prone for such miscreant activities.
 - b. Whenever construction is undertaken alongside the Railway line, based on the severity of risks and danger, fencing should be erected for complete length of the work section where to prevent any infringements to the moving dimensions likely to be caused by moving or stationary vehicles used for execution of the works. The fencing should conform to the design approved by CE/Construction.
 - c. Suitable gates/barriers should be installed across the new embankment, preferably adjoining the manned/unmanned level crossings. The entry for the vehicles should be regulated by an authorized representative of the Engineer-in-charge during the working hours.
 - d. The design & drawings of elevated corridor stretches other than standard designs/drawings, if adopted, should be adopted "in Toto" without any alterations. If any alternation, modification required fresh design should be done.
 - e. Any unusual noticed at site during fabrication & erection shall be viewed seriously and shall not be neglected. The design section should be consulted immediately. In case it is not possible to attend the same well in time do not keep it in a state affecting the running line till it is attended.
 - f. Open line Supervisors & Officers should be vigilant about the work being carried out by Construction Organization on & near running lines and promptly bring into the notice of any deficiencies/defects/unusual noticed and prompt remedial action should be taken.
 - g. During construction it should be ensured that any structure or part of the structure should not be subjected to loads for which it is not designed, especially at elevated sections. Precast slabs to be placed should not be stacked at one place.
- **Safety Audit:** Conducting Periodical Safety Audit, Electrical Safety Audit and External EHS Audit to assess potential risks, liabilities and the degree of compliance of construction Safety as per Safety legislation regulations and requirements of the employer;
 - **Safety Training:** Awareness/Orientation Training on Construction Safety and Workers'/Personnel Safety through Workshops, Tool Kit training, Mock Drills, etc.
 - **Safety Management** through campaigns and display of safety banners, posters, billboards, glow sign boards, etc. at and near work places;

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- **Accident reporting** and investigation as per Employer's requirements and Govt. Regulations
- Periodical Reporting of all accidents(fatal, injury, Near misses and minor accidents) and dangerous occurrences to the Employer and
- Periodical Reporting of Investigations conducted for Accidents and dangerous occurrences to Govt. organisations, as per requirement.
- Preparation of an Emergency Response Plan for all work sites including injury, sickness, evacuation, fire, chemical spillage, severe weather and rescue.
- All preventive measures shall be taken for Fire Safety. Adequate Fire extinguishers shall be provided at Plant site and Base Camp locations.
- The Contractor shall employ qualified personnel on site and for requirements of operation of electrical machinery/equipment, distribution, etc. and for handling of chemicals and other materials.
- Safety Reporting – reports, minutes, inspection reports, and Training & audit reports

Residual Impact: No impact on the ecosystem.

With proper implementation of the proposed mitigation measures the likelihood of any residual impact on occupational health and safety will be reduced as much as practically possible but are still considered as minor during construction.

8.6.15. Community Health and Safety Risks

Risks and Impacts : The risks and impacts of the project on the health and safety of the affected communities during the project are assessed as part of the Environmental Impact Assessment. Project-related activities may directly, indirectly or cumulatively change community exposure to hazards.

The preventive measures and plans to address Community Health and Safety will favour the prevention or avoidance of risks and impacts over their minimization and reduction. Appropriate ad project specific health and safety assessments are undertaken with good international practice, tailored to the project specific activities.

Health and Safety risks in the project are known to be associated with (a) nearby Water bodies with risks of drowning, flooding, or water-related diseases; (b) Waste disposal activities with risks of toxicity, waste dump collapse, or air pollution; (c) failure in the operation of equipment; (d) Water and sanitation services involving risks of contaminated water or spread of disease; (e) Electricity supply at work sites which may result in electric shock from electrical cabinets or cables; (f) Service providers, who may use their service for the purpose of financial, sexual, or other exploitation, particularly of vulnerable groups such as women, children, and the elderly people. The project shall be managed during construction by implementing all required health and safety protocols.

The assessment and adopted management measures take into account differences in risk exposure and sensitivity of women and men, as well as marginalized and disadvantaged groups, including children, older persons; persons with disabilities, minorities and local people.

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8.6.15.1. Infrastructure and equipment design and safety

The Structural Design of Structural elements of the project is carried out by the competent professional considering the climate change also and will be in accordance with the Indian Railway Standards, EHS guidelines and other applicable guidelines/Manual. The project location is not at high risk situations. However, the potential exposure of community to operational accidents or natural hazards including extreme weather conditions is considered.

- The construction or installation/commission of plants, equipment, machinery and structures shall be carried out by the Contractor with due care and concern to communities.
- Standard and approved plant, equipment and machinery shall be used in the project by the Contractor.
- Necessary caution/warning signage, safety barricades, shall be applied during work execution.
- Other than the workers no one shall be allowed to enter the work sites.
- Also the construction of the same will be carried out by competent contractors in accordance with the applicable standards.
- International EHS guidelines shall be followed by the Contractor to ensure community safety.

In addition, Contractors working for project-related construction activities, ensure appropriate control of site access (e.g. fencing, security), use of appropriate personal protective equipment, safely designed work platforms, appropriate engineering and administrative controls (e.g. detours, traffic calming, signs), and safety barriers. Construction personnel will have appropriate qualifications and training. Where public access is intended, incremental risks of public's potential exposure to operational accidents or natural hazards are considered. Additionally, during construction potential traffic and road safety risks associated with project activities will be identified, evaluated and monitored by the Contractor and the Supervision authorities. Contractors working on project sites will ensure that appropriately manage health and safety risks and address the requirements.

8.6.15.2. Traffic and Road safety

Traffic and Road Safety risks shall be assessed during every phase of construction by the Contractor in consultation with local traffic officials and the Environmental and Safety personnel of GC and K Ride Officials.

- Impacts associated with the increased movement of people will be mitigated by the traffic and safety management by the Contractor.
- Traffic measures shall be taken up as mentioned in the Section Traffic Management in this Chapter.
- Proper Training shall be provided for Drivers, as required.
- Safety records shall be maintained by the Contractor.
- Construction Vehicular maintenance shall be ensured by the Contractor.
- Haulage vehicles shall be covered with tarpaulins to avoid any spillage of materials on the public road to avoid any nuisance or accidents to community people and public properties.
- Necessary barricading and signage shall be adopted when equipment is operated at work sites near settlements or public movements.

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- Guiding and Safety person/security persons shall be employed to avoid any risks and impacts of hazards.
- Public/Community opinion shall be considered in case of needy situations.

Residual Impacts: No impact on the ecosystem.

8.6.15.3. Ecosystem Protection

Measures shall be taken to ensure that local ecosystem such as Water bodies along corridors 1 and 4 will not get disturbed and affect the community. Also it is noticed that nowhere community is dependent on the nearby water bodies and terrestrial ecosystem (particularly flora –plants for cattle) for their daily chores. The mitigation measures shall be undertaken as given under Environmental aspects such as climate change, Air Quality, Water Quality, Soil erosion, Protection of Flora, etc.

Residual Impacts: No negative impact on the ecosystem.

8.6.15.4. Hazardous materials and Safety

There are no hazardous materials or its handling /operation proposed in the project. There will be no carriage of hazardous goods or any materials. Hence, there is no risk of hazards due to hazardous materials. General measures are provided in EMAP – Table 10.2.

8.6.15.5. Universal access

Wherever feasible, it is ensured by the project authority that the concept of universal access is applied in the design and construction of facilities and services open to or provided to the public on an equal basis with others.

8.6.15.6. Emergency Preparedness and Response

Emergency events include unanticipated incidents arising from both natural and human-made hazards, typically in the form of fire, explosions, leaks or spills due to failure during operation of plants, equipment and machinery or during transportation of construction materials; or caused by failure to implement operating procedures, extreme weather or lack of early warning. An Emergency Response Plan (ERP) provided under the Chapter 10 – Environmental Management Plan (EMP) shall be referred and followed by the Contractor during construction. This ERP will be modified by the Contractor with respect to Workers safety and Community Safety, in co-ordination with local people, traffic Department and other concerned authorities. There is a requirement for personnel involved in the Emergency Response Plan to be familiar with and trained in terms of its requirements. Mock drill and training will be included in the same and local community will be invited for the same. Emergency Response Plan will be disclosed to public with proper notification. Records shall be maintained by the Contractor and submitted to K RIDE. The same will be implemented after the approval from the GC and K RIDE.

ERP is prepared by the Contractor to respond to accidental and emergency situations in a manner appropriate to prevent and mitigate any harm to people and/or the environment. Emergency preparedness, reflected in planning documents, includes the identification of areas where accidents and emergency situations may occur, communities and individuals that may be impacted, response procedures, provision of equipment and resources, designation of responsibilities, communication and notification channels, and periodic training to ensure effective response. The emergency preparedness and response activities is periodically reviewed and revised, as necessary to reflect changing conditions. Moreover, it is also ensured to consider the differential impacts of emergency

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situations on women and men, the elderly, children, persons with disabilities, and potentially marginalized groups, and strengthen the participation of women in decision-making processes on emergency preparedness and response strategies. Appropriate information about emergency preparedness and response activities, resources, and responsibilities with remedies will be disclosed to affected communities.

Residual Impacts: No negative impact on the ecosystem.

8.6.15.7. Security-related Safety

Security personnel shall be employed directly or through contracted agencies by the Contractor (during Construction) or by K Ride (during operation) to safeguard project facilities, personnel and properties or to otherwise engage in project activities. Human rights of security guards shall be protected in line with The National Security Guard Act, 1986. The risks and impacts of Security personnel anticipated include abuses and all allegations of unlawful or abusive acts to the community people inside or outside the project.

Mitigation Measures : The following mitigation measures shall be undertaken :

- Security arrangements shall be provided in a manner that does not violate international human rights standards or principles, or jeopardize the community's safety and security.
- Reasonable inquiries shall be made by the Contractor (during Construction) or by K RIDE (during operation) to verify that potential security personnel have not been implicated in past abuses and all allegations of unlawful or abusive acts; same will be reviewed and actions taken to prevent recurrence and reprisals against individuals and communities.
- Trained security personnel with good and proper back ground shall be assessed before deployment.
- Regular training shall be provided to the security personnel in the use of force and appropriate conduct towards workers and communities in the vicinity.
- Potential risks posed by security arrangements to those within and outside the project area shall be assessed, that those providing security are appropriately vetted, trained and supervised, and that security arrangements are appropriately monitored and reported by the Contractor during Construction Stage and K RIDE during operation stage. Wherever necessary, unlawful and abusive acts if noticed, will be reported to K Ride.
- K RIDE will review abuses and all allegations of unlawful or abusive acts of the security personnel and actions will be taken in line with the applicable law and regulations by reporting to the relevant authorities.

8.6.15.8. Health and Safety of Community Members Living and Working near Existing Railway Lines

Potential safety risks : The main risks to community near existing railway lines are:

- Being hit by a train, on-track plant, or a road-cum-rail vehicle while carelessly crossing railway lines
- Electrocution from an overhead live power line (or a conductor rail) or from the strung conductor due to induction
- Falls with fatal or non-fatal accidents at construction sites

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Mitigation Measures : Measures to avoid accidents include the following :

- Restricting access to the sites through a combination of institutional and administrative controls, with a focus on risk structures or areas depending on site specific situations including fencing, signage and communication of risks to the local community.
- Removing hazardous conditions on construction sites that cannot be controlled effectively with site access restrictions, such as covering any openings or pits left to small confined areas, ensuring means of escape to larger openings such as trenches or excavations, or locked storage of hazardous materials

Residual Impacts: No adverse impact on the ecosystem.

8.6.15.9. Health and Safety Risks due to Noise & Vibrations

Noise-induced hearing loss remains highly prevalent in occupational settings of workers working and local community living near existing railway lines. Impacts may be auditory or non-auditory impairments. Non-auditory effects of noise can cause tinnitus, headache, auricular plenitude, dizziness, and gastric, endocrine imbalance, cardiovascular disorders, loss of sleep/insomnia (6% population approximately) and mood disorders. Health effects of environmental noise are manifold, serious and, because of the widespread exposure, very prevalent.

Mitigation Measures : Measures to reduce the risk of health impacts include the following :

- Selecting equipment with lower sound power levels
- Installing silencers for fans, if applicable
- Installing suitable mufflers on engine exhausts and compressor components
- Installing acoustic enclosures for equipment radiating noise
- Installing temporary solid noise barriers or sound insulators near sensitive receptors and nearby community buildings
- Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 Kg/m² in order to minimize the transmission of sound through the barrier. Barriers should be located as close to the receptor locations to be effective
- Installing vibration isolation for mechanical equipment
- Limiting the hours of operation for specific equipment, especially mobile sources operating through community areas
- Re-locating noise sources to less sensitive areas to take advantage of distance and shielding
- Siting permanent facilities away from community areas, as far as possible
- Taking advantage of the natural topography as a source buffer during facility design
- Reducing project traffic through community areas wherever possible
- Developing a mechanism to record and respond to communities and to take remedial actions

Residual Impacts: No adverse impact on the ecosystem.

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8.6.15.10. Health and Safety Risks due to influx of Labour or Work Force

There may be chances of risks such as Gender-Based Violence (GBV) or Sexual Exploitation and Abuse (SEA) of children, or spread of communicable diseases, which may arise from the interaction of project workers with local communities. A significant concern is the spread of communicable diseases from the workforce to the surrounding communities. These risks are potentially high due to labour influx in the project, BSRP.

Mitigation Measures : General Health and Safety of the Public /local community shall be addressed with the following measures:

- Establishing workers camps separated from local communities (500ms away from the settlements) with strict protocols for interaction with local communities in order to avoid project impacts from labour influx;
- Implementing sensitization and specific mitigation measures for social impacts from labour influx during construction or service provision of the project;
- Adopting all required mitigation measures to avoid air, water, soil and noise pollution & vibration as mentioned under Mitigation Measures for air, water, soil and noise pollution & vibration Sections in this Chapter;
- Providing first aid facilities and establishing health clinics;
- Incorporating safe road crossings into project design;
- Implementing safety signage and traffic management during construction at work sites;
- Adopting all required safety protocols at work sites
- Strict following of protocols for temporary blasting during demolition at the reinstatement or restoration phase;
- Establishing emergency-response planning and monitoring for pollution or other incidents during operation.
- Attention shall be given to the health and safety risks posed by the influx of workers or people providing support services into an area as a result of the project. Risks such as Gender-Based Violence (GBV) or Sexual Exploitation and Abuse (SEA) of children, or communicable diseases, which may arise from the interaction of project workers with local communities, shall be totally avoided by taking diligent care and concerns.
- Measures also include the employing of skilled trainers to raise awareness among project workers of the risks, expected behaviours, and consequences of violations, communicated through training, and publicized codes of conduct. The environmental and social documents shall be maintained for the project to describe such community health and safety risks and measures to address them.
- Periodical Health and Safety Awareness programs shall be conducted among local community members and health authorities regarding the risks and measures among community members and inform them about available grievance mechanisms.
- The risks and mitigation measures relating to project workers shall be reflected in the labour management procedures for the project.

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- Local health authorities are advised and requested by the project authority K RIDE to ensure appropriate processes are in place for community feedback and taking any necessary action.

Residual Impacts: No adverse impact on the ecosystem.

8.6.15.11. Community Exposure to Health Risks

Air, Water and Vector-borne Diseases:

An airborne disease is any disease that is caused by pathogens and transmitted through the air. Airborne diseases such as common cold, pneumonia, tuberculosis, etc. are spread when droplets of pathogens are expelled into the air due to coughing, sneezing or talking. Water-borne disease is any disease that is caused by pathogenic microorganisms. Water-borne diseases such as Cholera, jaundice, dysentery, dengue, typhoid, etc. most commonly transmitted through contact or consumption of infected water.

Mitigation measures to prevent air borne diseases include the following :

- Stay away from the diseased person.
- Wear a mask when you need to contact a diseased person.
- Cover your mouth and nose while coughing or sneezing to prevent the spread of the disease.

Mitigation measures to prevent water borne diseases

- Ensure proper disposal of sewage.
- Ensure safe drinking water supply.

Mitigation measures to prevent vector borne diseases arising from wastes are as mentioned below :

- Provide a clean environment, which helps in preventing vectors like mosquitoes from breeding.
- Availability of proper nutrition - If proper and sufficient nutrition is not available, the immune system of the body will not function properly.

Communicable diseases

Sensitive people in the community are vulnerable to the communicable diseases such as HIV-AIDs, Influenza, COVID, etc. which are transmitted through contact with blood and bodily fluids; breathing in an airborne virus; or by being bitten by an insect. Following measures shall be followed and advised to adopt by the community and workers whoever affected :

- washing hands thoroughly and regularly after using toilet and before taking any food
- disinfecting commonly used surfaces at home and outside, especially doorknobs and food areas
- disinfecting personal items such as phones
- avoiding sharing Personal Items
- cooking foods thoroughly
- practicing good hygiene when preparing and handling food

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- using face masks
- coughing and sneezing into a Tissue or to Sleeve
- avoiding eating spoiled food
- avoiding touching wild animals
- receiving available vaccinations
- taking antimalarial medications when traveling where there is a malaria risk
- checking for ticks and other parasites
- resting when sick

Non-communicable diseases

Non-communicable diseases (NCDs) include hypertension, heart disease, stroke, cancer, diabetes, chronic lung disease, etc. which may arise due to night time works, air and noise pollution due to project activities such as earth works and plant, equipment or machinery operation, works at height, etc. without any proper care and safety and traffic management. Measures are as follows :

- following air and noise pollution mitigation measures as stated under Environmental aspects of this Chapter.
- Following traffic management during project activities and at work sites
- Avoiding night time works near habitats
- Alerting community people before commencing works
- Consulting local community regularly/periodically before commencing any works at site

Residual impact: With proper implementation of the proposed mitigation measures the likelihood of any residual impact on public health and safety will be reduced as much as possible.

8.6.16. Risks and Impacts on Cultural Heritage and Archaeological and Historical/Cultural Properties

8.6.16.1. Archaeological and Historical/Cultural Properties

The risks and impacts on legally protected Archaeological Monuments are anticipated only at Corridor 1 which has protected archaeological monuments such as Devanahalli Fort and Tippu Sultan's Birth Place at Devanahalli, as per The Ancient Monuments and Archaeological sites and Remains Act, 1958 amended in 2010. There are no Archaeological monuments or Heritages noticed along other 3 corridors of the project.

As per the base line study and impact analysis, no damage to Archeological Monuments is predicted. However, during construction, archaeological or historical structures may get affected by direct or indirect construction activities. There are about 106 cultural/religious structures present along the project corridors.

Mitigation Measures : A prior survey shall also be conducted before construction to identify if there is any historical structure nearby construction sites, which may get impacted. Necessary measures shall be undertaken accordingly, if any. Devanahalli Fort and Tippu Sultan birth Place at Devanahalli are the Archaeological Survey of India Protected monuments located at 228m and 271m respectively to the alignment – Corridor 1, for which necessary procedure will be followed to obtain the necessary

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construction permit from ASI. Prior to the initiation of construction, K RIDE will inform the ASI authority.

Stipulated measures shall be implemented as per the stipulated conditions of ASI and in line WB ESS 8 & EIB's ESS 10. ASI Stipulations to be followed are as follows -

- 1) Interpretation panels/signage must be provided for the monument.
- 2) Drainage system should be checked so that the corridor level should not be higher than the monument and water should not enter inside the monument complex.
- 3) Prior intimation should be given to ASI authority to monitor the site and also to check the impact on monument during /post digging (excavation) process.
- 4) Prior permission must be obtained from the Competent Authority for any construction or increase in height.
- 5) A certificate should be furnished to the Competent Authority on completion of proposed construction to effect that it has complied with all conditions of the permission.
- 6) The compliance must be with the heritage bye-laws of the protected monument concerned as and when the bye-laws are approved.
- 7) In case of cultural/religious structures, water sprinkling, barricading, flagman and signboard should be provided.

Residual Impacts: With proper implementation of prevention measures no impact on physical and cultural resources or environment is expected.

8.6.16.2. Chance find procedures

All fossils, coins, articles of value of antiquity, structures and other remains of archaeological interest discovered on the sites shall be the property of the Government and shall be dealt with as per provisions of the relevant legislation - The Ancient Monuments and Archaeological sites and Remains Act, 1958 amended in 2010 (as per the stipulated conditions of ASI) and in line WB ESS 8 and EIB Standard 10.

The Contractor shall take reasonable precautions to prevent his workmen or any other persons from removing and damaging any such article or thing. He shall, immediately upon discovery thereof and before removal acquaint the Environmental Specialist of GC of such discovery and carry out the GC's instructions for dealing with the same. Works shall be resumed once approval is obtained from the GC and K RIDE. The GC shall seek direction from the Archaeological Survey of India (ASI) before instructing the Contractor to recommence the work in the site. The Archaeological structures/ materials identified along the project corridors, if any, shall be protected/ preserved or enhanced and handed over to ASI as per the law. The details regarding Chance Find procedure is given in **Annexure 10.5**.

Residual Impacts: With proper implementation of chance find procedures no impact on physical and cultural resources is expected.

8.7. Impacts Due to Project Operation and its Mitigation Measures

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

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- Risks & Impacts on Noise Level
- Risks & Impacts on Vibration
- Risks & Impacts on Track Side Vegetation
- Energy Consumption at stations and Efficiency
- Electro-magnetic Compatibility
- Risks & Impacts on Ground water
- Risks & Impacts due to Depots and Stations
- Risks & Impacts on Air Quality due to Inter model operational vehicles
- Water supply, Waste water and Municipal solid waste disposal at Stations
- Risks & Impacts on Topography and Natural Drainage
- Soil Erosion at Closed Borrow areas and Embankments
- Pedestrian and Road Traffic Congestion around Stations
- Risks & Impacts on Operational and Community Safety
- Risks & Impacts on Community Health

8.7.1. Risks & Impacts on Noise Level

Impact of noise pollution caused due to the project activities during operation phase has been predicted as briefly discussed in sections below.

8.7.1.1. Noise Modelling

Noise Modelling is a powerful tool to assess noise from industrial facilities with many noise sources. The SoundPLAN 8.2 software was used to predict noise levels from the proposed rail traffic. Soundplan is used in

- Calculation of sound propagation from the noise source to the relevant receiver.
- Prognosis, documentation and noise reduction measures for a present or future noise situation

SoundPLAN 8.2 is integrated with a GIS tool which provides storing and retrieving, transforming and displaying spatial data. SoundPLAN 8.2 facilitates the visual representation of the noise effects and an additional tool for analysing the results. The model provides fast and accurate assessment of the anticipated sound pressure levels. Noise contours can be generated in the software based on the noise propagation calculation. It is possible to generate a continuous spatial model of noise levels using SoundPLAN 8.2. The maps are a graphical representation of the calculated sound pressure levels, considering the possible reflections and diffractions of sound, and the geometry of buildings at the site and topography. SoundPLAN 8.2 generates industrial noise maps using the calculation methods given by standards ISO 9613:1996 for noise propagation.

The detailed methodology used for the present study is given in **Figure 8.16**.

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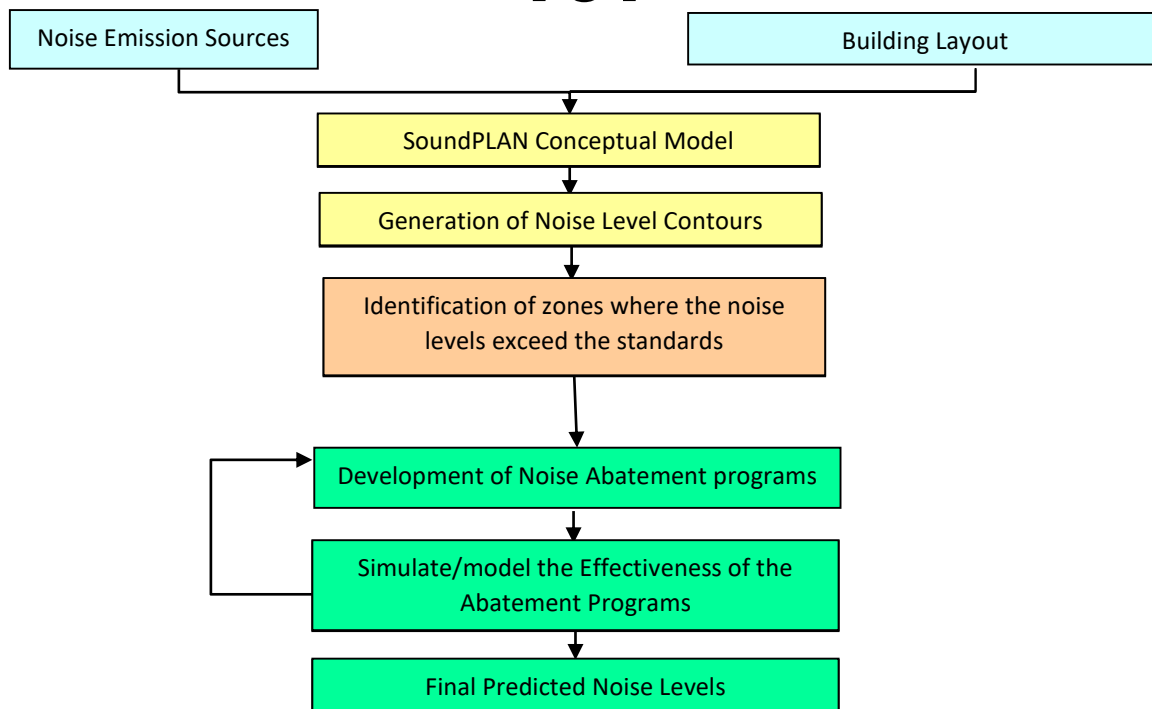


Figure 8.16. Modelling Methodology

Model Inputs and Assumptions

Standards Used

Railway Noise Calculation Standards – FTA/FRA-HGST (2005) Standards were used to compute the rail noise with the help of SoundPLAN 8.2.

Model Parameters Considered

- Assessment Period: Day Average (LrD), Night Average (LrN), Day-Night Average (LrDN)
- Emission Time Slices : 6-22, 22-6, 0-24
- Reflection Order : 2
- Maximum Search Radius: 1500 m
- Maximum Reflection Distance : 200 m
- Grid Map Spacing : 10 m

Study Area

A 50 m buffer on either side of all proposed railway line is generated using GIS software and the same was utilized as study area to assess the impacts of noise. Buildings falling within this 50 m buffer area was mapped and incorporated into the noise model.

Topography and Terrain

ASTER Digital Elevation Model (DEM) procured from Unites States Geological Survey (USGS) with a spatial resolution of 15 m was used to generate the Digital Ground Model.

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Building Attributes

Building footprint data was obtained from the open street map in the form of polygon shapefiles and imported into the SoundPLAN 8.2 software.

Rail Noise Inputs

Train Speed

The present study has been done considering the train design speed of 90 KMPH.

Proposed Railway Line, Bengaluru City – Devanahalli (Corridor 1)

The total length of the corridor is 41.40 Km out of which 18.98 Km is elevated and 'At Grade' is 22.42 Km. It has a total of 15 Nos. of stations out of which 8 Nos. of stations are elevated and 7 Nos. of stations are 'At Grade'.

Rail Traffic

The hourly train operation plan for the sub urban rail corridors for the year 2025, 2031 and 2041 were adopted from the detailed project report and presented in **Table 8.30**.

Table 8.30. Hourly Train Operation Plan for Bengaluru City – Devanahalli (Corridor 1)

| From | To | Cars/Train | Trains/Hour | | |
|----------|----------|------------|-------------|------|------|
| | | | 2025 | 2031 | 2041 |
| 12:00 AM | 1:00 AM | 6 | 0 | 0 | 0 |
| 1:00 AM | 2:00 AM | 6 | 0 | 0 | 0 |
| 2:00 AM | 3:00 AM | 6 | 0 | 0 | 0 |
| 3:00 AM | 4:00 AM | 6 | 0 | 0 | 0 |
| 4:00 AM | 5:00 AM | 6 | 0 | 0 | 0 |
| 5:00 AM | 6:00 AM | 6 | 2 | 2 | 3 |
| 6:00 AM | 7:00 AM | 6 | 3 | 4 | 5 |
| 7:00 AM | 8:00 AM | 6 | 4 | 5 | 6 |
| 8:00 AM | 9:00 AM | 6 | 6 | 7 | 9 |
| 9:00 AM | 10:00 AM | 6 | 6 | 7 | 9 |
| 10:00 AM | 11:00 AM | 6 | 5 | 6 | 7 |
| 11:00 AM | 12:00 PM | 6 | 4 | 4 | 5 |
| 12:00 PM | 1:00 PM | 6 | 3 | 4 | 5 |
| 1:00 PM | 2:00 PM | 6 | 2 | 2 | 3 |
| 2:00 PM | 3:00 PM | 6 | 3 | 4 | 5 |
| 3:00 PM | 4:00 PM | 6 | 4 | 4 | 5 |
| 4:00 PM | 5:00 PM | 6 | 5 | 6 | 7 |
| 5:00 PM | 6:00 PM | 6 | 6 | 7 | 9 |
| 6:00 PM | 7:00 PM | 6 | 6 | 7 | 9 |
| 7:00 PM | 8:00 PM | 6 | 5 | 6 | 7 |
| 8:00 PM | 9:00 PM | 6 | 4 | 4 | 5 |
| 9:00 PM | 10:00 PM | 6 | 3 | 4 | 5 |
| 10:00 PM | 11:00 PM | 6 | 2 | 3 | 4 |

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| From | To | Cars/Train | Trains/Hour | | |
|--------------|----------|------------|-------------|-----------|------------|
| | | | 2025 | 2031 | 2041 |
| 11:00 PM | 12:00 AM | 6 | 2 | 2 | 3 |
| Total | | | 75 | 88 | 111 |

Source: BSRP Feasibility Report

Post Project (Cumulative) Noise Estimation

The baseline noise readings and model predicted noise pressure values are added logarithmically to estimate the cumulative noise values. The estimated noise values of the different scenarios (horizon year) are given in the following tables.

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Table 8.31. Corridor 1 - Cumulative Noise Estimation for Baseline Noise Monitoring locations (without barrier)

| Noise Location | 2025 in dB(A) | | | | | | 2031 in dB(A) | | | | | | 2041 in dB(A) | | | | | |
|----------------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|
| | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | |
| | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN |
| NQ1 | 57.1 | 45.3 | 60.5 | 51 | 62.1 | 52.0 | 57.1 | 45.3 | 61.2 | 51 | 62.6 | 52.0 | 57.1 | 45.3 | 62.2 | 52.8 | 63.4 | 53.5 |
| NQ2 | 56.1 | 43.9 | 64.3 | 54.8 | 64.9 | 55.1 | 56.1 | 43.9 | 65 | 54.8 | 65.5 | 55.1 | 56.1 | 43.9 | 66 | 56.6 | 66.4 | 56.8 |
| NQ3 | 54.8 | 41.3 | 73.6 | 64.1 | 73.7 | 64.1 | 54.8 | 41.3 | 74.3 | 64.1 | 74.3 | 64.1 | 54.8 | 41.3 | 75.3 | 65.9 | 75.3 | 65.9 |
| NQ4 | 53.5 | 43.8 | 74.5 | 65 | 74.5 | 65.0 | 53.5 | 43.8 | 75.2 | 65 | 75.2 | 65.0 | 53.5 | 43.8 | 76.2 | 66.8 | 76.2 | 66.8 |
| NQ5 | 52.8 | 41.6 | 78 | 68.5 | 78.0 | 68.5 | 52.8 | 41.6 | 78.7 | 68.5 | 78.7 | 68.5 | 52.8 | 41.6 | 79.7 | 70.3 | 79.7 | 70.3 |
| NQ6 | 55.7 | 42.8 | 63 | 53.5 | 63.7 | 53.9 | 55.7 | 42.8 | 63.7 | 53.5 | 64.3 | 53.9 | 55.7 | 42.8 | 64.7 | 55.3 | 65.2 | 55.5 |
| NQ7 | 51.6 | 38.5 | 66.7 | 57.2 | 66.8 | 57.3 | 51.6 | 38.5 | 67.4 | 57.2 | 67.5 | 57.3 | 51.6 | 38.5 | 68.4 | 59 | 68.5 | 59.0 |
| NQ8 | 52.1 | 40.6 | 63.7 | 54.2 | 64.0 | 54.4 | 52.1 | 40.6 | 64.4 | 54.2 | 64.6 | 54.4 | 52.1 | 40.6 | 65.4 | 56 | 65.6 | 56.1 |
| NQ9 | 60.8 | 48.2 | 64.2 | 54.7 | 65.8 | 55.6 | 60.8 | 48.2 | 64.9 | 54.7 | 66.3 | 55.6 | 60.8 | 48.2 | 65.9 | 56.5 | 67.1 | 57.1 |
| NQ10 | 53.5 | 41.8 | 64.2 | 54.7 | 64.6 | 54.9 | 53.5 | 41.8 | 64.9 | 54.7 | 65.2 | 54.9 | 53.5 | 41.8 | 65.9 | 56.5 | 66.1 | 56.6 |
| NQ11 | 53.2 | 42.9 | 73.6 | 64.2 | 73.6 | 64.2 | 53.2 | 42.9 | 74.3 | 64.1 | 74.3 | 64.1 | 53.2 | 42.9 | 75.3 | 65.9 | 75.3 | 65.9 |
| NQ12 | 52.8 | 41.7 | 60.9 | 51.4 | 61.5 | 51.8 | 52.8 | 41.7 | 61.6 | 51.4 | 62.1 | 51.8 | 52.8 | 41.7 | 62.6 | 53.2 | 63.0 | 53.5 |
| NQ13 | 53.9 | 40.8 | 62.9 | 53.5 | 63.4 | 53.7 | 53.9 | 40.8 | 63.6 | 53.4 | 64.0 | 53.6 | 53.9 | 40.8 | 64.6 | 55.2 | 65.0 | 55.4 |
| NQ14 | 52.5 | 41.1 | 72.3 | 62.8 | 72.3 | 62.8 | 52.5 | 41.1 | 73 | 62.8 | 73.0 | 62.8 | 52.5 | 41.1 | 74 | 64.6 | 74.0 | 64.6 |
| NQ15 | 53.1 | 41.9 | 64 | 54.5 | 64.3 | 54.7 | 53.1 | 41.9 | 64.7 | 54.5 | 65.0 | 54.7 | 53.1 | 41.9 | 65.7 | 56.3 | 65.9 | 56.5 |
| NQ16 | 54.6 | 42.8 | 61.4 | 51.9 | 62.2 | 52.4 | 54.6 | 42.8 | 62.1 | 51.9 | 62.8 | 52.4 | 54.6 | 42.8 | 63.1 | 53.7 | 63.7 | 54.0 |
| NQ17 | 51.9 | 39.2 | 56.9 | 47.4 | 58.1 | 48.0 | 51.9 | 39.2 | 57.6 | 47.4 | 58.6 | 48.0 | 51.9 | 39.2 | 58.6 | 49.2 | 59.4 | 49.6 |
| NQ18 | 53.6 | 42.7 | 68.4 | 58.9 | 68.5 | 59.0 | 53.6 | 42.7 | 69.1 | 58.9 | 69.2 | 59.0 | 53.6 | 42.7 | 70.1 | 60.7 | 70.2 | 60.8 |
| NQ19 | 52.4 | 41.1 | 70.4 | 60.9 | 70.5 | 60.9 | 52.4 | 41.1 | 71.1 | 60.9 | 71.2 | 60.9 | 52.4 | 41.1 | 72.1 | 62.7 | 72.1 | 62.7 |

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Table 8.32. Corridor 1 - Cumulative Noise Estimation for Baseline Noise Monitoring locations (With Barrier)

| Noise Location | 2025 in dB(A) | | | | | | 2031 in dB(A) | | | | | | 2041 in dB(A) | | | | | |
|----------------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|
| | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | |
| | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN |
| NQ1 | 57.1 | 45.3 | 45.3 | 35.8 | 57.4 | 45.8 | 57.1 | 45.3 | 46.3 | 36.1 | 57.4 | 45.8 | 57.1 | 45.3 | 47 | 37.6 | 57.5 | 46.0 |
| NQ2 | 56.1 | 43.9 | 66.3 | 56.8 | 66.7 | 57.0 | 56.1 | 43.9 | 68.1 | 57.9 | 68.4 | 58.1 | 56.1 | 43.9 | 68 | 58.6 | 68.3 | 58.7 |
| NQ3 | 54.8 | 41.3 | 75.7 | 66.3 | 75.7 | 66.3 | 54.8 | 41.3 | 77.7 | 67.5 | 77.7 | 67.5 | 54.8 | 41.3 | 77.4 | 68 | 77.4 | 68.0 |
| NQ4 | 53.5 | 43.8 | 43.7 | 34.2 | 53.9 | 44.3 | 53.5 | 43.8 | 44.5 | 34.3 | 54.0 | 44.3 | 53.5 | 43.8 | 45.4 | 36 | 54.1 | 44.5 |
| NQ5 | 52.8 | 41.6 | 78.1 | 68.6 | 78.1 | 68.6 | 52.8 | 41.6 | 79 | 68.8 | 79.0 | 68.8 | 52.8 | 41.6 | 79.8 | 70.4 | 79.8 | 70.4 |
| NQ6 | 55.7 | 42.8 | 65.5 | 56 | 65.9 | 56.2 | 55.7 | 42.8 | 67.6 | 57.4 | 67.9 | 57.5 | 55.7 | 42.8 | 67.2 | 57.8 | 67.5 | 57.9 |
| NQ7 | 51.6 | 38.5 | 66.7 | 57.2 | 66.8 | 57.3 | 51.6 | 38.5 | 67.4 | 57.2 | 67.5 | 57.3 | 51.6 | 38.5 | 68.4 | 59 | 68.5 | 59.0 |
| NQ8 | 52.1 | 40.6 | 46.3 | 36.9 | 53.1 | 42.1 | 52.1 | 40.6 | 47.4 | 37.2 | 53.4 | 42.2 | 52.1 | 40.6 | 48 | 38.6 | 53.5 | 42.7 |
| NQ9 | 60.8 | 48.2 | 64.2 | 54.7 | 65.8 | 55.6 | 60.8 | 48.2 | 64.9 | 54.7 | 66.3 | 55.6 | 60.8 | 48.2 | 65.9 | 56.5 | 67.1 | 57.1 |
| NQ10 | 53.5 | 41.8 | 64.3 | 54.8 | 64.6 | 55.0 | 53.5 | 41.8 | 65.1 | 54.9 | 65.4 | 55.1 | 53.5 | 41.8 | 66 | 56.6 | 66.2 | 56.7 |
| NQ11 | 53.2 | 42.9 | 73.6 | 64.2 | 73.6 | 64.2 | 53.2 | 42.9 | 74.3 | 64.1 | 74.3 | 64.1 | 53.2 | 42.9 | 75.3 | 65.9 | 75.3 | 65.9 |
| NQ12 | 52.8 | 41.7 | 60.9 | 51.4 | 61.5 | 51.8 | 52.8 | 41.7 | 61.6 | 51.4 | 62.1 | 51.8 | 52.8 | 41.7 | 62.6 | 53.2 | 63.0 | 53.5 |
| NQ13 | 53.9 | 40.8 | 62.9 | 53.4 | 63.4 | 53.6 | 53.9 | 40.8 | 63.6 | 53.4 | 64.0 | 53.6 | 53.9 | 40.8 | 64.6 | 55.2 | 65.0 | 55.4 |
| NQ14 | 52.5 | 41.1 | 50.3 | 40.9 | 54.5 | 44.0 | 52.5 | 41.1 | 51 | 40.8 | 54.8 | 44.0 | 52.5 | 41.1 | 52 | 42.6 | 55.3 | 44.9 |
| NQ15 | 53.1 | 41.9 | 63.4 | 54 | 63.8 | 54.3 | 53.1 | 41.9 | 64.1 | 53.9 | 64.4 | 54.2 | 53.1 | 41.9 | 65.1 | 55.7 | 65.4 | 55.9 |
| NQ16 | 54.6 | 42.8 | 61.3 | 51.8 | 62.1 | 52.3 | 54.6 | 42.8 | 62 | 51.8 | 62.7 | 52.3 | 54.6 | 42.8 | 63 | 53.6 | 63.6 | 53.9 |
| NQ17 | 51.9 | 39.2 | 56.9 | 47.4 | 58.1 | 48.0 | 51.9 | 39.2 | 57.6 | 47.4 | 58.6 | 48.0 | 51.9 | 39.2 | 58.6 | 49.2 | 59.4 | 49.6 |
| NQ18 | 53.6 | 42.7 | 68.4 | 58.9 | 68.5 | 59.0 | 53.6 | 42.7 | 69.1 | 58.9 | 69.2 | 59.0 | 53.6 | 42.7 | 70.1 | 60.7 | 70.2 | 60.8 |
| NQ19 | 52.4 | 41.1 | 72.6 | 63.1 | 72.6 | 63.1 | 52.4 | 41.1 | 74.6 | 64.4 | 74.6 | 64.4 | 52.4 | 41.1 | 74.3 | 64.9 | 74.3 | 64.9 |

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The Noise modelling results for Corridor 1 for baseline environmental monitoring locations for the projected horizon period shows that, there is a considerable reduction in cumulative noise level ie., 8 to 10 db(A) for day time and night time for with barrier and without barrier scenario.

Impact on Sensitive Areas

Predicted Noise on the Building Façade

The impact on sensitive receptors for Corridor 1 for various years 2025, 2031 and 2041 are presented in table below. This has been done with proven statistical methods (by adopting Sound Attenuation - Inverse Square Law).

The inverse square law formula is as follows,

$$L_p(R2) = L_p(R1) - 20 \cdot \log_{10}(R2/R1)$$

Where:

$L_p(R1)$ = Known sound pressure level at the first location (typically measured data or equipment vendor data)

$L_p(R2)$ = Unknown sound pressure level at the second location Location

$R1$ = Distance from the noise source to location of known sound pressure level

$R2$ = Distance from noise source to the second location

Note: $L_p(R1)$ is taken from the model calculated value of SoundPLAN Rail Noise.

Impact on Sensitive Areas

Predicted Noise on the Building Façade

The impact on sensitive receptors for various years 2025, 2031 and 2041 are presented in **Table 8.33** and **Table 8.34**. Noise contour maps showing with barrier and without barrier for environmental features including receptors are presented in **Annexure 8.6**.

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Table 8.33. Predicted Noise on Environmental Sensitive Receptor Building Façade for Corridor 1 Right Hand Side

| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | Length and Height of CW Parallel to the Railway (m) if any | 2025 | | | 2031 | | | 2041 | | | With Barrier-2025 | | | Without Barrier-2025 | | | With Barrier-2031 | | | Without Barrier-2031 | | | With Barrier-2041 | | | Without Barrier-2041 | | |
|---------|---------------------------------|--|-------------------------------------|---------------------------|----------------------------|--|------|-----|------|------|-----|------|------|------|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN |
| 1 | 2+100 | New Clinton Public High School, Srirampura. | 35 | 38 | 18 | 40x1.2x0.2 | 86 | 78 | 82 | 87 | 79 | 83 | 88.3 | 80.3 | 84.3 | 43.2 | 37 | 40.0 | 60.4 | 52 | 56.4 | 44.0 | 38 | 40.8 | 61.4 | 53 | 57.4 | 45.1 | 39 | 41.9 | 62.7 | 55 | 58.7 |
| 2 | 2+770 | Manipal Hospital, Malleshwaram. | 45 | 47 | 18 | 50x1.2x0.2 | 86 | 78 | 82 | 87 | 79 | 83 | 88.3 | 80.3 | 84.3 | 41.4 | 35 | 38.2 | 58.6 | 51 | 54.6 | 42.2 | 36 | 39.0 | 59.6 | 52 | 55.6 | 43.2 | 37 | 40.0 | 60.9 | 53 | 56.9 |
| 3 | 3+200 | Cluny Convent High School Malleshwaram | 10 | 30 | 18 | 70x1.3x0.3 | 86 | 78 | 82 | 87 | 79 | 83 | 88.3 | 80.3 | 84.3 | 45.3 | 39 | 42.1 | 62.5 | 54 | 58.5 | 46.1 | 40 | 42.9 | 63.5 | 55 | 59.5 | 47.1 | 41 | 43.9 | 64.8 | 57 | 60.8 |
| 4 | 10+900 | Bishop Sergeant Central School, Lottegollahalli. | 10 | 10 | 12 | - | 86 | 78 | 82 | 87 | 79 | 83 | 88.3 | 80.3 | 84.3 | 54.8 | 48 | 51.6 | 72.0 | 64 | 68.0 | 55.6 | 49 | 52.4 | 73.0 | 65 | 69.0 | 56.7 | 50 | 53.5 | 74.3 | 66 | 70.3 |
| 5 | 13+500 | Dental Clinic, Kodigehalli. | 25 | 25 | 18 | 15x1.2x0.2 | 86 | 78 | 82 | 87 | 79 | 83 | 88.3 | 80.3 | 84.3 | 46.9 | 40 | 43.7 | 64.1 | 56 | 60.1 | 47.7 | 41 | 44.5 | 65.1 | 57 | 61.1 | 48.7 | 42 | 45.5 | 66.4 | 58 | 62.4 |
| 6 | 3+100 | Nitte Global Institute, Yelahanka. | 25 | 50 | 25 | 100x1.2x0.2 | 86 | 78 | 82 | 87 | 79 | 83 | 88.3 | 80.3 | 84.3 | 40.8 | 34 | 37.6 | 58.0 | 50 | 54.0 | 41.6 | 35 | 38.4 | 59.0 | 51 | 55.0 | 42.7 | 36 | 39.5 | 60.3 | 52 | 56.3 |
| 7 | 3+150 | Hostel, Nitte Global Institute, Yelahanka. | 30 | 50 | 20 | 70x1.2x0.2 | 86 | 78 | 82 | 87 | 79 | 83 | 88.3 | 80.3 | 84.3 | 40.8 | 34 | 37.6 | 58.0 | 50 | 54.0 | 41.6 | 35 | 38.4 | 59.0 | 51 | 55.0 | 42.7 | 36 | 39.5 | 60.3 | 52 | 56.3 |
| 8 | 12+580 | Clinic, Doddajala. | - | 15 | 14 | - | 86 | 78 | 82 | 87 | 79 | 83 | 88.3 | 80.3 | 84.3 | 51.3 | 45 | 48.1 | 68.5 | 60 | 64.5 | 52.1 | 46 | 48.9 | 69.5 | 61 | 65.5 | 53.1 | 47 | 49.9 | 70.8 | 63 | 66.8 |

Table 8.34. Predicted Noise on Environmental Sensitive Receptor Building Façade for Corridor 1 Left Hand Side

| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | Length and Height of CW Parallel to the Railway (m) if any | 2025 | | | 2031 | | | 2041 | | | With Barrier-2025 | | | Without Barrier-2025 | | | With Barrier-2031 | | | Without Barrier-2031 | | | With Barrier-2041 | | | Without Barrier-2041 | | |
|---------|---------------------------------|-----------------------|-------------------------------------|---------------------------|----------------------------|--|------|-----|------|------|-----|------|------|-----|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN |
| Nil | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

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Proposed Railway Line, Baiyyappanahalli Terminal to Chikkabanavara (Corridor 2)

The hourly train operation plan for the sub urban rail corridors for the year 2025, 2031 and 2041 were adopted from the detailed project report and presented in **Table 8.35**.

Table 8.35. Hourly Train Operation Plan Baiyyappanahalli Terminal to Chikkabanavara (Corridor 2)

| From | To | Cars/Train | Trains/Hour | | |
|--------------|----------|------------|-------------|-----------|-----------|
| | | | 2025 | 2031 | 2041 |
| 12:00 AM | 1:00 AM | 6 | 0 | 0 | 0 |
| 1:00 AM | 2:00 AM | 6 | 0 | 0 | 0 |
| 2:00 AM | 3:00 AM | 6 | 0 | 0 | 0 |
| 3:00 AM | 4:00 AM | 6 | 0 | 0 | 0 |
| 4:00 AM | 5:00 AM | 6 | 0 | 0 | 0 |
| 5:00 AM | 6:00 AM | 6 | 1 | 2 | 2 |
| 6:00 AM | 7:00 AM | 6 | 2 | 3 | 4 |
| 7:00 AM | 8:00 AM | 6 | 3 | 4 | 5 |
| 8:00 AM | 9:00 AM | 6 | 4 | 5 | 7 |
| 9:00 AM | 10:00 AM | 6 | 4 | 5 | 7 |
| 10:00 AM | 11:00 AM | 6 | 3 | 4 | 6 |
| 11:00 AM | 12:00 PM | 6 | 2 | 3 | 4 |
| 12:00 PM | 1:00 PM | 6 | 2 | 3 | 4 |
| 1:00 PM | 2:00 PM | 6 | 1 | 2 | 2 |
| 2:00 PM | 3:00 PM | 6 | 2 | 3 | 4 |
| 3:00 PM | 4:00 PM | 6 | 2 | 3 | 4 |
| 4:00 PM | 5:00 PM | 6 | 3 | 4 | 6 |
| 5:00 PM | 6:00 PM | 6 | 4 | 5 | 7 |
| 6:00 PM | 7:00 PM | 6 | 4 | 5 | 7 |
| 7:00 PM | 8:00 PM | 6 | 3 | 4 | 6 |
| 8:00 PM | 9:00 PM | 6 | 2 | 3 | 4 |
| 9:00 PM | 10:00 PM | 6 | 2 | 3 | 4 |
| 10:00 PM | 11:00 PM | 6 | 2 | 2 | 3 |
| 11:00 PM | 12:00 AM | 6 | 1 | 2 | 2 |
| Total | | | 47 | 65 | 88 |

Source: BSRP Feasibility Report

Post Project (Cumulative) Noise Estimation

The baseline noise readings and model predicted noise pressure values are added logarithmically to estimate the cumulative noise values. The estimated noise values of the different scenarios (horizon year) are given in the following **Table 8.36** & **Table 8.37**.

Impact on Sensitive Areas

Predicted Noise on the Building Façade

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The impact on sensitive receptors for various years 2025, 2031 and 2041 are presented in **Table 8.38** & **Table 8.39**. Noise contour maps showing with barrier and without barrier for environmental features including receptors are presented in **Annexure 8.6**.

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Table 8.36. Corridor 2 - Cumulative Noise Estimation for Baseline Noise Monitoring locations (without barrier)

| Noise Location | 2025 in dB(A) | | | | | | 2031 in dB(A) | | | | | | 2041 in dB(A) | | | | | |
|----------------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|
| | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | |
| | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN |
| NQ1 | 54.3 | 43.6 | 1 | 11 | 54.3 | 43.6 | 54.3 | 43.6 | 0.3 | 8.5 | 54.3 | 43.6 | 54.3 | 43.6 | 1.7 | 8.5 | 54.3 | 43.6 |
| NQ2 | 52.1 | 41.4 | 21.2 | 10.7 | 52.1 | 41.4 | 52.1 | 41.4 | 22.5 | 13.7 | 52.1 | 41.4 | 52.1 | 41.4 | 23.9 | 13.7 | 52.1 | 41.4 |
| NQ3 | 52.7 | 41.9 | 34.2 | 23.7 | 52.8 | 42.0 | 52.7 | 41.9 | 35.5 | 26.7 | 52.8 | 42.0 | 52.7 | 41.9 | 36.9 | 26.7 | 52.8 | 42.0 |
| NQ4 | 56.7 | 44.6 | 63.6 | 53.1 | 64.4 | 53.7 | 56.7 | 44.6 | 65 | 56.2 | 65.6 | 56.5 | 56.7 | 44.6 | 66.4 | 56.2 | 66.8 | 56.5 |
| NQ5 | 54.2 | 43.5 | 65 | 54.4 | 65.3 | 54.7 | 54.2 | 43.5 | 66.3 | 57.5 | 66.6 | 57.7 | 54.2 | 43.5 | 67.7 | 57.5 | 67.9 | 57.7 |
| NQ6 | 56.1 | 45.8 | 62.6 | 52.1 | 63.5 | 53.0 | 56.1 | 45.8 | 63.9 | 55.1 | 64.6 | 55.6 | 56.1 | 45.8 | 65.3 | 55.1 | 65.8 | 55.6 |
| NQ7 | 53.2 | 42.9 | 70.8 | 60.2 | 70.9 | 60.3 | 53.2 | 42.9 | 72.1 | 63.3 | 72.2 | 63.3 | 53.2 | 42.9 | 73.5 | 63.3 | 73.5 | 63.3 |
| NQ8 | 55.8 | 43.6 | 69.3 | 58.8 | 69.5 | 58.9 | 55.8 | 43.6 | 70.6 | 61.8 | 70.7 | 61.9 | 55.8 | 43.6 | 72 | 61.8 | 72.1 | 61.9 |
| NQ9 | 53.6 | 44.1 | 57.2 | 46.7 | 58.8 | 48.6 | 53.6 | 44.1 | 58.6 | 49.8 | 59.8 | 50.8 | 53.6 | 44.1 | 60 | 49.8 | 60.9 | 50.8 |
| NQ10 | 52.8 | 43.7 | 56.4 | 45.9 | 58.0 | 47.9 | 52.8 | 43.7 | 57.7 | 48.9 | 58.9 | 50.0 | 52.8 | 43.7 | 59.1 | 48.9 | 60.0 | 50.0 |
| NQ11 | 51.4 | 40.8 | 52.3 | 41.8 | 54.9 | 44.3 | 51.4 | 40.8 | 53.6 | 44.8 | 55.6 | 46.3 | 51.4 | 40.8 | 55 | 44.8 | 56.6 | 46.3 |

Table 8.37. Corridor 2 - Cumulative Noise Estimation for Baseline Noise Monitoring locations (with barrier)

| Noise Location | 2025 in dB(A) | | | | | | 2031 in dB(A) | | | | | | 2041 in dB(A) | | | | | |
|----------------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|
| | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | |
| | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN |
| NQ1 | 54.3 | 43.6 | 0.7 | 6 | 54.3 | 43.6 | 54.3 | 43.6 | 0.6 | 6 | 54.3 | 43.6 | 54.3 | 43.6 | 2 | 5 | 54.3 | 43.6 |
| NQ2 | 52.1 | 41.4 | 21.4 | 10.9 | 52.1 | 41.4 | 52.1 | 41.4 | 22.7 | 13.9 | 52.1 | 41.4 | 52.1 | 41.4 | 24.1 | 13.9 | 52.1 | 41.4 |
| NQ3 | 52.7 | 41.9 | 33.8 | 23.3 | 52.8 | 42.0 | 52.7 | 41.9 | 35.1 | 26.3 | 52.8 | 42.0 | 52.7 | 41.9 | 36.5 | 26.3 | 52.8 | 42.0 |
| NQ4 | 56.7 | 44.6 | 63.6 | 53.1 | 64.4 | 53.7 | 56.7 | 44.6 | 64.9 | 56.1 | 65.5 | 56.4 | 56.7 | 44.6 | 66.3 | 56.1 | 66.8 | 56.4 |
| NQ5 | 54.2 | 43.5 | 65 | 54.4 | 65.3 | 54.7 | 54.2 | 43.5 | 66.3 | 57.5 | 66.6 | 57.7 | 54.2 | 43.5 | 67.7 | 57.5 | 67.9 | 57.7 |

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| Noise Location | 2025 in dB(A) | | | | | | 2031 in dB(A) | | | | | | 2041 in dB(A) | | | | | |
|----------------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|
| | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | |
| | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN |
| NQ6 | 56.1 | 45.8 | 62.6 | 52.1 | 63.5 | 53.0 | 56.1 | 45.8 | 63.9 | 55.1 | 64.6 | 55.6 | 56.1 | 45.8 | 65.3 | 55.1 | 65.8 | 55.6 |
| NQ7 | 53.2 | 42.9 | 70.8 | 60.2 | 70.9 | 60.3 | 53.2 | 42.9 | 72.1 | 63.3 | 72.2 | 63.3 | 53.2 | 42.9 | 73.5 | 63.3 | 73.5 | 63.3 |
| NQ8 | 55.8 | 43.6 | 69.3 | 58.8 | 69.5 | 58.9 | 55.8 | 43.6 | 70.6 | 61.8 | 70.7 | 61.9 | 55.8 | 43.6 | 72 | 61.8 | 72.1 | 61.9 |
| NQ9 | 53.6 | 44.1 | 40.4 | 29.9 | 53.8 | 44.3 | 53.6 | 44.1 | 41.7 | 32.9 | 53.9 | 44.4 | 53.6 | 44.1 | 43.1 | 32.9 | 54.0 | 44.4 |
| NQ10 | 52.8 | 43.7 | 56.4 | 45.9 | 58.0 | 47.9 | 52.8 | 43.7 | 57.7 | 48.9 | 58.9 | 50.0 | 52.8 | 43.7 | 59.1 | 48.9 | 60.0 | 50.0 |
| NQ11 | 51.4 | 40.8 | 52.3 | 41.8 | 54.9 | 44.3 | 51.4 | 40.8 | 53.7 | 44.9 | 55.7 | 46.3 | 51.4 | 40.8 | 55.1 | 44.9 | 56.6 | 46.3 |

Table 8.38. Predicted Noise on Environmental Sensitive Receptor Building Façade for Corridor 2 Right Hand Side

| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | Length and Height of CW Parallel to the Railway (m) if any | 2025 | | | 2031 | | | 2041 | | | With Barrier-2025 | | | Without Barrier-2025 | | | With Barrier-2031 | | | Without Barrier-2031 | | | With Barrier-2041 | | | Without Barrier-2041 | | |
|---------|---------------------------------|---|-------------------------------------|---------------------------|----------------------------|--|------|-----|------|------|-----|------|------|------|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the Building (m) | | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN |
| 1 | 204+890 | New Pratham Public School, Mahadevapura. | 34 | 35 | 15 | 70x2x0.2 | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 32.7 | 30 | 31.1 | 47.1 | 43 | 45.1 | 33.5 | 30 | 31.9 | 48.1 | 44 | 46.1 | 34.6 | 31 | 33.0 | 49.4 | 45 | |
| 2 | 206+400 | NMT Elder Care J P Nagar. | 40 | 43 | 5 | 25x2x0.2 | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 31.0 | 28 | 29.4 | 45.4 | 41 | 43.4 | 31.8 | 29 | 30.2 | 46.4 | 42 | 44.4 | 32.8 | 30 | 31.2 | 47.7 | 44 | |
| 3 | 207+440 | Mother Mary English School, Chikkabanasawadi. | - | 30 | 14 | - | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 34.1 | 31 | 32.5 | 48.5 | 44 | 46.5 | 34.9 | 32 | 33.3 | 49.5 | 45 | 47.5 | 35.9 | 33 | 34.3 | 50.8 | 47 | |
| 4 | 210+710 | Siddhartha PU College, 7th Cross Lingarajapura Hennur Main Road. | 60 | 70 | 6 | 100x2x0.2 | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 26.7 | 24 | 25.1 | 41.1 | 37 | 39.1 | 27.5 | 24 | 25.9 | 42.1 | 38 | 40.1 | 28.6 | 25 | 27.0 | 43.4 | 39 | |
| 5 | 213+750 | Jauhar Shifa Khana, Clinic in Byrappa Layout, R M V 2nd Stage. | - | 35 | 8 | - | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 32.7 | 30 | 31.1 | 47.1 | 43 | 45.1 | 33.5 | 30 | 31.9 | 48.1 | 44 | 46.1 | 34.6 | 31 | 33.0 | 49.4 | 45 | |
| 6 | 214+680 | St Pauls Public School and Apartment, Arabic college Road, Jogappa Layout Nagavara. | 30 | 45 | 130 | 200x2x0.3 | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 30.6 | 27 | 29.0 | 45.0 | 41 | 43.0 | 31.4 | 28 | 29.8 | 46.0 | 42 | 44.0 | 32.4 | 29 | 30.8 | 47.3 | 43 | |
| 7 | 15+550 | Clinic | - | - | 15 | - | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 30.6 | 27 | 29.0 | 45.0 | 41 | 43.0 | 31.4 | 28 | 29.8 | 46.0 | 42 | 44.0 | 32.4 | 29 | 30.8 | 47.3 | 43 | |
| 8 | 15+800 | Hospital | - | - | 20 | - | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 30.6 | 27 | 29.0 | 45.0 | 41 | 43.0 | 31.4 | 28 | 29.8 | 46.0 | 42 | 44.0 | 32.4 | 29 | 30.8 | 47.3 | 43 | |
| 9 | 16+500 | Clinic | - | - | 14 | - | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 30.6 | 27 | 29.0 | 45.0 | 41 | 43.0 | 31.4 | 28 | 29.8 | 46.0 | 42 | 44.0 | 32.4 | 29 | 30.8 | 47.3 | 43 | |
| 10 | 18+740 | Other govt hospital | 30 | 36 | 5 | 300x2x0.5 | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 32.5 | 29 | 30.9 | 46.9 | 43 | 44.9 | 33.3 | 30 | 31.7 | 47.9 | 44 | 45.9 | 34.3 | 31 | 32.7 | 49.2 | 45 | |
| 11 | 23+700 | R.R Institute college | 5 | 35 | 24 | 20x2.5x0.5 | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 32.7 | 30 | 31.1 | 47.1 | 43 | 45.1 | 33.5 | 30 | 31.9 | 48.1 | 44 | 46.1 | 34.6 | 31 | 33.0 | 49.4 | 45 | |
| 12 | 23+900 | National Public School, Chikkabanasawadi. | 10 | 15 | 27 | 30x2.5x0.2 | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 40.1 | 37 | 38.5 | 54.5 | 50 | 52.5 | 40.9 | 38 | 39.3 | 55.5 | 51 | 53.5 | 41.9 | 39 | 40.3 | 56.8 | 53 | |

Table 8.39. Predicted Noise on Environmental Sensitive Receptor Building Façade for Corridor 2 Left Hand Side

| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | Length and Height of CW Parallel to the Railway (m) if any | 2025 | | | 2031 | | | 2041 | | | With Barrier-2025 | | | Without Barrier-2025 | | | With Barrier-2031 | | | Without Barrier-2031 | | | With Barrier-2041 | | | Without Barrier-2041 | | |
|---------|---------------------------------|---|-------------------------------------|---------------------------|----------------------------|--|------|-----|------|------|-----|------|------|------|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN |
| 1 | 205+360 | Government Higher Primary School, Benniganahalli. | 30 | 32 | 14 | 36x1.5x0.2 | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 33.5 | 30 | 31.9 | 47.9 | 44 | 45.9 | 34.3 | 31 | 32.7 | 48.9 | 45 | 46.9 | 35.4 | 32 | 33.8 | 50.2 | 46 | |
| 2 | 205+780 | Little Angels Modern High School, NGEF Layout, | 32 | 34 | 14 | 30x1.5x0.2 | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 33.0 | 30 | 31.4 | 47.4 | 43 | 45.4 | 33.8 | 31 | 32.2 | 48.4 | 44 | 46.4 | 34.8 | 32 | 33.2 | 49.7 | 46 | |

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| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | Length and Height of CW Parallel to the Railway (m) if any | 2025 | | | 2031 | | | 2041 | | | With Barrier-2025 | | | Without Barrier-2025 | | | With Barrier-2031 | | | Without Barrier-2031 | | | With Barrier-2041 | | | Without Barrier-2041 | | |
|---------|---------------------------------|--|-------------------------------------|---------------------------|----------------------------|--|------|-----|------|------|-----|------|------|------|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN |
| 18 | 16+270 | Sir Hanuman Vidhyalaya, Mohankumar Nagar, Yeshwanthpur. | - | - | 14 | - | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 32.7 | 30 | 31.1 | 47.1 | 43 | 45.1 | 33.5 | 30 | 31.9 | 48.1 | 44 | 46.1 | 34.6 | 31 | 33.0 | 49.4 | 45 | |
| 19 | 16+270 | Venkateswara clinic, Yeshwanthpur. | - | - | 12 | - | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 32.7 | 30 | 31.1 | 47.1 | 43 | 45.1 | 33.5 | 30 | 31.9 | 48.1 | 44 | 46.1 | 34.6 | 31 | 33.0 | 49.4 | 45 | |
| 20 | 23+460 | Cecilia English Nursery & High School, Maruthi Seva Nagar. | 25 | 35 | 30 | 50x2x0.2 | 72 | 68 | 70 | 73 | 69 | 71 | 74.3 | 70.3 | 72.3 | 32.7 | 30 | 31.1 | 47.1 | 43 | 45.1 | 33.5 | 30 | 31.9 | 48.1 | 44 | 46.1 | 34.6 | 31 | 33.0 | 49.4 | 45 | |

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Proposed Railway Line, Kengeri to Bengaluru Cantonment (Corridor 3)

The hourly train operation plan for the sub urban rail corridors for the year 2025, 2031 and 2041 were adopted from the detailed project report and presented in table below,

Table 8.40. Hourly Train Operation Plan Kengeri to Bengaluru Cantonment (Corridor 3)

| From | To | Cars/Train | Trains/Hour | | |
|--------------|----------|------------|-------------|-----------|-----------|
| | | | 2025 | 2031 | 2041 |
| 12:00 AM | 1:00 AM | 6.00 | 0 | 0 | 0 |
| 1:00 AM | 2:00 AM | 6.00 | 0 | 0 | 0 |
| 2:00 AM | 3:00 AM | 6.00 | 0 | 0 | 0 |
| 3:00 AM | 4:00 AM | 6.00 | 0 | 0 | 0 |
| 4:00 AM | 5:00 AM | 6.00 | 0 | 0 | 0 |
| 5:00 AM | 6:00 AM | 6.00 | 1 | 1 | 2 |
| 6:00 AM | 7:00 AM | 6.00 | 2 | 2 | 3 |
| 7:00 AM | 8:00 AM | 6.00 | 2 | 3 | 4 |
| 8:00 AM | 9:00 AM | 6.00 | 3 | 4 | 5 |
| 9:00 AM | 10:00 AM | 6.00 | 3 | 4 | 5 |
| 10:00 AM | 11:00 AM | 6.00 | 2 | 3 | 4 |
| 11:00 AM | 12:00 PM | 6.00 | 2 | 2 | 3 |
| 12:00 PM | 1:00 PM | 6.00 | 2 | 2 | 3 |
| 1:00 PM | 2:00 PM | 6.00 | 1 | 1 | 2 |
| 2:00 PM | 3:00 PM | 6.00 | 2 | 2 | 3 |
| 3:00 PM | 4:00 PM | 6.00 | 2 | 2 | 3 |
| 4:00 PM | 5:00 PM | 6.00 | 2 | 3 | 4 |
| 5:00 PM | 6:00 PM | 6.00 | 3 | 4 | 5 |
| 6:00 PM | 7:00 PM | 6.00 | 3 | 4 | 5 |
| 7:00 PM | 8:00 PM | 6.00 | 2 | 3 | 4 |
| 8:00 PM | 9:00 PM | 6.00 | 2 | 2 | 3 |
| 9:00 PM | 10:00 PM | 6.00 | 2 | 2 | 3 |
| 10:00 PM | 11:00 PM | 6.00 | 1 | 2 | 2 |
| 11:00 PM | 12:00 AM | 6.00 | 1 | 1 | 2 |
| Total | | | 38 | 47 | 65 |

Post Project (Cumulative) Noise Estimation

The baseline noise readings and model predicted noise pressure values are added logarithmically to estimate the cumulative noise values. The estimated noise values of the different scenarios (horizon year) are given in **Table 8.41** & **Table 8.42**.

Impact on Sensitive Areas

Predicted Noise on the Building Façade

The impact on sensitive receptors for various years 2025, 2031 and 2041 are presented in **Table 8.43** & **Table 8.44**. Noise contour maps showing with barrier and without barrier for environmental features including receptors are presented in **Annexure 8.6**.

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Table 8.41. Corridor 3 - Cumulative Noise Estimation for Baseline Noise Monitoring locations (without barrier)

| Noise Location | 2025 in dB(A) | | | | | | 2031 in dB(A) | | | | | | 2041 in dB(A) | | | | | |
|----------------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|
| | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | |
| | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN |
| NQ1 | 53.8 | 42.9 | 65.5 | 55.9 | 65.8 | 56.1 | 53.8 | 42.9 | 66.4 | 55.9 | 66.6 | 56.1 | 53.8 | 42.9 | 67.7 | 58.9 | 67.9 | 59.0 |
| NQ2 | 52.6 | 39.1 | 66.1 | 56.5 | 66.3 | 56.6 | 52.6 | 39.1 | 67.1 | 56.6 | 67.3 | 56.7 | 52.6 | 39.1 | 68.4 | 59.6 | 68.5 | 59.6 |
| NQ3 | 53.5 | 40.8 | 78.3 | 68.8 | 78.3 | 68.8 | 53.5 | 40.8 | 79.3 | 68.8 | 79.3 | 68.8 | 53.5 | 40.8 | 80.6 | 71.8 | 80.6 | 71.8 |
| NQ4 | 52.8 | 41.4 | 69 | 59.4 | 69.1 | 59.5 | 52.8 | 41.4 | 70 | 59.5 | 70.1 | 59.6 | 52.8 | 41.4 | 71.3 | 62.5 | 71.4 | 62.5 |
| NQ5 | 57.1 | 43.9 | 77.1 | 67.6 | 77.1 | 67.6 | 57.1 | 43.9 | 78.1 | 67.6 | 78.1 | 67.6 | 57.1 | 43.9 | 79.4 | 70.6 | 79.4 | 70.6 |
| NQ6 | 56.2 | 42.7 | 65.5 | 56 | 66.0 | 56.2 | 56.2 | 42.7 | 66.5 | 56 | 66.9 | 56.2 | 56.2 | 42.7 | 67.8 | 59 | 68.1 | 59.1 |
| NQ7 | 52.2 | 41.9 | 66.5 | 57 | 66.7 | 57.1 | 52.2 | 41.9 | 67.5 | 57 | 67.6 | 57.1 | 52.2 | 41.9 | 68.8 | 60 | 68.9 | 60.1 |
| NQ8 | 54.1 | 42.6 | 65.5 | 55.9 | 65.8 | 56.1 | 54.1 | 42.6 | 66.5 | 56 | 66.7 | 56.2 | 54.1 | 42.6 | 67.8 | 59 | 68.0 | 59.1 |
| NQ9 | 54.3 | 44 | 60 | 50.5 | 61.0 | 51.4 | 54.3 | 44 | 61 | 50.5 | 61.8 | 51.4 | 54.3 | 44 | 62.3 | 53.5 | 62.9 | 54.0 |
| NQ10 | 52.2 | 40.4 | 58.8 | 49.2 | 59.7 | 49.7 | 52.2 | 40.4 | 59.8 | 49.3 | 60.5 | 49.8 | 52.2 | 40.4 | 61.1 | 52.3 | 61.6 | 52.6 |

Table 8.42. Corridor 3 - Cumulative Noise Estimation for Baseline Noise Monitoring locations (with barrier)

| Noise Location | 2025 in dB(A) | | | | | | 2031 in dB(A) | | | | | | 2041 in dB(A) | | | | | |
|----------------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|
| | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | |
| | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN |
| NQ1 | 53.8 | 42.9 | 66 | 56.4 | 66.3 | 56.6 | 53.8 | 42.9 | 67 | 56.5 | 67.2 | 56.7 | 53.8 | 42.9 | 68.3 | 59.5 | 68.5 | 59.6 |
| NQ2 | 52.6 | 39.1 | 66.2 | 56.6 | 66.4 | 56.7 | 52.6 | 39.1 | 67.2 | 56.7 | 67.3 | 56.8 | 52.6 | 39.1 | 68.5 | 59.7 | 68.6 | 59.7 |
| NQ3 | 53.5 | 40.8 | 78.3 | 68.8 | 78.3 | 68.8 | 53.5 | 40.8 | 79.3 | 68.8 | 79.3 | 68.8 | 53.5 | 40.8 | 80.6 | 71.8 | 80.6 | 71.8 |
| NQ4 | 52.8 | 41.4 | 69 | 59.4 | 69.1 | 59.5 | 52.8 | 41.4 | 70 | 59.5 | 70.1 | 59.6 | 52.8 | 41.4 | 71.3 | 62.5 | 71.4 | 62.5 |
| NQ5 | 57.1 | 43.9 | 77.1 | 67.6 | 77.1 | 67.6 | 57.1 | 43.9 | 78.1 | 67.6 | 78.1 | 67.6 | 57.1 | 43.9 | 79.4 | 70.6 | 79.4 | 70.6 |
| NQ6 | 56.2 | 42.7 | 65.5 | 56 | 66.0 | 56.2 | 56.2 | 42.7 | 66.5 | 56 | 66.9 | 56.2 | 56.2 | 42.7 | 67.8 | 59 | 68.1 | 59.1 |
| NQ7 | 52.2 | 41.9 | 66.5 | 57 | 66.7 | 57.1 | 52.2 | 41.9 | 67.5 | 57 | 67.6 | 57.1 | 52.2 | 41.9 | 68.8 | 60 | 68.9 | 60.1 |

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| Noise Location | 2025 in dB(A) | | | | | | 2031 in dB(A) | | | | | | 2041 in dB(A) | | | | | |
|----------------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|
| | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | |
| | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN |
| NQ8 | 54.1 | 42.6 | 65.5 | 55.9 | 65.8 | 56.1 | 54.1 | 42.6 | 66.5 | 56 | 66.7 | 56.2 | 54.1 | 42.6 | 67.8 | 59 | 68.0 | 59.1 |
| NQ9 | 54.3 | 44 | 60 | 50.5 | 61.0 | 51.4 | 54.3 | 44 | 61 | 50.5 | 61.8 | 51.4 | 54.3 | 44 | 62.3 | 53.5 | 62.9 | 54.0 |
| NQ10 | 52.2 | 40.4 | 58.8 | 49.2 | 59.7 | 49.7 | 52.2 | 40.4 | 59.8 | 49.3 | 60.5 | 49.8 | 52.2 | 40.4 | 61.1 | 52.3 | 61.6 | 52.6 |

Table 8.43. Predicted Noise on Environmental Sensitive Receptor Building Façade for Corridor 3 Right Hand Side

| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | Length and Height of CW Parallel to the Railway (m) if any | 2025 | | | 2031 | | | 2041 | | | With Barrier-2025 | | | Without Barrier-2025 | | | With Barrier-2031 | | | Without Barrier-2031 | | | With Barrier-2041 | | | Without Barrier-2041 | | |
|---------|---------------------------------|---|-------------------------------------|---------------------------|----------------------------|--|------|-----|------|------|-----|------|------|------|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the Building (m) | | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN |
| 1 | 10+500 | BIMS, Boys Hostel, Kengeri Satellite Town. | 15 | 17 | 40 | 80x1.2x0.3 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 38.4 | 34 | 36.3 | 52.6 | 47 | 50.0 | 39.2 | 35 | 37.1 | 53.6 | 48 | 51.0 | 40.2 | 36 | 38.1 | 54.9 | 50 | 52.3 |
| 2 | 10+400 | Orchids School, Mysore Road, Kengeri satellite Town. | 10 | 15 | 30 | 30x1.2x0.2 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 39.5 | 35 | 37.4 | 53.7 | 48 | 51.1 | 40.3 | 36 | 38.2 | 54.7 | 49 | 52.1 | 41.3 | 37 | 39.2 | 56.0 | 51 | 53.4 |
| 3 | 10+300 | Bengaluru Institute of Management, Mysore Road, Kengeri Satellite Town. | 10 | 15 | 10 | 50x1.2x0.2 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 39.5 | 35 | 37.4 | 53.7 | 48 | 51.1 | 40.3 | 36 | 38.2 | 54.7 | 49 | 52.1 | 41.3 | 37 | 39.2 | 56.0 | 51 | 53.4 |
| 4 | 8+150 | College | 12 | 15 | 15 | 20x1.2x0.3 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 39.5 | 35 | 37.4 | 53.7 | 48 | 51.1 | 40.3 | 36 | 38.2 | 54.7 | 49 | 52.1 | 41.3 | 37 | 39.2 | 56.0 | 51 | 53.4 |
| 5 | 6+830 | Piles and Fistula Clinic | - | 15 | 9 | - | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 39.5 | 35 | 37.4 | 53.7 | 48 | 51.1 | 40.3 | 36 | 38.2 | 54.7 | 49 | 52.1 | 41.3 | 37 | 39.2 | 56.0 | 51 | 53.4 |
| 6 | 5+900 | Madarasa Women's Arabic School, Roshan Nagar. | - | 10 | - | - | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 43.0 | 39 | 40.9 | 57.2 | 52 | 54.6 | 43.8 | 40 | 41.7 | 58.2 | 53 | 55.6 | 44.8 | 41 | 42.7 | 59.5 | 54 | 56.9 |
| 7 | 5+860 | Government Urdu Primary School, Roshan Nagar. | 10 | 11 | 10 | 12x1.2x0.2 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 42.2 | 38 | 40.1 | 56.4 | 51 | 53.8 | 43.0 | 39 | 40.9 | 57.4 | 52 | 54.8 | 44.0 | 40 | 41.9 | 58.7 | 53 | 56.1 |
| 8 | 349+570 | City Multi Speciality and Trauma Centre, Hospital, Pulikeshi Nagar. | 15 | 16 | 20 | 20x1.2x0.3 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 38.9 | 35 | 36.8 | 53.1 | 48 | 50.5 | 39.7 | 36 | 37.6 | 54.1 | 49 | 51.5 | 40.7 | 37 | 38.7 | 55.4 | 50 | 52.8 |

Table 8.44. Predicted Noise on Environmental Sensitive Receptor Building Façade for Corridor 3 Left Hand Side

| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | Length and Height of CW Parallel to the Railway (m) if any | 2025 | | | 2031 | | | 2041 | | | With Barrier-2025 | | | Without Barrier-2025 | | | With Barrier-2031 | | | Without Barrier-2031 | | | With Barrier-2041 | | | Without Barrier-2041 | | |
|---------|---------------------------------|---|-------------------------------------|---------------------------|----------------------------|--|------|-----|------|------|-----|------|------|------|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the Building (m) | | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN |
| 1 | 12+700 | Government, High School and First Grade College, Kengeri. | 13 | 35 | 20 | 30x1.5x0.3 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 32.1 | 28 | 30.0 | 46.3 | 41 | 43.7 | 32.9 | 29 | 30.8 | 47.3 | 42 | 44.7 | 33.9 | 30 | 31.9 | 48.6 | 43 | 46.0 |
| 2 | 11+950 | Dr.Suhasini Hospital, Kengeri Satellite Town. | - | 18 | 30 | - | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 37.9 | 34 | 35.8 | 52.1 | 47 | 49.5 | 38.7 | 35 | 36.6 | 53.1 | 48 | 50.5 | 39.7 | 36 | 37.6 | 54.4 | 49 | 51.8 |
| 3 | 11+470 | National Public School, Kengeri Satellite Town. | 20 | 24 | 35 | 30x1.5x0.3 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 35.4 | 31 | 33.3 | 49.6 | 44 | 47.0 | 36.2 | 32 | 34.1 | 50.6 | 45 | 48.0 | 37.2 | 33 | 35.1 | 51.9 | 47 | 49.3 |
| 4 | 9+320 | Indian Statistical Institute, Mysore Road. | 10 | 20 | - | 100x2.5x0.3 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 37.0 | 33 | 34.9 | 51.2 | 46 | 48.6 | 37.8 | 34 | 35.7 | 52.2 | 47 | 49.6 | 38.8 | 35 | 36.7 | 53.5 | 48 | 50.9 |
| 5 | 5+150 | Ananya Hospital | 15 | 16 | 25 | 75x1x0.2 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 38.9 | 35 | 36.8 | 53.1 | 48 | 50.5 | 39.7 | 36 | 37.6 | 54.1 | 49 | 51.5 | 40.7 | 37 | 38.7 | 55.4 | 50 | 52.8 |
| 6 | 4+950 | Dhanvantari Clinic, Railway Parallel Road, Vijayanagar. | - | 15 | 20 | - | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 39.5 | 35 | 37.4 | 53.7 | 48 | 51.1 | 40.3 | 36 | 38.2 | 54.7 | 49 | 52.1 | 41.3 | 37 | 39.2 | 56.0 | 51 | 53.4 |
| 7 | 4+925 | St. Michaels, High School, Hampinagar. | - | 15 | 22 | - | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 39.5 | 35 | 37.4 | 53.7 | 48 | 51.1 | 40.3 | 36 | 38.2 | 54.7 | 49 | 52.1 | 41.3 | 37 | 39.2 | 56.0 | 51 | 53.4 |
| 8 | 2+130 | Roses Convent School, Binnipete, Kempapura. | 10 | 14 | 20 | 350x7x0.5 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 40.1 | 36 | 38.0 | 54.3 | 49 | 51.7 | 40.9 | 37 | 38.8 | 55.3 | 50 | 52.7 | 41.9 | 38 | 39.8 | 56.6 | 51 | 54.0 |
| 9 | 353+890 | Star Health Allied | 10 | 13 | 30 | 100x1.2x0.2 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 40.7 | 37 | 38.6 | 54.9 | 50 | 52.3 | 41.5 | 37 | 39.4 | 55.9 | 51 | 53.3 | 42.5 | 38 | 40.5 | 57.2 | 52 | 54.6 |
| 10 | 353+680 | Eye Hospital and Squite Centre. | 14 | 15 | 12 | 40x1x0.2 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 39.5 | 35 | 37.4 | 53.7 | 48 | 51.1 | 40.3 | 36 | 38.2 | 54.7 | 49 | 52.1 | 41.3 | 37 | 39.2 | 56.0 | 51 | 53.4 |
| 11 | 350+390 | MQI Degree College, Benson Town. | 20 | 22 | 30 | 30x1.2x0.5 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 36.1 | 32 | 34.1 | 50.4 | 45 | 47.8 | 36.9 | 33 | 34.9 | 51.4 | 46 | 48.8 | 38.0 | 34 | 35.9 | 52.7 | 47 | 50.1 |
| 12 | 349+220 | Clarence High School, Rechards Town. | 10 | 20 | 20 | 70x1.5x0.35 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 37.0 | 33 | 34.9 | 51.2 | 46 | 48.6 | 37.8 | 34 | 35.7 | 52.2 | 47 | 49.6 | 38.8 | 35 | 36.7 | 53.5 | 48 | 50.9 |
| 13 | 348+770 | Medico Pertrol Association Center for Mental Health | 15 | 18 | 15 | 45x1.5x0.35 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 37.9 | 34 | 35.8 | 52.1 | 47 | 49.5 | 38.7 | 35 | 36.6 | 53.1 | 48 | 50.5 | 39.7 | 36 | 37.6 | 54.4 | 49 | 51.8 |
| 14 | 347+600 | Jeevan Clinic | 10 | 10 | 15 | 10x1x0.10 | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 43.0 | 39 | 40.9 | 57.2 | 52 | 54.6 | 43.8 | 40 | 41.7 | 58.2 | 53 | 55.6 | 44.8 | 41 | 42.7 | 59.5 | 54 | 56.9 |
| 15 | 377+340 | Chaithanya Clinic, Saketha Nagar, Hoodi. | 10 | 10 | 8 | - | 71.2 | 66 | 68.6 | 72.2 | 67 | 69.6 | 73.5 | 68.3 | 70.9 | 43.0 | 39 | 40.9 | 57.2 | 52 | 54.6 | 43.8 | 40 | 41.7 | 58.2 | 53 | 55.6 | 44.8 | 41 | 42.7 | 59.5 | 54 | 56.9 |

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Proposed Railway Line, Heelalige to Rajanakunte (Corridor 4)

Rail Traffic

The hourly train operation plan for the sub urban rail corridors for the year 2025, 2031 and 2041 were adopted from the detailed project report and presented in **Table 8.45**.

Table 8.45. Hourly Train Operation Plan Heelalige to Rajanakunte (Corridor 4)

| From | To | Cars/Train | Trains/Hour | | |
|--------------|----------|------------|-------------|-----------|-----------|
| | | | 2025 | 2031 | 2041 |
| 12:00 AM | 1:00 AM | 6 | 0 | 0 | 0 |
| 1:00 AM | 2:00 AM | 6 | 0 | 0 | 0 |
| 2:00 AM | 3:00 AM | 6 | 0 | 0 | 0 |
| 3:00 AM | 4:00 AM | 6 | 0 | 0 | 0 |
| 4:00 AM | 5:00 AM | 6 | 0 | 0 | 0 |
| 5:00 AM | 6:00 AM | 6 | 1 | 2 | 2 |
| 6:00 AM | 7:00 AM | 6 | 2 | 3 | 3 |
| 7:00 AM | 8:00 AM | 6 | 3 | 4 | 4 |
| 8:00 AM | 9:00 AM | 6 | 4 | 6 | 6 |
| 9:00 AM | 10:00 AM | 6 | 4 | 6 | 6 |
| 10:00 AM | 11:00 AM | 6 | 3 | 5 | 5 |
| 11:00 AM | 12:00 PM | 6 | 2 | 4 | 4 |
| 12:00 PM | 1:00 PM | 6 | 2 | 3 | 3 |
| 1:00 PM | 2:00 PM | 6 | 1 | 2 | 2 |
| 2:00 PM | 3:00 PM | 6 | 2 | 3 | 3 |
| 3:00 PM | 4:00 PM | 6 | 2 | 4 | 4 |
| 4:00 PM | 5:00 PM | 6 | 3 | 5 | 5 |
| 5:00 PM | 6:00 PM | 6 | 4 | 6 | 6 |
| 6:00 PM | 7:00 PM | 6 | 4 | 6 | 6 |
| 7:00 PM | 8:00 PM | 6 | 3 | 5 | 5 |
| 8:00 PM | 9:00 PM | 6 | 2 | 4 | 4 |
| 9:00 PM | 10:00 PM | 6 | 2 | 3 | 3 |
| 10:00 PM | 11:00 PM | 6 | 2 | 2 | 2 |
| 11:00 PM | 12:00 AM | 6 | 1 | 2 | 2 |
| Total | | | 47 | 75 | 75 |

Post Project (Cumulative) Noise Estimation

The baseline noise readings and model predicted noise pressure values are added logarithmically to estimate the cumulative noise values. The estimated noise values of the different scenarios (horizon year) are given in **Table 8.46** and **Table 8.47**.

Impact on Sensitive Areas

Predicted Noise on the Building Façade

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The impact on sensitive receptors for various years 2025, 2031 and 2041 are presented in **Table 8.48** and **Table 8.49**. Noise contour maps showing with barrier and without barrier for environmental features including receptors are presented in **Annexure 8.6**.

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Table 8.46. Corridor 4 - Cumulative Noise Estimation for Baseline Noise Monitoring locations (without barrier)

| Noise Location | 2025 in dB(A) | | | | | | 2031 in dB(A) | | | | | | 2041 in dB(A) | | | | | |
|----------------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|
| | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | |
| | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN |
| NQ1 | 51.2 | 39.6 | 64.9 | 54.4 | 65.1 | 54.5 | 51.2 | 39.6 | 66.9 | 57.4 | 67.0 | 57.5 | 51.2 | 39.6 | 66.9 | 57.4 | 67.0 | 57.5 |
| NQ2 | 52.8 | 42.7 | 67.5 | 57 | 67.6 | 57.2 | 52.8 | 42.7 | 69.5 | 60 | 69.6 | 60.1 | 52.8 | 42.7 | 69.5 | 60 | 69.6 | 60.1 |
| NQ3 | 51.6 | 43.9 | 62.7 | 52.2 | 63.0 | 52.8 | 51.6 | 43.9 | 64.7 | 55.2 | 64.9 | 55.5 | 51.6 | 43.9 | 64.7 | 55.2 | 64.9 | 55.5 |
| NQ4 | 53.1 | 42.8 | 63.6 | 53 | 64.0 | 53.4 | 53.1 | 42.8 | 65.6 | 56.1 | 65.8 | 56.3 | 53.1 | 42.8 | 65.6 | 56.1 | 65.8 | 56.3 |
| NQ5 | 52.4 | 41.6 | 62.6 | 52.1 | 63.0 | 52.5 | 52.4 | 41.6 | 64.6 | 55.1 | 64.9 | 55.3 | 52.4 | 41.6 | 64.6 | 55.1 | 64.9 | 55.3 |
| NQ6 | 51.7 | 41.2 | 65.2 | 54.6 | 65.4 | 54.8 | 51.7 | 41.2 | 67.2 | 57.7 | 67.3 | 57.8 | 51.7 | 41.2 | 67.2 | 57.7 | 67.3 | 57.8 |
| NQ7 | 50.6 | 43.5 | 57.2 | 46.7 | 58.1 | 48.4 | 50.6 | 43.5 | 59.3 | 49.8 | 59.8 | 50.7 | 50.6 | 43.5 | 59.3 | 49.8 | 59.8 | 50.7 |
| NQ8 | 52.2 | 42.6 | 69.5 | 59 | 69.6 | 59.1 | 52.2 | 42.6 | 71.6 | 62.1 | 71.6 | 62.1 | 52.2 | 42.6 | 71.6 | 62.1 | 71.6 | 62.1 |
| NQ9 | 53.7 | 41.9 | 64.6 | 54.1 | 64.9 | 54.4 | 53.7 | 41.9 | 66.6 | 57.1 | 66.8 | 57.2 | 53.7 | 41.9 | 66.6 | 57.1 | 66.8 | 57.2 |
| NQ10 | 54.8 | 40.9 | 66.4 | 55.9 | 66.7 | 56.0 | 54.8 | 40.9 | 68.4 | 58.9 | 68.6 | 59.0 | 54.8 | 40.9 | 68.4 | 58.9 | 68.6 | 59.0 |
| NQ11 | 52.5 | 41.2 | 61.7 | 51.2 | 62.2 | 51.6 | 52.5 | 41.2 | 63.7 | 54.2 | 64.0 | 54.4 | 52.5 | 41.2 | 63.7 | 54.2 | 64.0 | 54.4 |
| NQ12 | 53.4 | 40.6 | 67.6 | 57 | 67.8 | 57.1 | 53.4 | 40.6 | 69.6 | 60.1 | 69.7 | 60.1 | 53.4 | 40.6 | 69.6 | 60.1 | 69.7 | 60.1 |
| NQ13 | 53.8 | 39.2 | 62.5 | 52 | 63.0 | 52.2 | 53.8 | 39.2 | 64.5 | 55 | 64.9 | 55.1 | 53.8 | 39.2 | 64.5 | 55 | 64.9 | 55.1 |
| NQ14 | 54.8 | 42.8 | 62.5 | 52 | 63.2 | 52.5 | 54.8 | 42.8 | 64.6 | 55.1 | 65.0 | 55.3 | 54.8 | 42.8 | 64.6 | 55.1 | 65.0 | 55.3 |
| NQ15 | 50.3 | 41.4 | 61.9 | 51.4 | 62.2 | 51.8 | 50.3 | 41.4 | 63.9 | 54.4 | 64.1 | 54.6 | 50.3 | 41.4 | 63.9 | 54.4 | 64.1 | 54.6 |
| NQ16 | 52.1 | 40.8 | 67.6 | 57.1 | 67.7 | 57.2 | 52.1 | 40.8 | 69.6 | 60.1 | 69.7 | 60.2 | 52.1 | 40.8 | 69.6 | 60.1 | 69.7 | 60.2 |
| NQ17 | 53.3 | 43.5 | 65.7 | 55.2 | 65.9 | 55.5 | 53.3 | 43.5 | 67.7 | 58.2 | 67.9 | 58.3 | 53.3 | 43.5 | 67.7 | 58.2 | 67.9 | 58.3 |
| NQ18 | 52.9 | 39.7 | 65.6 | 55.1 | 65.8 | 55.2 | 52.9 | 39.7 | 67.6 | 58.1 | 67.7 | 58.2 | 52.9 | 39.7 | 67.6 | 58.1 | 67.7 | 58.2 |
| NQ19 | 51.8 | 42.9 | 66.3 | 55.8 | 66.5 | 56.0 | 51.8 | 42.9 | 68.3 | 58.8 | 68.4 | 58.9 | 51.8 | 42.9 | 68.3 | 58.8 | 68.4 | 58.9 |
| NQ20 | 52.5 | 41.6 | 68.7 | 58.2 | 68.8 | 58.3 | 52.5 | 41.6 | 70.7 | 61.2 | 70.8 | 61.2 | 52.5 | 41.6 | 70.7 | 61.2 | 70.8 | 61.2 |
| NQ21 | 53.5 | 43.9 | 61.6 | 51.1 | 62.2 | 51.9 | 53.5 | 43.9 | 63.6 | 54.1 | 64.0 | 54.5 | 53.5 | 43.9 | 63.6 | 54.1 | 64.0 | 54.5 |
| NQ22 | 51.9 | 41.8 | 68 | 57.5 | 68.1 | 57.6 | 51.9 | 41.8 | 70 | 60.5 | 70.1 | 60.6 | 51.9 | 41.8 | 70 | 60.5 | 70.1 | 60.6 |

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| Noise Location | 2025 in dB(A) | | | | | | 2031 in dB(A) | | | | | | 2041 in dB(A) | | | | | |
|----------------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|
| | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | |
| | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN |
| NQ23 | 53.8 | 43.6 | 70 | 59.5 | 70.1 | 59.6 | 53.8 | 43.6 | 72 | 62.5 | 72.1 | 62.6 | 53.8 | 43.6 | 72 | 62.5 | 72.1 | 62.6 |
| NQ24 | 52.9 | 40.5 | 71.8 | 61.2 | 71.9 | 61.2 | 52.9 | 40.5 | 73.8 | 64.3 | 73.8 | 64.3 | 52.9 | 40.5 | 73.8 | 64.3 | 73.8 | 64.3 |

Table 8.47. Corridor 4 - Cumulative Noise Estimation for Baseline Noise Monitoring locations (with barrier)

| Noise Location | 2025 in dB(A) | | | | | | 2031 in dB(A) | | | | | | 2041 in dB(A) | | | | | |
|----------------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|
| | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | |
| | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN |
| NQ1 | 51.2 | 39.6 | 64.9 | 54.4 | 65.1 | 54.5 | 51.2 | 39.6 | 66.9 | 57.4 | 67.0 | 57.5 | 51.2 | 39.6 | 66.9 | 57.4 | 67.0 | 57.5 |
| NQ2 | 52.8 | 42.7 | 67.5 | 57 | 67.6 | 57.2 | 52.8 | 42.7 | 69.6 | 60.1 | 69.7 | 60.2 | 52.8 | 42.7 | 69.6 | 60.1 | 69.7 | 60.2 |
| NQ3 | 51.6 | 43.9 | 62.7 | 52.2 | 63.0 | 52.8 | 51.6 | 43.9 | 64.7 | 55.2 | 64.9 | 55.5 | 51.6 | 43.9 | 64.7 | 55.2 | 64.9 | 55.5 |
| NQ4 | 53.1 | 42.8 | 63.6 | 53 | 64.0 | 53.4 | 53.1 | 42.8 | 65.6 | 56.1 | 65.8 | 56.3 | 53.1 | 42.8 | 65.6 | 56.1 | 65.8 | 56.3 |
| NQ5 | 52.4 | 41.6 | 62.6 | 52.1 | 63.0 | 52.5 | 52.4 | 41.6 | 64.6 | 55.1 | 64.9 | 55.3 | 52.4 | 41.6 | 64.6 | 55.1 | 64.9 | 55.3 |
| NQ6 | 51.7 | 41.2 | 65.2 | 54.6 | 65.4 | 54.8 | 51.7 | 41.2 | 67.2 | 57.7 | 67.3 | 57.8 | 51.7 | 41.2 | 67.2 | 57.7 | 67.3 | 57.8 |
| NQ7 | 50.6 | 43.5 | 57.2 | 46.7 | 58.1 | 48.4 | 50.6 | 43.5 | 59.3 | 49.8 | 59.8 | 50.7 | 50.6 | 43.5 | 59.3 | 49.8 | 59.8 | 50.7 |
| NQ8 | 52.2 | 42.6 | 69.5 | 59 | 69.6 | 59.1 | 52.2 | 42.6 | 71.6 | 62.1 | 71.6 | 62.1 | 52.2 | 42.6 | 71.6 | 62.1 | 71.6 | 62.1 |
| NQ9 | 53.7 | 41.9 | 64.6 | 54.1 | 64.9 | 54.4 | 53.7 | 41.9 | 66.6 | 57.1 | 66.8 | 57.2 | 53.7 | 41.9 | 66.6 | 57.1 | 66.8 | 57.2 |
| NQ10 | 54.8 | 40.9 | 66.4 | 55.9 | 66.7 | 56.0 | 54.8 | 40.9 | 68.4 | 58.9 | 68.6 | 59.0 | 54.8 | 40.9 | 68.4 | 58.9 | 68.6 | 59.0 |
| NQ11 | 52.5 | 41.2 | 61.7 | 51.2 | 62.2 | 51.6 | 52.5 | 41.2 | 63.8 | 54.3 | 64.1 | 54.5 | 52.5 | 41.2 | 63.8 | 54.3 | 64.1 | 54.5 |
| NQ12 | 53.4 | 40.6 | 67.6 | 57 | 67.8 | 57.1 | 53.4 | 40.6 | 69.6 | 60.1 | 69.7 | 60.1 | 53.4 | 40.6 | 69.6 | 60.1 | 69.7 | 60.1 |
| NQ13 | 53.8 | 39.2 | 62.5 | 51.9 | 63.0 | 52.1 | 53.8 | 39.2 | 64.5 | 55 | 64.9 | 55.1 | 53.8 | 39.2 | 64.5 | 55 | 64.9 | 55.1 |
| NQ14 | 54.8 | 42.8 | 62.5 | 52 | 63.2 | 52.5 | 54.8 | 42.8 | 64.5 | 55 | 64.9 | 55.3 | 54.8 | 42.8 | 64.5 | 55 | 64.9 | 55.3 |
| NQ15 | 50.3 | 41.4 | 61.9 | 51.4 | 62.2 | 51.8 | 50.3 | 41.4 | 63.9 | 54.4 | 64.1 | 54.6 | 50.3 | 41.4 | 63.9 | 54.4 | 64.1 | 54.6 |
| NQ16 | 52.1 | 40.8 | 67.6 | 57.1 | 67.7 | 57.2 | 52.1 | 40.8 | 69.6 | 60.1 | 69.7 | 60.2 | 52.1 | 40.8 | 69.6 | 60.1 | 69.7 | 60.2 |

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| Noise Location | 2025 in dB(A) | | | | | | 2031 in dB(A) | | | | | | 2041 in dB(A) | | | | | |
|----------------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|---------------|------|-----------|------|------------|------|
| | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | | Baseline | | Predicted | | Cumulative | |
| | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN | LrD | LrN |
| NQ17 | 53.3 | 43.5 | 65.7 | 55.2 | 65.9 | 55.5 | 53.3 | 43.5 | 67.7 | 58.2 | 67.9 | 58.3 | 53.3 | 43.5 | 67.7 | 58.2 | 67.9 | 58.3 |
| NQ18 | 52.9 | 39.7 | 65.6 | 55.1 | 65.8 | 55.2 | 52.9 | 39.7 | 67.6 | 58.1 | 67.7 | 58.2 | 52.9 | 39.7 | 67.6 | 58.1 | 67.7 | 58.2 |
| NQ19 | 51.8 | 42.9 | 66.3 | 55.8 | 66.5 | 56.0 | 51.8 | 42.9 | 68.3 | 58.8 | 68.4 | 58.9 | 51.8 | 42.9 | 68.3 | 58.8 | 68.4 | 58.9 |
| NQ20 | 52.5 | 41.6 | 68.7 | 58.2 | 68.8 | 58.3 | 52.5 | 41.6 | 70.8 | 61.3 | 70.9 | 61.3 | 52.5 | 41.6 | 70.8 | 61.3 | 70.9 | 61.3 |
| NQ21 | 53.5 | 43.9 | 61.6 | 51.1 | 62.2 | 51.9 | 53.5 | 43.9 | 63.6 | 54.1 | 64.0 | 54.5 | 53.5 | 43.9 | 63.6 | 54.1 | 64.0 | 54.5 |
| NQ22 | 51.9 | 41.8 | 68 | 57.5 | 68.1 | 57.6 | 51.9 | 41.8 | 70 | 60.5 | 70.1 | 60.6 | 51.9 | 41.8 | 70 | 60.5 | 70.1 | 60.6 |
| NQ23 | 53.8 | 43.6 | 70 | 59.5 | 70.1 | 59.6 | 53.8 | 43.6 | 72 | 62.5 | 72.1 | 62.6 | 53.8 | 43.6 | 72 | 62.5 | 72.1 | 62.6 |
| NQ24 | 52.9 | 40.5 | 71.8 | 61.2 | 71.9 | 61.2 | 52.9 | 40.5 | 73.8 | 64.3 | 73.8 | 64.3 | 52.9 | 40.5 | 73.8 | 64.3 | 73.8 | 64.3 |

Table 8.48. Predicted Noise on Environmental Sensitive Receptor Building Façade for Corridor 4 Right Hand Side

| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | Length and Height of CW Parallel to the Railway (m) if any | 2025 | | | 2031 | | | 2041 | | | With Barrier-2025 | | | Without Barrier-2025 | | | With Barrier-2031 | | | Without Barrier-2031 | | | With Barrier-2041 | | | Without Barrier-2041 | | |
|---------|---------------------------------|---|-------------------------------------|---------------------------|----------------------------|--|------|------|------|------|------|------|------|------|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN |
| 1 | 190+400 | Silkworm Seed Technology Laboratory, Kodathi. | 20 | 45 | 9 | 100x2.5x0.2 | 72.6 | 66.4 | 69.5 | 73.6 | 67.4 | 70.5 | 74.9 | 68.7 | 71.8 | 31.0 | 26 | 28.6 | 45.6 | 39 | 42.5 | 31.8 | 27 | 29.4 | 46.6 | 40 | 43.5 | 32.9 | 28 | 30.4 | 47.9 | 42 | |
| 2 | 191+050 | College | 25 | 30 | 4 | 70x2x0.5 | 72.6 | 66.4 | 69.5 | 73.6 | 67.4 | 70.5 | 74.9 | 68.7 | 71.8 | 34.6 | 30 | 32.1 | 49.1 | 43 | 46.0 | 35.4 | 30 | 32.9 | 50.1 | 44 | 47.0 | 36.4 | 31 | 33.9 | 51.4 | 45 | |
| 3 | 197/790 | Smile Dental Care, Munnekollal, Marathahalli. | | 20 | 14 | - | 72.6 | 66.4 | 69.5 | 73.6 | 67.4 | 70.5 | 74.9 | 68.7 | 71.8 | 38.1 | 33 | 35.6 | 52.6 | 46 | 49.5 | 38.9 | 34 | 36.4 | 53.6 | 47 | 50.5 | 39.9 | 35 | 37.4 | 54.9 | 49 | |
| 4 | 198/580 | Lions Airport city Hospital, Munnekollal, Marathahalli. | 22 | 30 | 10 | 20x1.5x0.4 | 72.6 | 66.4 | 69.5 | 73.6 | 67.4 | 70.5 | 74.9 | 68.7 | 71.8 | 34.6 | 30 | 32.1 | 49.1 | 43 | 46.0 | 35.4 | 30 | 32.9 | 50.1 | 44 | 47.0 | 36.4 | 31 | 33.9 | 51.4 | 45 | |
| 5 | 199/290 | Kids Mansion School, Chinnappanahalli. | 15 | 18 | 9 | 25x2.5x0.3 | 72.6 | 66.4 | 69.5 | 73.6 | 67.4 | 70.5 | 74.9 | 68.7 | 71.8 | 39.0 | 34 | 36.5 | 53.5 | 47 | 50.4 | 39.8 | 35 | 37.3 | 54.5 | 48 | 51.4 | 40.8 | 36 | 38.4 | 55.8 | 50 | |

Table 8.49. Predicted Noise on Environmental Sensitive Receptor Building Façade for Corridor 4 Left Hand Side

| Sl. No. | Indian Railway Chainage in (km) | Name of Envi. Feature | Distance from the Ex. Railway Track | | | Length and Height of CW Parallel to the Railway (m) if any | 2025 | | | 2031 | | | 2041 | | | With Barrier-2025 | | | Without Barrier-2025 | | | With Barrier-2031 | | | Without Barrier-2031 | | | With Barrier-2041 | | | Without Barrier-2041 | | |
|---------|---------------------------------|---|-------------------------------------|---------------------------|----------------------------|--|------|------|------|------|------|------|------|------|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|-------------------|-----|------|----------------------|-----|------|
| | | | To Compound Wall (m) | To the first Building (m) | Height of the building (m) | | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN | LrD | LrN | LrDN |
| 1 | 182+800 | Bangalore college of Engineering, Heelalige, Bommasandra. | 40 | 50 | 15 | 160x3x0.1 | 72.6 | 66.4 | 69.5 | 73.6 | 67.4 | 70.5 | 74.9 | 68.7 | 71.8 | 30.1 | 25 | 27.6 | 44.6 | 38 | 41.5 | 30.9 | 26 | 28.4 | 45.6 | 39 | 42.5 | 32.0 | 27 | 29.5 | 46.9 | 41 | 4 |
| 2 | 184+100 | School | 20 | 25 | 10 | 50x2x0.2 | 72.6 | 66.4 | 69.5 | 73.6 | 67.4 | 70.5 | 74.9 | 68.7 | 71.8 | 36.1 | 31 | 33.7 | 50.7 | 44 | 47.6 | 36.9 | 32 | 34.5 | 51.7 | 45 | 48.6 | 38.0 | 33 | 35.5 | 53.0 | 47 | 4 |
| 3 | 203+050 | Dental Hospital | 20 | 22 | 15 | 20x1.5x0.2 | 72.6 | 66.4 | 69.5 | 73.6 | 67.4 | 70.5 | 74.9 | 68.7 | 71.8 | 37.3 | 32 | 34.8 | 51.8 | 46 | 48.7 | 38.1 | 33 | 35.6 | 52.8 | 47 | 49.7 | 39.1 | 34 | 36.6 | 54.1 | 48 | 5 |
| 4 | 23+100 | Sai Speciality Center, Hospital East of NGEF Layout, Kasturi Nagar. | - | 10 | 15 | - | 72.6 | 66.4 | 69.5 | 73.6 | 67.4 | 70.5 | 74.9 | 68.7 | 71.8 | 44.1 | 39 | 41.6 | 58.6 | 52 | 55.5 | 44.9 | 40 | 42.4 | 59.6 | 53 | 56.5 | 45.9 | 41 | 43.5 | 60.9 | 55 | 5 |
| 5 | 15+650 | Dental Health Center | - | 10 | 5 | - | 72.6 | 66.4 | 69.5 | 73.6 | 67.4 | 70.5 | 74.9 | 68.7 | 71.8 | 44.1 | 39 | 41.6 | 58.6 | 52 | 55.5 | 44.9 | 40 | 42.4 | 59.6 | 53 | 56.5 | 45.9 | 41 | 43.5 | 60.9 | 55 | 5 |
| 6 | 18+100 | Masjid | 10 | 11 | 10 | 10x2.5x0.2 | 72.6 | 66.4 | 69.5 | 73.6 | 67.4 | 70.5 | 74.9 | 68.7 | 71.8 | 43.3 | 38 | 40.8 | 57.8 | 52 | 54.7 | 44.1 | 39 | 41.6 | 58.8 | 53 | 55.7 | 45.1 | 40 | 42.6 | 60.1 | 54 | 5 |

Since, noise level is beyond the permissible limits of Noise standards for sensitive receptor for day and night time, solid concrete noise barriers are provided wherever existing compound wall are there and at places where sufficient land available to erect new concrete walls. Chainage wise details of solid concrete noise barriers proposed for each corridor is given in Table 8.51. At receptors where there is no existing compound walls such as clinics in a shop facing roads, backside of the few educational institutes/health center on railway land, etc., noise measures shall be undertaken in due consultation with Indian railway officials and land owners during pre-construction stage. Project proponent need to monitor the noise environment at these locations before erecting the solid noise barriers during operation.

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Mitigation Measures: The impact of project on noise level during the construction period will be mainly due to operation of machinery/equipment at plant sites and construction sites; and transportation of vehicles. Noise control measures during construction will be required to minimize noise levels on existing noise-sensitive land uses. All construction activities will have to comply with Noise Pollution (Regulation and Control) Rules, 2000 & amendments and ESS 3 of World Bank and EIB Standards 1 & 3. Night time work could require a variance for local noise regulations.

The increase in noise levels varies from marginal to moderate impact; hence local population will not be adversely affected. Noise level mitigation will be achieved by following control measures:

- Source Control : Each internal combustion engine used for any purpose on the project or related to the project will be equipped with a muffler of a type recommended by the manufacturer. No internal combustion engine will be operated without a muffler.
- All Construction plants and equipment used in construction shall strictly conform to the MoEF&CC/CPCB noise standards.
- All Vehicles and equipment used in construction shall be fitted with exhaust silencers.
- Construction of permanent and temporary noise barriers; and natural and artificial barriers could be considered for use as shielding against construction noise. Strategic placement of stationary equipment, such as compressors and generators, could reduce effects at sensitive receivers.
- A main source of noise shall be controlled by Re-routing and regulating the traffic,
- Electric equipment shall be used instead of diesel powered equipment,
- Hydraulic tools shall be used instead of pneumatic tools,
- Provision of acoustic enclosures : Acoustic enclosures shall be provided for individual noise generating construction equipment. Special acoustic enclosures should be provided for individual noise generating equipment, wherever possible. Workers in those sections where periodic adjustment of equipment/machinery is necessary, shall be provided with sound proof control rooms so that exposure to higher noise level is reduced.
- Scheduling of truck loading, unloading and hauling operation,
- In Loading and un-loading areas with machinery noise muffles, etc. and personal protective gear shall be provided to workers.
- Maintenance of vehicles, equipment and machinery shall be regular and up to the satisfaction of the Environmental Specialist of GC to keep noise levels at the minimum. Proper operation and maintenance of the construction vehicles and equipment would keep them within noise limit,
- Servicing of all construction vehicles and machinery shall be done regularly and during routine servicing operations, the effectiveness of exhaust silencers shall be checked and if found defective shall be replaced,
- Job rotation - Shifting of workers to the extent possible from high noise level area to low noise level areas and vice-versa from time to time avoid the workers to get impacted due to continuous exposure to high level noise,
- Scheduling work to avoid simultaneous activities,

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- Automation of equipment and machineries - Wherever possible the Automation of equipment and machineries shall be applied to avoid continuous exposure of workers to noise. If automation of machineries is not possible or feasible, then the workers exposed to noise shall be provided with protective devices.
- Related Noise Control Measures – The following noise control measures shall be undertaken:
 - Use of Anti-drumming floor and noise absorption material,
 - Use of Low speed compressor, blower and air conditioner,
 - Mounting of under frame equipment on anti-vibration pad,
 - Provision of Smooth and gradual control of door,
 - Provision of GRP baffle on the via-duct for elimination of noise transmission,
 - Provision of sound absorbing material in the supply duct and return grill of air conditioner,
 - Sealing design to reduce the aspiration of noise through the gap in the sliding doors and piping holes,
- Noise reduction from various sources - The noise reduction from various sources is possible with the following effective measures during the construction period:
 - The noise from air compressor can be reduced by fitting exhaust and intake mufflers.
 - Noise proof barriers will be provided on the construction boundary near the residential area.
 - Noise level from loading and unloading of construction materials can be reduced by usage of various types of cranes and placing materials on sand or sandy bag beds.
- Alternate Construction Methods – During pile driving activity increase in noise levels is anticipated even when noise mitigation measures are implemented, however, noise levels will be within acceptable limits. During these activities, alternate methods of construction may be applied to reduce noise Risks and Impacts. Vibratory or hydraulic insertion may be used for pile driving, depending on a variety of factors. Drilling holes for cast-in-place piles is an alternative construction method that may produce significantly lower level noise.
- Management of Time Schedule and Activity Constraints - Noisier activities involving large machinery will be limited to daytime hours as practical, when most people normally get affected are either not present or engaged in less noise-sensitive activities. Night time construction will require a variance. Compliance with local noise ordinances would mitigate effects associated with construction noise. To comply with these ordinances, all construction activities adjacent to residential uses will be limited to day time hours (7:00 A.M. to 6:00 P.M.) from Monday to Saturday.
- The contractor shall comply with standard specifications and all local sound control and noise level rules, regulations, and ordinances that apply to any work performed pursuant to the contract.

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- At the construction sites within 150 m of the nearest habitation, noisy construction work such as crushing, operation of DG sets, use of high noise generation equipment shall be stopped during the night time between 10.00 pm to 6.00 am. Working hours of the construction activities shall be restricted around educational institutions/Health Centers (silent zones) up to a distance of 100 m from the sensitive receptors i.e., School, Health Centers and Hospitals etc.
- Environmental Sensitive Receptors - At sensitive receptors where there is no existing compound walls such as health centres/clinics and educational institutions facing roads, backside of the few educational institutes/health center on railway land, etc., noise measures shall be undertaken in due consultation with Indian railway officials and land owners prior to the commencement of construction activities and the commencement of activities will be informed to the public in advance by erecting precautionary direction and safety boards.
- With respect to occupational exposure, noise generating construction activities shall be restricted to a distance of 125 m away from all the sensitive receptors such as educational institutions and Health Centers (silent zones); also including labour camps.
- At construction sites within 150m of sensitive receptors construction will be stopped from 22:00 to 06:00.
- Noise barriers (Stone walls and plantation) for silence zones including schools and hospitals, noise barriers at sharp curves.
- Noise monitoring shall be carried out at the locations specified in monitoring plan by the K RIDE and the Engineer through the approved monitoring agency.
- Contractor shall provide noise barriers to the suggested locations of educational Institutions & health centers. List of locations for noise barriers is given in **Table 8.43** of Section 8.6.1.2. Guidelines for provision of Noise Barrier are provided as **Annexure 10.14**.

The project will implement above mentioned Noise Mitigation Measures and thus, comply with the Indian regulations and WBESF guidelines.

Residual impact: With proper implementation of the proposed mitigation measures the residual impact will be minor to moderate, some level of noise due to construction activities will likely be unavoidable. Impacts will be local and temporary and are therefore considered to be acceptable as long as every effort has been taken to prevent these impacts.

8.7.1.2. Airborne noise impact and prediction

Airborne noise is radiated from at-grade and elevated structures. During the operation phase, the main source of noise will be from running of Suburban trains. Basic sources of wayside airborne noise are:

- Wheel / Rail Noise : Due to wheel /rail roughness
- Propulsion Equipment: Traction motors, cooling fans for TM, reduction gears etc.
- Auxiliary Equipment: Compressors, motor generators, brakes, ventilation systems, other car mounted equipment

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

8.7.1.3. Noise Impact on Sensitive Receptors

Noise impact on sensitive receptors along the project corridors are modelled and given at Section 8.7.1.2. Background noise levels at the receptor are considered as noise levels of the nearest baseline noise monitoring location. The analysis of the results indicates the following:

- The cumulative noise levels at all these receptors are exceeding the permissible limits issued by CPCB and IFC.
- Noise impact criteria on these receptors is categorised as follows.
- No Impact - difference between baseline noise levels and cumulative noise levels are less than 3 dB (A)
- Severe Impact - difference between baseline noise levels and cumulative noise levels are less than 3 dB (A)

Mitigation Measures : Following noise mitigation measures need to be provided wherever noise impact criteria are severe at the receptors.

- During operation of Suburban rails at elevated stretches the use of ballast-less track with elastic and absorbent fittings is a standard provision for noise control.
- The use of green belt with vegetation of thick foliage at Depots and stations act as noise screeners and helps to reduce noise;
- Wherever site layout permits, barrier blocks of less-vulnerable buildings may be used.
- Alternatively solid noise barrier walls may also be built (Manual on norms and standards for environment clearance of large construction projects, MoEFCC, 2007).
- Screening of noise shall be ensured by providing parabolic noise barriers on each side of the track along the curved portion of the viaduct and at sensitive receptors during operation. Polycarbonate noise barriers 15mm to 25 mm thick are known to reduce noise level by 30dB.
- Required solid Noise barriers as given below shall be erected and shall be maintained.
- Corridor 1 : Noise Barrier proposed for a length of 545 m
- Corridor 2 : Noise Barrier proposed for a length of 1161 m
- Corridor 3 : Noise Barrier proposed for a length of 937 m
- Corridor 4 : Noise Barrier proposed for a length of 415 m
- During operation of suburban rails, solid noise barriers are proposed at sharp curved portions, structures falling within 20m distance from the alignment and at sensitive receptors like educational institutions and hospitals where noise impact criteria is severe. The noise barriers are provided wherever existing compound wall are there and at places where sufficient land

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available to erect new concrete walls. At receptors where there is no existing compound walls such as clinics in a shop facing roads, backside of the few educational institutes/health center on railway land, etc., noise measures shall be undertaken in due consultation with Indian railway officials and land owners during pre-construction stage. Details of solid concrete noise barriers proposed for each corridor is given in **Table 8.50**. Project proponent need to monitor the noise environment at these locations before erecting the solid noise barriers during operation.

Residual Impacts: Minor impacts predicted, however, no adverse impacts on ecosystem is anticipated.

Table 8.50. Details of Noise Barriers at Environmental Sensitive Receptor Locations

| Ex. Chainage in m | | Total Length of Barrier in m | Side | Remarks |
|--|---------|------------------------------|------|---|
| From | To | | | |
| Corridor I: KSR Bengaluru City to Devanahalli | | | | |
| 2/100 | 2/140 | 40 | RHS | New Clinton Public High School, Srirampura. |
| 3/200 | 3/270 | 70 | RHS | Cluny Convent High School Malleshwaram |
| 3/100 | 3/200 | 200 | RHS | Nitte Global Institute, Yelahanka. |
| 3/150 | 3/220 | 70 | RHS | Hostel, Nitte Global Institute, Yelahanka. |
| 10/000 | 10/100 | 100 | RHS | Sri Revana Siddeswara Institute of Technology, Chokkanahalli, Chikkajala. |
| 2/770 | 2/820 | 50 | RHS | Manipal Hospital, Malleshwaram. |
| 13/500 | 13/515 | 15 | RHS | Dental Clinic, Kodigehalli. |
| Corridor 2: Baiyyappanahalli Terminal to Chikkabanavara | | | | |
| 205/360 | 205/396 | 36 | LHS | Government Higher Primary School, Benniganahalli. |
| 205/780 | 205/810 | 30 | LHS | Little Angels Modern High School, NGEF Layout, Sadananda Nagar, Benniganahalli. |
| 210/600 | 210/660 | 60 | LHS | Eunice English Medium High School, Thomas Town, Lingarajapuram, Bengaluru. |
| 210/650 | 210/680 | 30 | LHS | Manahil English High School, Kadugondanahalli. |
| 213/250 | 213/280 | 30 | LHS | Beacon English High School, 1st main Road, Shampura, Kaval Bairasandra. |
| 213/640 | 213/670 | 30 | LHS | School, Kaval Bairasandra. |
| 214/380 | 214/410 | 30 | LHS | BIG Institute of Managerial |
| 215/500 | 215/520 | 20 | LHS | Government School |
| 216/900 | 217/000 | 10 | LHS | Hebbal Agriculture School |
| 14/900 | 14/920 | 20 | LHS | Ashwin Vidyalaya, 4th cross Road, Ramakrishna Gardens, Sundar Nagar, Gokula Extension, Mathikere. |
| 16/150 | 16/220 | 70 | LHS | P.R Public School, Mohankumar Nagar, Yeshwanthpur. |
| 23/460 | 23/510 | 50 | LHS | Cecilia English Nursery & High School, Maruthi Seva Nagar. |
| 204/890 | 204/960 | 70 | RHS | New Pratham Public School, Mahadevapura. |

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| Ex. Chainage in m | | Total Length of Barrier in m | Side | Remarks |
|---|---------|------------------------------|------|---|
| From | To | | | |
| 210/710 | 210/810 | 100 | RHS | Siddhartha PU College, 7th Cross Lingarajapura Hennur Main Road. |
| 214/680 | 214/880 | 200 | RHS | St Pauls Public School and Apartment, Arabic college Road, Jogappa Layout Nagavara. |
| 23/700 | 23/730 | 20 | RHS | R.R Institute college |
| 23/900 | 23/930 | 30 | RHS | National Public School, Chikkabanavara. |
| 206/400 | 206/425 | 25 | RHS | NMT Elder Care J P Nagar. |
| 18/740 | 19/040 | 300 | RHS | Government hospital |
| Corridor 3: Kengeri to Whitefield (via KSR and Cantonment) | | | | |
| 12/700 | 12/730 | 30 | LHS | Government, High School and First Grade College, Kengeri. |
| 11/470 | 11/500 | 30 | LHS | National Public School, Kengeri Satellite Town. |
| 2/130 | 2/480 | 350 | LHS | Roses Convent School, Binnipete, Kempapura. |
| 350/390 | 350/420 | 30 | LHS | MQI Degree College, Benson Town. |
| 349/220 | 349/290 | 70 | LHS | Clerence High School, Rechards Town. |
| 5/150 | 5/225 | 75 | LHS | Ananya Hospital |
| 353/890 | 353/990 | 100 | LHS | Star Health Allied |
| 353/680 | 353/720 | 40 | LHS | Eye Hospital and Squite Centre. |
| 348/770 | 348/815 | 45 | LHS | Medico Petrol Association Center for Mental Health |
| 347/600 | 347/610 | 10 | LHS | Jeevan Clinic jeevanahalli |
| 10/400 | 10/430 | 30 | RHS | Orchids School, Mysore Road, Kengeri satellite Town. |
| 10/300 | 10/350 | 50 | RHS | Bengaluru Institute of Management, Mysore Road, Kengeri Satellite Town. |
| 8/150 | 8/170 | 20 | RHS | College |
| 5/860 | 5/872 | 12 | RHS | Government Urdu Primary School, Roshan Nagar. |
| 348/540 | 348/545 | 5 | RHS | Government Primary School, Pulikeshi Nagar |
| 339/250 | 339/270 | 20 | RHS | The Brigade School, Mahadevapura. |
| 349/570 | 349/590 | 20 | RHS | City Multi Speciality and Trauma Centre, Hospital, Pulikeshi Nagar. |
| Corridor 4: Heelalige to Rajanukunte | | | | |
| 182/800 | 182/960 | 160 | LHS | Bangalore college of Engineering, Heelalige, Bommasandra. |
| 184/100 | 184/150 | 50 | LHS | Norwich High School sampigenagara to Ramanagar mainroad Ramasagara, Electronics city Bengaluru. |
| 180/600 | 180/645 | 45 | LHS | Athreya Hospital Anekal Main Road, Suryanagar phase 1. |
| 203/050 | 203/070 | 20 | LHS | Smiles Dental Care, C V Raman Nagar, Kaggadasapur |
| 191/050 | 191/120 | 70 | RHS | College Chikkakanneli |

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| Ex. Chainage in m | | Total Length of Barrier in m | Side | Remarks |
|-------------------|---------|------------------------------|------|--|
| From | To | | | |
| 199/290 | 191/315 | 25 | RHS | Kids Mansion School, Chinnappanahalli. |
| 202/400 | 202/425 | 25 | RHS | Geethanjali Vidyalaya & Montress, Kaggadaspura. |
| 198/580 | 198/600 | 20 | RHS | Lions Airportcity Hospital, Munnekollal, Marathahalli. |

8.7.2. Risks & Impacts on Vibration

Ground vibrations by railway traffic are generated by two prime excitation mechanisms (i) the quasi-static displacement caused by the axle load as the wheel moves along the track, and (ii) the inertia forces due to the acceleration of the unsprung mass of the train as it rolls over the irregular profile of the railhead. Rail irregularity profiles, have generally an erratic nature. Therefore, the associated ground vibrations tend to display a stochastic character.

Vibration levels reveal that most of the receptor locations fall within vibration damage threshold criteria.

Mitigation Measures : Vibration monitoring and building condition surveys at sensitive structures shall be implemented, as per requirement in line with WB's ESS 3 and EIB ESS 3. The proper maintenance of track and rolling stock during operation helps in controlling vibration. The vibration level can be significantly reduced by incorporating the following standard measures/factors:

- Vehicles with No stiff primary suspension
- No Worn or Wheel with flats
- No Worn/Corrugated Track
- With Floor-to-Floor Attenuation in receptor buildings

In case of ballast less track, the following are some measures for vibration damping:

- Use of Resilient soft base plates between rail and track slab;
- Use of Resilient rubber between the base plate and track slab;
- Application of Soft elastic fastening system and
- Deep and narrow trenches in the ground shall be tested at vibration-sensitive structures.

The project will implement the above mentioned Noise and Vibration mitigation measures and thus, comply with the Indian regulations and WBESF guidelines.

8.7.3. Risks & Impacts on Track Side Vegetation

Vegetation (shrubs, climbers and small trees) may be developed and spread along the proposed BSRP tracks. Vegetation including trees and bushes will become a danger to passing trains. The leaves they drop are also the cause of low rail adhesion.

Mitigation Measures: At present, manual clearing of vegetation along the railway tracks is practiced by Indian Railway. It is proposed to adopt same method to clear the vegetation for BSRP. Vegetation (shrubs, climbers and small trees) along the proposed BSRP tracks will be cleared manually without using any weedicide and herbicides.

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Residual Impacts: No negative impact on ecosystem is anticipated.

8.7.4. Energy Consumption at Stations and Efficiency

Electricity is required at stations for facilities like lighting, passenger information, access, security, climate control, escalators/elevators etc. Proper utilization of electricity shall be made at stations in need.

8.7.5. Electro-Magnetic Compatibility

The railway project and its operating systems have been so designed to address concerns on Electro Magnetic Compatibility (EMC) and Electro Magnetic Interference (EMI). EMC is an issue that is mitigated through the application of EMC industry accepted practice during design and installation of the system, and these conform to the limits provided by the International Commission on Non-Ionizing Radiation Protection (ICNIRP 1998 guidelines). This limits the minimal effects of EMI to the environment.

8.7.6. Risks & Impacts on Ground Water

No impact on ground water is predicted. However, K RIDE shall implement Rain Water Harvesting Methods in line with WB ESS 1, 3 and 6, to augment storage of ground water. It is proposed to construct rainwater harvesting unit/structure of suitable capacity at the elevated stations and at the elevated alignment. Each pillar can have inbuilt downpipes to collect the rainwater from the viaduct and lead in to underground tanks; water collected will percolate down to the subsoil through layers of sand and gravel.

Average annual rainfall of Bengaluru is 1200 mm. Rainwater harvesting shall be carried out for Ground water recharge at each stations – at grade and elevated stations at each corridor. Total 100 numbers of Recharge Units for Corridor 1, 65 units for Corridor 2, 51 units for Corridor 3; and 114 units for Corridor 4 are proposed. The cost estimated is ₹ 94.7 Lakhs for Corridor 1, ₹ 61.56 Lakhs for Corridor 2 and ₹ 48.30 Lakhs for Corridor 3; and ₹ 108.4 Lakhs for Corridor 4.

Residual Impacts: No negative impacts are predicted on ecosystem.

8.7.7. Risks & Impacts due to Depots and Stations

The land for establishing the depots is at Akkupete (13°14'50.40"N & 77°41'26.37"E) and Soledivanahalli (13° 5'15.65"N & 77°29'34.64"E). It is proposed to mobilize the Akkupete land of about 18.6 Ha and 9.3 Ha for Soledivanahalli depot. The cost of the land is not considered as it is owned by the government depts.

Akkupete depot in the Suburban Rail Corridor 1 will be of about 18.6 Ha Acres /186000 Sqm, which needs to be diverted from Forest Department. Process obtaining depot lands from the respective department is in progress. The Depot lands are with local vegetation but without any habitat or human settlement. There will not be any major impacts on valued environmental component except tree felling due to construction of depots at these locations.

Further, two micro depots are also proposed along with Stations at Heelalige and Kengeri. Every train which ply through Corridor 3 and Corridor 4 are planned to undergo maintenance in a period of 3 days,

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15 days and 45 days' time. The total cost of dry run of all the trains to perform the above scheduled maintenance is works out to Rs 75 crore/year which is 25% of the yearly maintenance cost.

The station area will be leveled through cut and fill method, as per requirement. There will be totally 58 (5 stations between Bengaluru Cant. and Whitefield) Stations along the 4 Corridors of the Suburban railway network. Each Station will be with standard size of 205m in length and 26 m in width (5330 Sqm).

General Provisions accommodated in the proposed Micro Depots are;

- Air brake checking equipment,
- Pit Bay,
- Cat walk and
- Automatic Wash plan.

Following are the main facilities of project which will be provided at these Major Depots:

- Washing Lines,
- Operation and Maintenance Lines,
- Workshop,
- Offices and
- The depot area will be levelled through cut and fill method within the depot.

Following are the main facilities of Project which will be provided at each Station :

- Offices (Station Control Room, Station Master's Office, Information & Enquiries, Ticket Office, Passenger Office, etc.)
- Cleaner's Room
- Security Room
- First Aid Room
- Miscellaneous Operations Room
- Platform Supervisor's Booth
- Traction Substation
- Staff Area
- Fire Tank and Pump Room
- Staff Toilets
- Commercial Outlets and Kiosks
- Station Store Room
- UPS and Battery Room
- Refuse Store
- Signaling/Communication Room

Issues of Impacts at Depot and Stations

- Water supply

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- Effluent generation
- Solid Waste generation
- Oil Pollution
- Noise Pollution
- Surface drainage
- Loss of trees

Issues of impacts foreseen at stations are same except oil pollution and effluent treatment.

8.7.7.1. Risks & Impacts on Water Supply, Waste Water and Municipal Solid Waste (MSW) Disposal at Stations

The daily Ridership of Suburban Railways as predicted is given in Column no 3 for horizon years in **Table 8.51** to **Table 8.54**. The Corridor wise water demand at stations for drinking and toilet demands; and solid waste generation for passengers and staff will be of the order of magnitude as indicated in the following Tables (**Table 8.51** to **Table 8.54**) individually for all the 4 corridors - Corridor 1, Corridor 2, Corridor 3, Corridor 4, respectively and followed by summary in **Table 8.55**. The demand is estimated on the following assumptions:

- Alighting passenger for Year 2025, 2031 & 2041 as given in Feasibility Report are considered for the calculations.
- 15% of Alighting passengers at each station will use the toilets
- Water requirement for each user will be 5 lit/passenger/day
- 10% of Alighting passenger at each station will generate Solid Waste
- Solid Waste generation will be 100gm/passenger/day

The water demand during operation phase will be supplied by Bruhat Bengaluru Mahanagara Palike (BBMP). Daily sewage flow is considered as 90% of the water requirement at each station as given in the Table, which will be treated through Bio Digesters.

According to the CPCB regulations, railway stations generating waste water equal to or more than 100 KLD would be categorised as red, those greater than 10 KLD but less than 100 KLD would come under the orange category. Railway stations with less than 10 KLD waste water generation would be branded green category. As per estimation, the waste water generation per station is >10 KLD but < 100 KLD, as per CPCB regulations. Therefore, the project comes under Orange Category. The estimated details of Water Demand, Waste Water Generation and Solid Waste Generation are presented in the Tables (**Table 8.51** to **Table 8.54**) and summarized in **Table 8.55**. Graphical representation of Total Water Demand (KLD), Waste Water Generation (KLD), Solid Waste Generation (Kg) and consolidated for 4 Corridors are presented in **Figure 8.17** to **Figure 8.20**.

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Table 8.51. Water Demand, Waste Water and Municipal Solid Waste (MSW) for Corridor 1 (KSR Bengaluru City - Devanahalli)

| Sl. No. | Station Name | Water Demand (KLD) | | | Waste Water Generation (KLD) | | | Solid Waste Generation (Kg) | | |
|--------------|----------------------------|--------------------|-----------------|-----------------|------------------------------|----------------|----------------|-----------------------------|-----------------|-----------------|
| | | 2025 | 2031 | 2041 | 2025 | 2031 | 2041 | 2025 | 2031 | 2041 |
| 1 | KSR Bengaluru city | 203.975 | 258.870 | 336.065 | 27.537 | 34.947 | 45.369 | 407.950 | 517.740 | 672.130 |
| 2 | Srirampura | 79.050 | 96.125 | 115.800 | 10.672 | 12.977 | 15.633 | 158.100 | 192.250 | 231.600 |
| 3 | Malleswaram | 162.140 | 195.325 | 225.900 | 21.889 | 26.369 | 30.497 | 324.280 | 390.650 | 451.800 |
| 4 | Yeshwantpur | 167.810 | 193.140 | 243.500 | 22.654 | 26.074 | 32.873 | 335.620 | 386.280 | 487.000 |
| 5 | Muthyalanagar | 138.140 | 165.145 | 192.450 | 18.649 | 22.295 | 25.981 | 276.280 | 330.290 | 384.900 |
| 6 | Lottegolahalli | 259.315 | 319.735 | 415.510 | 35.008 | 43.164 | 56.094 | 518.630 | 639.470 | 831.020 |
| 7 | Kodigehalli | 171.025 | 239.205 | 300.280 | 23.088 | 32.293 | 40.538 | 342.050 | 478.410 | 600.560 |
| 8 | Judicial layout | 241.330 | 305.125 | 410.510 | 32.580 | 41.192 | 55.419 | 482.660 | 610.250 | 821.020 |
| 9 | Yelahanka | 215.545 | 292.990 | 439.510 | 29.099 | 39.554 | 59.334 | 431.090 | 585.980 | 879.020 |
| 10 | Nitte Meenakshi | 68.140 | 87.035 | 148.655 | 9.199 | 11.750 | 20.068 | 136.280 | 174.070 | 297.310 |
| 11 | Betalasuru | 11.640 | 18.385 | 36.195 | 1.571 | 2.482 | 4.886 | 23.280 | 36.770 | 72.390 |
| 12 | Doddajala | 102.885 | 173.845 | 305.320 | 13.889 | 23.469 | 41.218 | 205.770 | 347.690 | 610.640 |
| 13 | Airport Trumpet | 35.465 | 48.195 | 68.560 | 4.788 | 6.506 | 9.256 | 70.930 | 96.390 | 137.120 |
| 14 | Future Station @ Km 38/800 | 90 | 123.51 | 211.89 | 12.18 | 16.67 | 28.61 | 180.46 | 247.02 | 423.78 |
| 15 | Airport KIADB | 96.175 | 145.545 | 274.760 | 12.984 | 19.649 | 37.093 | 192.350 | 291.090 | 549.520 |
| 16 | Devanahalli | 84.280 | 101.470 | 149.020 | 11.378 | 13.698 | 20.118 | 168.560 | 202.940 | 298.040 |
| Total | | 2127.143 | 2763.643 | 3873.925 | 287.166 | 373.093 | 522.983 | 4254.285 | 5527.285 | 7747.850 |

Table 8.52. Water Demand, Waste Water and Municipal Solid Waste (MSW) for Corridor 2 (Baiyappanahalli - Chikkabanawar)

| Sl. No. | Station Name | Alighting Passengers | | | Water Demand (KLD) | | | Waste Water Generation (KLD) | | | Solid Waste Generation (Kg) | | |
|---------|--------------------------|----------------------|-------|-------|--------------------|---------|---------|------------------------------|--------|--------|-----------------------------|---------|---------|
| | | 2025 | 2031 | 2041 | 2025 | 2031 | 2041 | 2025 | 2031 | 2041 | 2025 | 2031 | 2041 |
| 1 | Baiyappanahalli Terminal | 12779 | 17714 | 23102 | 63.895 | 88.570 | 115.510 | 8.626 | 11.957 | 15.594 | 127.790 | 177.140 | 231.020 |
| 2 | Kasturi Nagar | 13657 | 15930 | 18016 | 68.285 | 79.650 | 90.080 | 9.218 | 10.753 | 12.161 | 136.570 | 159.300 | 180.160 |
| 3 | Sevanagar | 16282 | 21052 | 22740 | 81.410 | 105.260 | 113.700 | 10.990 | 14.210 | 15.350 | 162.820 | 210.520 | 227.400 |
| 4 | Banaswadi | 11486 | 12985 | 15483 | 57.430 | 64.925 | 77.415 | 7.753 | 8.765 | 10.451 | 114.860 | 129.850 | 154.830 |

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| Sl. No. | Station Name | Alighting Passengers | | | Water Demand (KLD) | | | Waste Water Generation (KLD) | | | Solid Waste Generation (Kg) | | |
|--------------|----------------|----------------------|---------------|---------------|--------------------|-----------------|-----------------|------------------------------|----------------|----------------|-----------------------------|-----------------|-----------------|
| | | 2025 | 2031 | 2041 | 2025 | 2031 | 2041 | 2025 | 2031 | 2041 | 2025 | 2031 | 2041 |
| 5 | Kaveri Nagar | 22517 | 27966 | 33067 | 112.585 | 139.830 | 165.335 | 15.199 | 18.877 | 22.320 | 225.170 | 279.660 | 330.670 |
| 6 | Nagawara | 32987 | 41833 | 52015 | 164.935 | 209.165 | 260.075 | 22.266 | 28.237 | 35.110 | 329.870 | 418.330 | 520.150 |
| 7 | Kanakanagara | 14926 | 18229 | 23318 | 74.630 | 91.145 | 116.590 | 10.075 | 12.305 | 15.740 | 149.260 | 182.290 | 233.180 |
| 8 | Hebbal | 11436 | 13835 | 17699 | 57.180 | 69.175 | 88.495 | 7.719 | 9.339 | 11.947 | 114.360 | 138.350 | 176.990 |
| 9 | Lottegolahalli | 18039 | 21481 | 27652 | 90.195 | 107.405 | 138.260 | 12.176 | 14.500 | 18.665 | 180.390 | 214.810 | 276.520 |
| 10 | Yeshwantpur | 33905 | 42958 | 52641 | 169.525 | 214.790 | 263.205 | 22.886 | 28.997 | 35.533 | 339.050 | 429.580 | 526.410 |
| 11 | Jalahalli | 23066 | 30344 | 41814 | 115.330 | 151.720 | 209.070 | 15.570 | 20.482 | 28.224 | 230.660 | 303.440 | 418.140 |
| 12 | Shettihalli | 30418 | 41942 | 53647 | 152.090 | 209.710 | 268.235 | 20.532 | 28.311 | 36.212 | 304.180 | 419.420 | 536.470 |
| 13 | Mydarahalli | 16513 | 22495 | 30680 | 82.565 | 112.475 | 153.400 | 11.146 | 15.184 | 20.709 | 165.130 | 224.950 | 306.800 |
| 14 | Chikkabanavar | 14163 | 18222 | 26359 | 70.815 | 91.110 | 131.795 | 9.560 | 12.300 | 17.792 | 141.630 | 182.220 | 263.590 |
| Total | | 272174 | 346988 | 438234 | 1360.870 | 1734.930 | 2191.165 | 183.717 | 234.216 | 295.807 | 2721.740 | 3469.860 | 4382.330 |

Table 8.53. Water Demand, Waste Water and Municipal Solid Waste (MSW) for Corridor 3 (Kengeri - White Field)

| Sl. No. | Station Name | Water Demand (KLD) | | | Waste Water Generation (KLD) | | | Solid Waste Generation (Kg) | | |
|---------|---------------------|--------------------|---------|---------|------------------------------|----------|----------|-----------------------------|--------|--------|
| | | 2025 | 2031 | 2041 | 2025 | 2031 | 2041 | 2025 | 2031 | 2041 |
| 1 | Kengeri | 187.565 | 248.465 | 321.53 | 25.321275 | 33.54278 | 43.40655 | 375.13 | 496.93 | 643.06 |
| 2 | RV College | 88 | 121.165 | 169.685 | 11.88 | 16.35728 | 22.90748 | 176 | 242.33 | 339.37 |
| 3 | Jnanabharati | 115.895 | 152.085 | 185.62 | 15.645825 | 20.53148 | 25.0587 | 231.79 | 304.17 | 371.24 |
| 4 | Nayandahalli | 45.365 | 57.02 | 67.725 | 6.124275 | 7.6977 | 9.142875 | 90.73 | 114.04 | 135.45 |
| 5 | Krishnadevaraya | 45.74 | 54.55 | 59.28 | 6.1749 | 7.36425 | 8.0028 | 91.48 | 109.1 | 118.56 |
| 6 | Jagajeevanram Nagar | 54.25 | 64.53 | 69.895 | 7.32375 | 8.71155 | 9.435825 | 108.5 | 129.06 | 139.79 |
| 7 | KSR Bengaluru City | 140.485 | 163.095 | 182.015 | 18.965475 | 22.01783 | 24.57203 | 280.97 | 326.19 | 364.03 |
| 8 | Kumarapark (BDA) | 76.51 | 96.89 | 112.355 | 10.32885 | 13.08015 | 15.16793 | 153.02 | 193.78 | 224.71 |
| 9 | Bengaluru Cantt. | 97.04 | 117.11 | 136.3 | 13.1004 | 15.80985 | 18.4005 | 194.08 | 234.22 | 272.6 |
| 10 | Bengaluru East | 74.15 | 90.745 | 111.82 | 10.01025 | 12.25058 | 15.0957 | 148.3 | 181.49 | 223.64 |
| 11 | Baiyyappanahalli | 48.195 | 62.53 | 75.585 | 6.506325 | 8.44155 | 10.20398 | 96.39 | 125.06 | 151.17 |
| 12 | Krishanrajapuram | 63.3 | 91.58 | 113.625 | 8.5455 | 12.3633 | 15.33938 | 126.6 | 183.16 | 227.25 |
| 13 | Hoodi | 44.275 | 65.075 | 84.93 | 5.977125 | 8.785125 | 11.46555 | 88.55 | 130.15 | 169.86 |

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| Sl. No. | Station Name | Water Demand (KLD) | | | Waste Water Generation (KLD) | | | Solid Waste Generation (Kg) | | |
|--------------|--------------|--------------------|----------------|-----------------|------------------------------|-----------------|-----------------|-----------------------------|----------------|----------------|
| | | 2025 | 2031 | 2041 | 2025 | 2031 | 2041 | 2025 | 2031 | 2041 |
| 14 | White Field | 5.22 | 8.24 | 10.68 | 0.7047 | 1.1124 | 1.4418 | 10.44 | 16.48 | 21.36 |
| Total | | 1085.99 | 1393.08 | 1701.045 | 146.60865 | 188.0658 | 229.6411 | 2171.98 | 2786.16 | 3402.09 |

Table 8.54. Water Demand, Waste Water and Municipal Solid Waste (MSW) for Corridor 4 (Heelalige - Rajankunte)

| Sl. No. | Station Name | Water Demand (KLD) | | | Waste Water Generation (KLD) | | | Solid Waste Generation (Kg) | | |
|--------------|------------------------------|--------------------|-----------------|-----------------|------------------------------|-----------------|-----------------|-----------------------------|----------------|----------------|
| | | 2025 | 2031 | 2041 | 2025 | 2031 | 2041 | 2025 | 2031 | 2041 |
| 1 | Heelalige | 23.085 | 40.000 | 72.000 | 3.116 | 5.400 | 9.720 | 46.170 | 80.000 | 144.000 |
| 2 | Bommasandra | 21.785 | 37.750 | 67.950 | 2.941 | 5.096 | 9.173 | 43.570 | 75.500 | 135.900 |
| 3 | Singena Agrahara | 17.890 | 31.000 | 55.800 | 2.415 | 4.185 | 7.533 | 35.780 | 62.000 | 111.600 |
| 4 | Huskur | 67.015 | 84.600 | 110.975 | 9.047 | 11.421 | 14.982 | 134.030 | 169.200 | 221.950 |
| 5 | Ambedkar Nagar | 46.070 | 58.815 | 78.330 | 6.219 | 7.940 | 10.575 | 92.140 | 117.630 | 156.660 |
| 6 | Karmelram | 180.180 | 222.635 | 292.675 | 24.324 | 30.056 | 39.511 | 360.360 | 445.270 | 585.350 |
| 7 | Belandur Road | 75.110 | 92.960 | 115.625 | 10.140 | 12.550 | 15.609 | 150.220 | 185.920 | 231.250 |
| 8 | Marathahalli | 94.225 | 136.785 | 182.540 | 12.720 | 18.466 | 24.643 | 188.450 | 273.570 | 365.080 |
| 9 | Future Station at Km 199/700 | 104.075 | 145.005 | 186.24 | 14.05 | 19.5755 | 25.1425 | 208.15 | 290.01 | 372.48 |
| 10 | Kagadapura | 113.925 | 153.225 | 189.940 | 15.380 | 20.685 | 25.642 | 227.850 | 306.450 | 379.880 |
| 11 | Benniganahalli | 60.675 | 81.115 | 108.285 | 8.191 | 10.951 | 14.618 | 121.350 | 162.230 | 216.570 |
| 12 | Channasandra | 106.245 | 149.435 | 184.050 | 14.343 | 20.174 | 24.847 | 212.490 | 298.870 | 368.100 |
| 13 | Horamavu | 143.070 | 197.005 | 235.935 | 19.314 | 26.596 | 31.851 | 286.140 | 394.010 | 471.870 |
| 14 | Hennur | 222.300 | 306.640 | 381.160 | 30.011 | 41.396 | 51.457 | 444.600 | 613.280 | 762.320 |
| 15 | Tannisandra | 271.375 | 433.345 | 506.225 | 36.636 | 58.502 | 68.340 | 542.750 | 866.690 | 1012.450 |
| 16 | RK Hegde Nagar | 155.340 | 245.390 | 296.700 | 20.971 | 33.128 | 40.055 | 310.680 | 490.780 | 593.400 |
| 17 | Jakkur | 63.675 | 96.875 | 152.695 | 8.596 | 13.078 | 20.614 | 127.350 | 193.750 | 305.390 |
| 18 | Yelahanka | 76.710 | 105.000 | 172.705 | 10.356 | 14.175 | 23.315 | 153.420 | 210.000 | 345.410 |
| 19 | Muddenahalli | 41.895 | 52.745 | 73.355 | 5.656 | 7.121 | 9.903 | 83.790 | 105.490 | 146.710 |
| 20 | Rajanukunte | 35.000 | 48.990 | 72.310 | 4.725 | 6.614 | 9.762 | 70.000 | 97.980 | 144.620 |
| Total | | 1919.645 | 2719.315 | 3535.495 | 259.151 | 367.1095 | 477.2925 | 3839.29 | 5438.63 | 7070.99 |

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Table 8.55. Summary of the Water Demand, Waste Water and Municipal Solid Waste (MSW) Generation at 4 Corridors

| Sl. No. | Corridor Name | Water Demand (KLD) | | | Waste Water Generation (KLD) | | | Solid Waste Generation (Kg) | | |
|--------------|---|--------------------|-----------------|------------------|------------------------------|-----------------|-----------------|-----------------------------|------------------|------------------|
| | | 2025 | 2031 | 2041 | 2025 | 2031 | 2041 | 2025 | 2031 | 2041 |
| 1. | Corridor 1 (KSR Bengaluru City - Devanahalli) | 2127.143 | 2763.643 | 3873.925 | 287.166 | 373.093 | 522.983 | 4254.285 | 5527.285 | 7747.850 |
| 2. | Corridor 2 (Baiyappanahalli -Chikkabanawar) | 1360.87 | 1734.93 | 2191.165 | 183.717 | 234.216 | 295.807 | 2721.74 | 3469.86 | 4382.33 |
| 3. | Corridor 3 (Kengeri - White Field) | 1085.99 | 1393.08 | 1701.045 | 146.6087 | 188.0658 | 229.6411 | 2171.98 | 2786.16 | 3402.09 |
| 4. | Corridor 4 (Heelalige - Rajankunte) | 1919.645 | 2719.315 | 3535.495 | 259.151 | 367.110 | 477.293 | 3839.290 | 5438.630 | 7070.990 |
| Total | | 6493.648 | 8610.968 | 11301.630 | 876.643 | 1162.484 | 1525.723 | 12987.295 | 17221.935 | 22603.260 |

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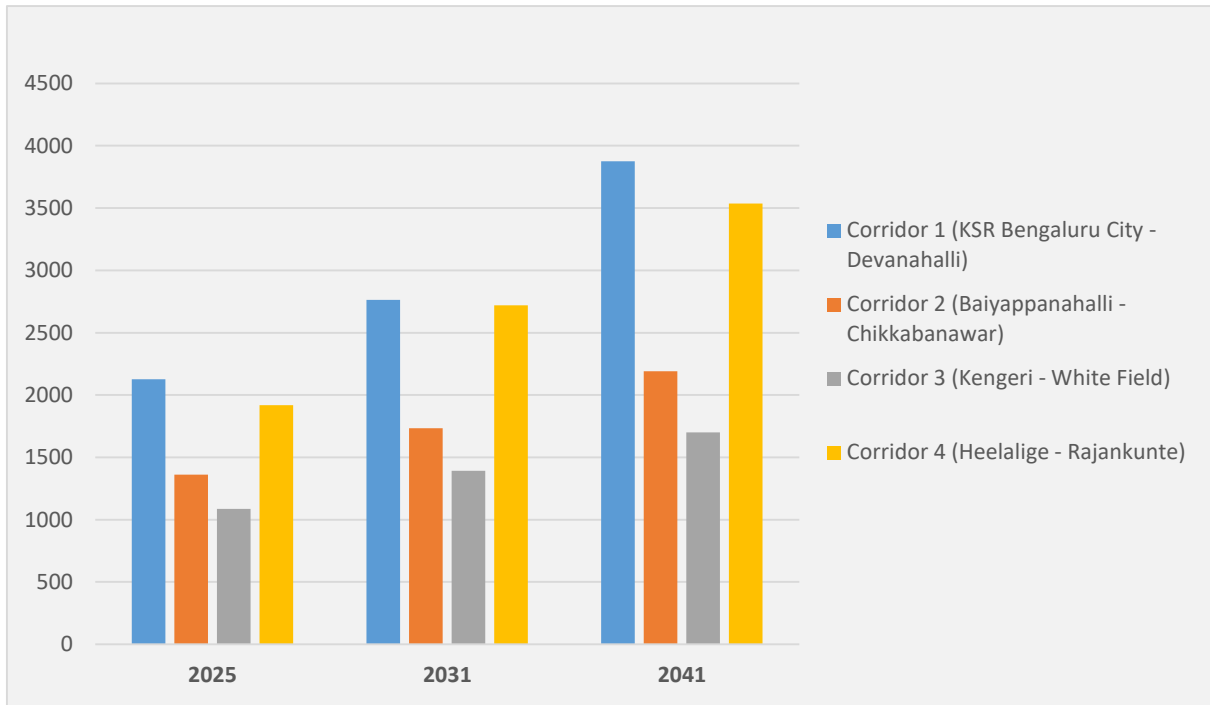


Figure 8.17. Water Demand (KLD) at 4 Corridors

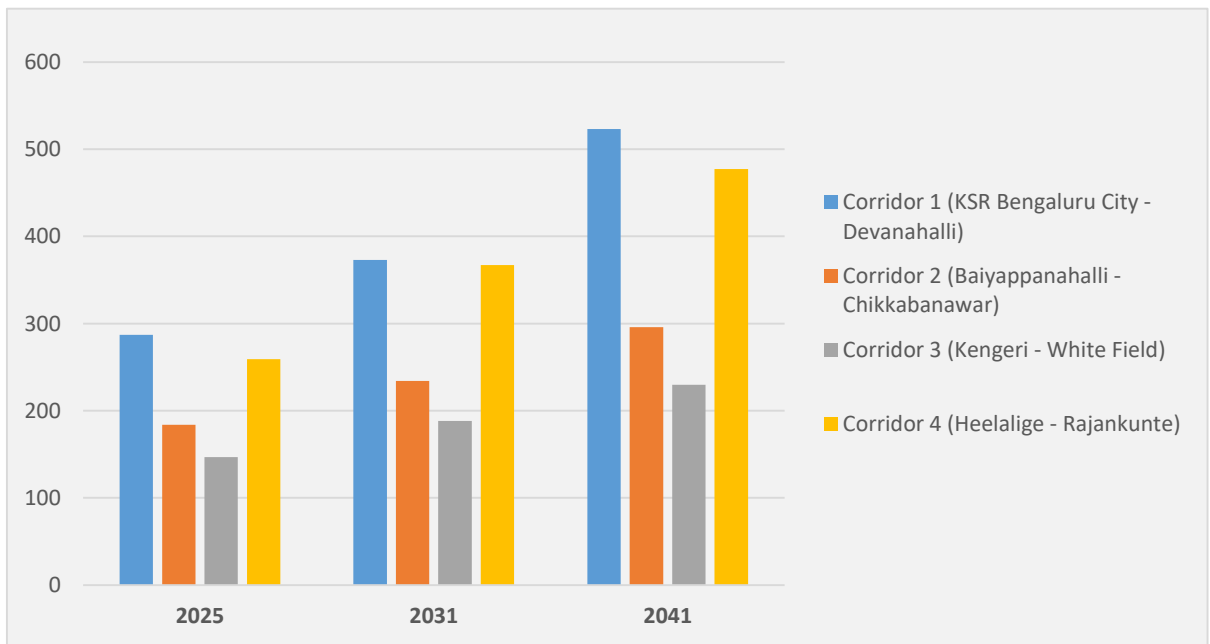


Figure 8.18. Waste Water Generation (KLD) at 4 Corridors

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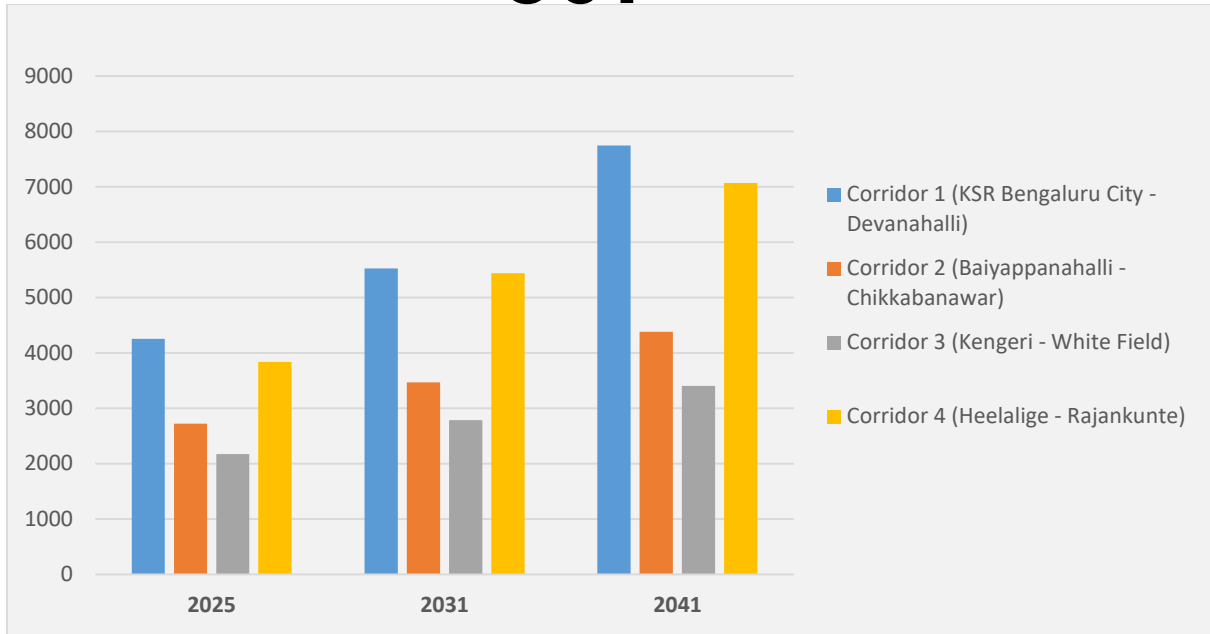


Figure 8.19. Solid Waste Generation (Kg) at 4 Corridors

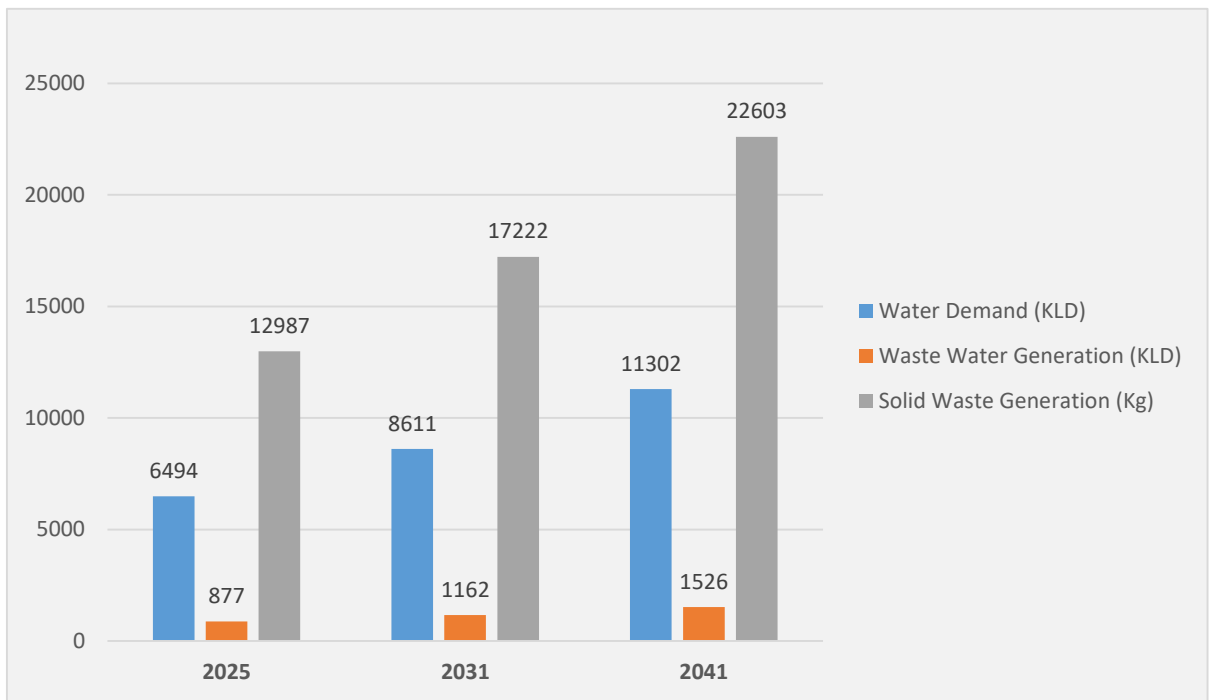


Figure 8.20. Total Water Demand (KLD), Waste Water Generation (KLD) and Solid Waste Generation (Kg) at 4 Corridors

Mitigation Measures : In accordance with the Railways Works Manual, 2000, adequate water supply and sillage and storm water drains will be provided. The water supply system shall be designed on the basis of water demand for drinking and sanitation purpose. Necessary measures will be taken to ensure zero or minimized wastage of water, wherever hydrants are provided. For multi-storeyed buildings, as per requirement, necessary static tanks may be provided for the fire-fighting arrangements in accordance with the specified regulations.

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Water Supply:

The source of water supply at Depots is municipal water supply and ground water. This will be supplemented by re-use of treated water of effluent treatment plant which may be used for cleaning floor, washing and flushing purpose. Water supply system will be provided with overhead storage facilities and where no sewerage system exists in the vicinity.

All stations and depots will be provided with basic public amenities such as drinking water, water supply, sanitation and toilets. Drinking water; and water supply for air conditioning facilities, cleaning purpose and for the use of staff and passengers will be procured mainly from municipal water supply.

Liquid waste - sewage & Effluent disposal at stations and Depots :

Water Quality Management at Stations and Depots will be in accordance with Water and Waste Water Management Plan in compliance with Indian Standards and ESS 3 of World Bank and ESS 3 of EIB.

Open drains and soak-pits shall be implemented where water-borne sewerage exists in the vicinity. Required number of Latrines or urinals shall be provided as per specifications and guidelines mentioned in the Railways Works Manual, 2000 and CPCB/KSPCB regulations.

Other Measures include treatment and reuse of waste water by installing Bio-digesters at Stations and Effluent treatment plant for Depots. Treated water shall be reused for flushing, rail car cleaning and floor cleaning purpose.

Typical cross section for Bio-digesters is given in **Figure 8.11**. Sewage and Effluents from depots sites shall be collected and treated using Effluent Treatment Plant in the premises. Proper maintenance of Bio-digesters shall be followed.

Corridor 1 : No. of Bio-digester at Stations = 15 and No. of ETP at Depots = 1 (Major Depot at Akkupete)

Corridor 2 : No. of Bio-digester at Stations = 14 and No. of ETP = 1 (Major Depot at Soladevanahalli)

Corridor 3 : No. of Bio-digester at Stations = 14 and No. of ETP = 1 (Micro Depot at Kengeri)

Corridor 4 : No. of Bio-digester at Stations = 20 and No. of ETP = 1 (Micro Depot at Heelalige)

Bio-Digesters: Considering disposal of human waste as a major concern, K RIDE shall install eco-friendly DRDO approved zero waste bio-digesters at all stations for on-site disposal of human waste.

Defense Research and Development Organisation (DRDO) /Defence Research Development Establishment (DRDE) in association with Research Design and Standard Organisation (RDSO) have developed this technology. DRDO has developed different versions of bio-digester to take care of disposal of human waste. The bio-digesters have been extensively fitted in different types of rail coaches by Indian Railways with collaboration of DRDO. The technology has no dependence on the limited and costly conventional energy sources.

Salient features:

- Eco-friendly & cost-effective
- Minimal maintenance

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- No need for sludge removal
- More than 90% organic matter reduction
- More than 99% pathogens reduction
- Generation of odorless & inflammable biogas
- Bio-digester can tolerate toilet cleaning agents to certain extent
- Technology transferred to industries for commercialization

The zero-waste bio-digester technology treats human excreta/waste at source by decomposing it into usable water and gas through anaerobic process. It does not have any geographical or temperature limitation. The bio-digester based eco-friendly sanitation technology will convert human faecal waste into water and gas. The bio-digesters treat human waste by a biological process called composting under anaerobic environment (in the absence of Oxygen) by anaerobic bacteria. They decompose human excretory waste in the digester tank converting it into methane gas, carbon dioxide, and water. The anaerobic process inactivates the pathogens responsible for water-borne diseases and treats the fecal matter without the use of an external energy source. Organic waste will be segregated and treated by on-site bio-composter technique. Bio-digestion process is briefed below at the end of this sub-section.

Bio-toilets do not require sewage connectivity (sewerage networks) and because the process is self-contained and bio-toilets are maintenance free. The only by-products of the waste treatment process are pathogen-free water, which is good for gardening, and bio-gas, which can be used for cooking. The total quantity of Waste water generation and requirement of DRDO approved Bio-digesters with capacity and cost estimate for all stations at each corridor of the Suburban Rail Project are given below in **Table 8.56**.

Table 8.56. Provision of Bio-digesters at Suburban Railway Stations

| Sl. No. | Station Name | Waste Water in KLD | Capacity of Bio Digester System in KLD | Cost of Bio Digester in ₹ Lakh | Cost of Bio Digester in ₹ |
|--|----------------------------|--------------------|--|--------------------------------|---------------------------|
| Corridor 1 (KSR Bengaluru City - Devanahalli) | | | | | |
| 1 | KSR Bengaluru City | 27.537 | 5 | 2.50 | 2,50,336 |
| 2 | Srirampura | 10.672 | 2 | 0.97 | 97,018 |
| 3 | Malleswaram | 21.889 | 4 | 1.99 | 1,98,991 |
| 4 | Yeshwantpur | 22.654 | 4 | 2.06 | 2,05,945 |
| 5 | Muthyalanagar | 18.649 | 3 | 1.70 | 1,69,536 |
| 6 | Lottegolahalli | 35.008 | 6 | 3.18 | 3,18,255 |
| 7 | Kodigehalli | 23.088 | 4 | 2.10 | 2,09,891 |
| 8 | Judicial Layout | 32.58 | 6 | 2.96 | 2,96,182 |
| 9 | Yelahanka | 29.099 | 5 | 2.65 | 2,64,536 |
| 10 | Nitte Meenakshi | 9.199 | 2 | 0.84 | 83,627 |
| 11 | Betalahasuru | 1.571 | 0 | 0.14 | 14,282 |
| 12 | Doddajala | 13.889 | 3 | 1.26 | 1,26,264 |
| 13 | Airport Trumpet | 4.788 | 1 | 0.44 | 43,527 |
| 14 | Airport KIADB | 12.984 | 2 | 1.18 | 1,18,036 |
| 15 | Future Station @ Km 38/800 | 12.181 | 2 | 1.11 | 1,11,000 |

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| Sl. No. | Station Name | Waste Water in KLD | Capacity of Bio Digester System in KLD | Cost of Bio Digester in ₹ Lakh | Cost of Bio Digester in ₹ |
|---|--------------------------|--------------------|--|--------------------------------|---------------------------|
| | Devanahalli | 11.378 | 2 | 1.03 | 1,03,436 |
| Total | | 287.166 | 52 | 26.110 | 26,10,862 |
| Corridor 2 (Baiyappanahalli - Chikkabanawar) | | | | | |
| 1 | Baiyappanahalli Terminal | 8.626 | 2 | 0.78 | 78,418 |
| 2 | Kasturi Nagar | 9.218 | 2 | 0.84 | 83,800 |
| 3 | Sevanagar | 10.99 | 2 | 1.00 | 99,909 |
| 4 | Banaswadi | 7.753 | 1 | 0.70 | 70,482 |
| 5 | Kaveri Nagar | 15.199 | 3 | 1.38 | 1,38,173 |
| 6 | Nagawara | 22.266 | 4 | 2.02 | 2,02,418 |
| 7 | Kanakanagara | 10.075 | 2 | 0.92 | 91,591 |
| 8 | Hebbal | 7.719 | 1 | 0.70 | 70,173 |
| 9 | Lottegolahalli | 12.176 | 2 | 1.11 | 1,10,691 |
| 10 | Yeshwantpur | 22.886 | 4 | 2.08 | 2,08,055 |
| 11 | Jalahalli | 15.57 | 3 | 1.42 | 1,41,545 |
| 12 | Shettihalli | 20.532 | 4 | 1.87 | 1,86,655 |
| 13 | Mydarahalli | 11.146 | 2 | 1.01 | 1,01,327 |
| 14 | Chikkabanavar | 9.56 | 2 | 0.87 | 86,909 |
| Total | | 183.717 | 33 | 17 | 16,70,145 |
| Corridor 3 (Kengeri - White Field) | | | | | |
| 1 | Kengeri | 25.321275 | 5 | 2.30 | 2,30,193 |
| 2 | RV College | 11.88 | 2 | 1.08 | 1,08,000 |
| 3 | Jnanabharati | 15.645825 | 3 | 1.42 | 1,42,235 |
| 4 | Nayandahalli | 6.124275 | 1 | 0.56 | 55,675 |
| 5 | Krishnadevaraya | 6.1749 | 1 | 0.56 | 56,135 |
| 6 | Jagajeevanram Nagar | 7.32375 | 1 | 0.67 | 66,580 |
| 7 | KSR Bengaluru City | 18.965475 | 3 | 1.72 | 1,72,413 |
| 8 | Kumarapark (BDA) | 10.32885 | 2 | 0.94 | 93,899 |
| 9 | Bengaluru Cantt. | 13.1004 | 2 | 1.19 | 1,19,095 |
| 10 | Bengaluru East | 10.01025 | 2 | 0.91 | 91,002 |
| 11 | Baiyappanahalli | 6.506325 | 1 | 0.59 | 59,148 |
| 12 | Krishanrajapuram | 8.5455 | 2 | 0.78 | 77,686 |
| 13 | Hoodi | 5.977125 | 1 | 0.54 | 54,338 |
| 14 | White Field | 0.7047 | 0 | 0.06 | 6,406 |
| Total | | 146.60865 | 27 | 13 | 13,32,806 |
| Corridor 4 (Heelalige - Rajankunte) | | | | | |
| 1 | Heelalige | 3.116 | 1 | 0.28 | 28,327 |
| 2 | Bommasandra | 2.941 | 1 | 0.27 | 26,736 |
| 3 | Singena Agrahara | 2.415 | 0 | 0.22 | 21,955 |
| 4 | Huskur | 9.047 | 2 | 0.82 | 82,245 |
| 5 | Ambedkar Nagar | 6.219 | 1 | 0.57 | 56,536 |
| 6 | Karmelram | 24.324 | 4 | 2.21 | 2,21,127 |

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| Sl. No. | Station Name | Waste Water in KLD | Capacity of Bio Digester System in KLD | Cost of Bio Digester in ₹ Lakh | Cost of Bio Digester in ₹ |
|--------------|-----------------------------|--------------------|--|--------------------------------|---------------------------|
| 7 | Belandur Road | 10.14 | 2 | 0.92 | 92,182 |
| 8 | Marathahalli | 12.72 | 2 | 1.16 | 1,15,636 |
| 9 | Future Station @ Km 199/700 | 14.05 | 3 | 1.28 | 1,28,000 |
| 10 | Kagadaspura | 15.38 | 3 | 1.40 | 1,39,818 |
| 11 | Benniganahalli | 8.191 | 1 | 0.74 | 74,464 |
| 12 | Channasandra | 14.343 | 3 | 1.30 | 1,30,391 |
| 13 | Horamavu | 19.314 | 4 | 1.76 | 1,75,582 |
| 14 | Hennur | 30.011 | 5 | 2.73 | 2,72,827 |
| 15 | Tannisandra | 36.636 | 7 | 3.33 | 3,33,055 |
| 16 | RK Hegde Nagar | 20.971 | 4 | 1.91 | 1,90,645 |
| 17 | Jakkur | 8.596 | 2 | 0.78 | 78,145 |
| 18 | Yelahanka | 10.356 | 2 | 0.94 | 94,145 |
| 19 | Muddenahalli | 5.656 | 1 | 0.51 | 51,418 |
| 20 | Rajanukunte | 4.725 | 1 | 0.43 | 42,955 |
| Total | | 259.151 | 49 | 23.56 | 23,56,189 |

Note: Corridor 3's 5 stations i.e., stations between Bengaluru Cant. and Whitefield is also consider for Bio-digester and separate bio-digesters are proposed for C1 and C4 Integrated Yelahanka Stations.

Anticipated influent & effluent waste water quality parameters from the bio-digesters are given in **Table 8.57** and typical cross section of a Bio-digester is shown in **Figure 8.21**.

Table 8.57. Waste Water Quality Parameters (Influent & Effluent)

| Sl. No. | Parameter | Unit | Characteristics | |
|---------|--|-----------|-----------------|----------|
| | | | Influent | Effluent |
| 1. | pH | - | 7.0 -7.5 | 7.0 -7.5 |
| 2. | Turbidity | NTU | 70 -90 | 2-5 |
| 3. | Total Suspended Solids (TSS) | mg/l | 90-120 | 50 -80 |
| 4. | Total Dissolved Solids (TDS) | mg/l | 350 -450 | 100 -300 |
| 5. | Biochemical Oxygen Demand (BOD) at 5 days and 20°C | mg/l | 70-120 | 2-4 |
| 6. | Chemical Oxygen Demand (COD) | mg/l | 250 -300 | 15 -25 |
| 7. | Coliforms | MPN/100ml | 300 -350 | 0-12 |

Source: DRDO Website

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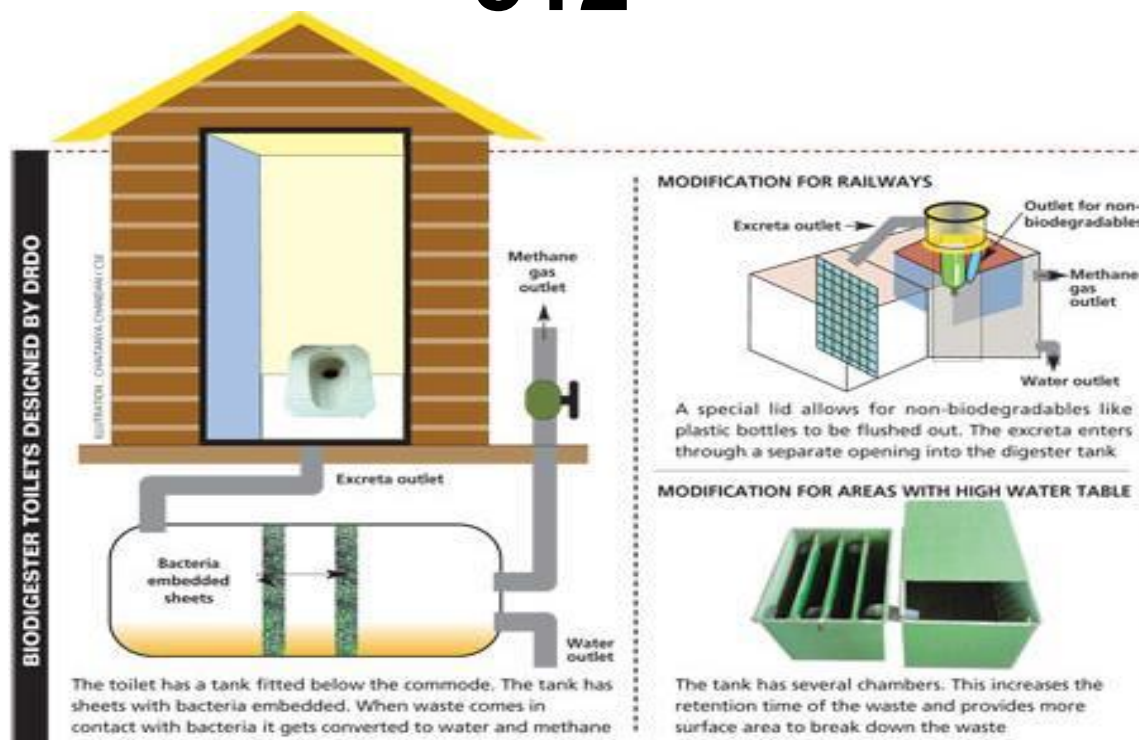


Figure 8.21. Typical Cross Section of Bio-digester

Septic Tanks shall be provided as per requirement according to KSPCB guidelines. The treated grey water will be used for flushing and floor cleaning purpose.

As the project will implement the above mentioned Water supply and Sanitation measures the Indian regulations and WBESF guidelines will be complied with.

***Bio-digestion process by Anaerobic bacteria :** Bacteria are active in temperatures ranging from 0°C to 55°C. To use it in a toilet, a tank was fitted below the commode to collect the excreta. The tank made of cement had sheets with bacteria embedded in it and free-floating bacteria. The bacteria cannot move out of the sheets but can multiply. When human excreta comes in contact with bacteria, it gets converted into methane and water through a series of steps of anaerobic digestion—hydrolysis, acidogenesis, acetogenesis and methanogenesis (Fermentative bacteria, Syntrophic bacteria, Acetogenic bacteria, Methogenic bacteria, etc.).

Faecal matter is composed of carbohydrates, protein and fats. In the first step, they are converted into simple sugars, amino acids and fatty acids. In the next step, these break to form carbonic acid, alcohols, hydrogen and water. In the third step, acetic acid, hydrogen and carbon dioxide are formed. In the last step, methane, carbon dioxide and water are formed. Methane can be used for cooking while water for irrigation. The best benefit is that once applied, the bacteria can work for a lifetime.

8.7.7.2. Water Supply at Depots

Water supply/demand will be there at Depot for different purposes. A three day cycle is assumed for train washing at depot. As per the Indian Railways Works Manual, 2000, the water demand for train washing is 3500 liters per day. The fresh water demand at stations & depot for the project year 2025, would be about 2,88,249 KLD required to be used for different purposes such as for train washing – 720 KLD, floor washing/cleaning – 2,80,000 KLD, for drinking purpose – 6494 KLD for passengers and

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official staffs at Stations and Depot and for sanitation purpose – 1012 KLD. It is suggested to use recycled water for other purposes like flushing urinals/closet, etc. In case of non-availability of recycled water supply from local Municipal sources may be utilized. Potable water requirement will be met from water supply by BBMP. Potable water requirement required for Stations are estimated in **Table 8.55**. Estimated water demands are as given in the **Table 8.58**.

Table 8.58. Water Demand Depots

| Sl. No. | Depot | Projected for Years | | |
|--------------|---|---------------------|-------------------|-------------------|
| | | 2025 | 2031 | 2041 |
| 1 | Projected Number of Trains | 24 | 24 | 24 |
| 2 | Water requirement (in KLD) for Car/train Washing (0.5 KLD /Car) | 720 | 720 | 720 |
| 3 | Floor Washing @ 0.5 litres/Sqm (2 Major and 2 Micro Depots + 64 Stations) =5,60,000 Sq.m. | 2,80,000 | 2,80,000 | 2,80,000 |
| 4 | Drinking Water Requirement in KLD @ 5 lit per person per day at 2 Major and 2 Micro Depots + 64 Stations. | 6494.148 | 8611.468 | 11302.130 |
| 5 | Sanitation purpose @13.6 litres per use (Minimum usage) at 2 Major and 2 Micro Depots + 64 Stations. | 1,012 | 1,315 | 1,761 |
| Total | | 288249.708 | 290670.911 | 293807.353 |

As per the requirement, the Reverse Osmosis (RO) technology may be used for conventionally treated water at Depot for specific purpose such as to use for washing of equipment and trains. This helps in the reduction of depletion of fresh water for washing purpose.

Mitigation Measure: The source of water supply at Depot is municipal water supply and Potable water shall be supplied for drinking purpose. This will be supplemented by re-use of treated water of effluent treatment plant. The fresh water demand at stations & depot for the project year 2025, would be about 2,88,249 KLD required to be used for different purposes such as for train washing – 720 KLD, floor washing/cleaning – 2,80,000 KLD, for drinking purpose – 6494 KLD for passengers and official staffs at Stations and Depot and for sanitation purpose – 1012 KLD.

Ground Water Recharge / Rain water Harvesting: In view of augmentation of storage of ground water, it is proposed to construct roof top rain water harvesting structure of suitable capacity in the Depot. Ground water shall be recharged through Rainwater harvesting at each depot. One Rainwater harvesting unit for each depot is proposed. The cost estimated is ₹ 91,700.00 +3000 surcharges (KPWD Schedule of Rates) for installation of rainwater harvest units during construction phase.

Residual Impacts: No adverse impact on the ecosystem.

8.7.7.3. Waste Water/Effluent Generation

The trade effluent or waste water generated due to Depot activities such as washing of trains is about 720 KLD (Depots) and domestic sewage of about 876.643 KLD at depots and stations. Waste water generation from Stations are estimated in **Table 8.55**. The waste water will be treated and recycled to use for flushing, floor cleaning and train car washing purposes etc.

Mitigation Measure: Implementation Bio-digester with Reed bed system approved by DRDO will help to handle human waste as well as waste water at Depot. The details of waste water generated and

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estimated cost of each depot is given in **Table 8.59**. The treated waste water may be reused for washing and flushing purpose in the depot area. Total estimated cost for waste water treatment is ₹ 7.18 Lakhs for each depot.

Table 8.59. Capacity and Estimated Cost of Bio-Digester & ETP at Depot

| Sl. No. | Corridor No. | Depot Name | Domestic Waste Water in KLD | Waste Water from Car/Train Washing in KLD | Capacity of Bio Digester System in KLD | Estimated cost of Bio-Digester in ₹ Lakh | Estimated cost of ETP ₹ Lakh |
|---------------------|--------------|-----------------------|-----------------------------|---|--|--|------------------------------|
| Major Depots | | | | | | | |
| 1 | Corridor 1 | Akkupete Depot | 2.04 | 3.5 | 0.371 | 0.19 | 1.75 |
| 2 | Corridor 2 | Soladevanahalli Depot | 2.04 | 3.5 | 0.371 | 0.19 | 1.75 |
| Micro Depots | | | | | | | |
| 1 | Corridor 3 | Kengeri Station | 1.7 | 3 | 0.309 | 0.15 | 1.5 |
| 2 | Corridor 4 | Heelalige Station | 1.7 | 3 | 0.309 | 0.15 | 1.5 |
| Total = 4 | | | 7.48 | 13 | 1.36 | 0.68 | 6.5 |

Residual Impacts: No adverse impact on the ecosystem.

8.7.7.4. Solid Waste generation

As per the estimation for the projected year 2025, about 1.4 to 1.5 Tons/day of MSW and about 1 to 4.2 Tons/day (4.25 Tons/day in Corridor-1, 2.72 Tons/day in Corridor-2, 2.17 Tons/day in Corridor-3 and 3.84 Tons/day in Corridor-4) of MSW is likely to be generated from the Depot and Stations respectively. Solid waste generation from Stations are estimated in **Table 8.55**. The dry and wet solid waste shall be collected separately, segregated and stored in separate bins / barrels. Solid waste such as Paper, cotton waste, etc. will be reutilized, as far as possible after segregation. Finally, the total dry and wet solid waste will be handed over to BBMP authority for further Solid waste treatment and management. During operation phase, no hazardous substances are used.

Mitigation Measures: Solid waste generated from the Depot which includes mostly hazardous wastes - muck, oil & grease, paints, etc., will be handed over weekly to the approved agency, recycled/treated and disposed-off at designated waste disposal sites in accordance with KSPCB rules.

Municipal Solid Waste Management at Stations & Depots will be in accordance with Solid Waste Management Plan (**Annexure 10.9**) and in compliance with Indian Standards and ESS 3 of World Bank and EIB Standard 3.

Separate colour coded garbage bins for wet and dry wastes collection will be provided at Depots. Organic waste shall be segregated and treated by in-situ bio composter technique.

Frequently, the municipal solid waste shall be cleared off by the conservancy staff; and handed over to BBMP authority for proper treatment and disposal.

Residual Impacts: There will be insignificant or no impact to the environment. No adverse impact on surrounding ecosystem is anticipated.

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8.7.7.5. Oil Pollution

During maintenance of rolling stock in the Maintenance Depots/Workshop change of lubricants, cleaning and repair processes are routine activities. During these maintenance activities and Storage area for Oils & Grease there is the possibility of oil spillage. Care will be taken to ensure that there will be minimal oil spillage while transferring the contents to other containers or during cleaning and repairing activities. However, the spilled oil will be trapped / collected in oil/grease traps. The collected oil/grease would be disposed-off to authorised vendors/collectors, so as to avoid any underground/ surface water contamination.

Mitigation measures: The maintenance at Depot/Workshop for rolling stock includes change of lubricants, cleaning and repair activities, during which there may be oil spillage or leakage. The oil and grease traps shall be provided to trap waste grease and oil; and disposed-off to authorised collecting agency, so that any underground/surface water contamination is avoided. These oil and grease traps need to be installed before effluent treatment plant.

Residual Impacts: No adverse impact on the ecosystem.

8.7.7.6. Noise Pollution

The main source of noise from depot is the operation of workshop. The roughness of the contact surfaces of rail and wheel and train speed is the factors, which influence the magnitude of rail - wheel noise. The vibration of concrete structures also radiates noise. No impact on the ambient noise is anticipated due to mild activities.

8.7.7.7. Surface Drainage

In case of filling in low-lying area of depot and station sites, the surface drainage pattern may change.

Mitigation Measures: Suitable drainage measures will be adopted to drain off the area properly in to the sewerage drain nearby water body. Monitoring of waste-water generated from the stations during the initial stages of project operation will be required to be carried out to confirm that the water does not contain any harmful pollutants. Drains shall be provided to collect the storm water in Depot. Rain water harvesting pits are provided at different locations in the drains and for surplus storm water; and the drainage system shall be connected to a nearby disposal site. K RIDE shall ensure that all drains (side drains, median drain and all cross drainages) are periodically cleared especially before monsoon season to facilitate the quick passage of rainwater & avoid flooding in low lying areas, as per the Contract Document & WB ESS 1 and EIB Standard 1.

Residual Impacts: No adverse impact on the ecosystem is anticipated. In order to verify this expectation, the effluent of the Depots will be monitored during the initial stage of operations.

8.7.7.8. Loss of Vegetation/ Biomass

About 17323 trees in Akkupete Depot and 22 trees in Soladevanahalli depot are affected due to proposed project. Trees affected in the Stations sites are incorporated in along with trees affected in alignment. Karnataka Forest Department is the nodal agency to issue approval for tree felling. After the joint tree inventory by the Forest Department, numbers of trees to be felled and translocated will be undertaken as at the suitable site jointly identified by forest department. Afforestation cost is given in the Environmental Management Plan.

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Green Belt Development (plantation) as Compensation for loss of vegetation/Biomass

The green belt development (plantation) is one of the major operational activities of the proposed project during operation phase. The provision of green belt in the depot area harmonizes the depot with surrounding environment and acts as noise barrier; and air and noise pollution sink. It will check soil erosion. Compensatory afforestation cost at depot area is included in the compensatory afforestation cost of the project. Treated waste water can be used for watering the green belt.

8.7.7.9. Loss of Livelihood

There will be no loss of livelihood due to the depots, as land selected for depots are mainly open lands. Further, details are provided in SIA Report.

Residual Impacts: No negative impacts are predicted on ecosystem.

Above are the areas of concern regarding the required mitigation measures at Stations & Depots during operation phase of the project. Except the Waste water treatment and oil pollution measures, all other required measures shall be implemented at stations during operation stage of the project.

8.7.8. Risks & Impact on Air Quality due to inter modal operational vehicles

There are operational inter modal vehicles such as autorickshaws, taxis, two-wheelers or four wheelers to transport BSR commuters to reach nearby Suburban Railway Stations from source and Suburban Railway Stations to their destinations such as work place, residence, etc.

Air Pollution monitoring shall be carried out in accordance with Air (Prevention and Control) Act, 1981 and CPCB regulations and WB ESS 3 and EIB ESS 3.

Residual Impacts: No negative impacts are predicted on ecosystem.

8.7.9. Risks & Impact on Topography and Natural Drainage

The main effects on topography are due to elevation changes in the BSR may impact air pressure and temperature affect topography. Topography has a significant effect on climate. The lower the site elevation, the smaller the site relief, the lower the site roughness, and higher the likelihood that the site will experience urban flooding. Surface roughness is the topographical influencing factor with the greatest influence on urban flooding.

During extreme weather events particularly due to heavy rainfall transport infrastructure can be directly or indirectly damaged, posing a threat to human safety, and causing significant disruption and associated economic and social impacts. Flooding, especially as a result of intense precipitation, is the predominant cause of weather-related disruption to the transport sector. Surface water flooding is a risk because of its effect as the whole infrastructure rail and road networks and utilities, etc. in the vicinity gets affected disrupting much all aspects of modern life.

Flooding can strain transportation networks in both the short- and long-term through transportation delays, infrastructure damage, and recovery, and potentially affect economies.

In BSRP as the Suburban Rail network is designed to be at grade and at elevated levels, that too mostly within the RoW, impact on topography is very much negligible. However, chance of induced flooding may be predicted due to at grade BSR because of design issues and its impact on vulnerable

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community and road networks nearby. In such case, following are the mitigation measures need to be implemented.

Mitigation Measures: In case there is Flooding in BSR stations or Depots this will be may be mainly due to the encroachment of surface flooding in the vicinity of BSR lines. The flood risk level of the BSR system shall be extracted from the regional risk level map. The flood risk level of the concerned BSR line shall be analysed by PIA or concerned hired agency, if any, which enables timely enabling emergency response and the implementation of flood prevention measures to reduce casualties and losses before the onset of heavy rainfall and floods. Based on Hydrologic and hydrodynamic situations under different precipitation scenarios, a comprehensive risk assessment of the BSR system could be conducted by combining topographic, hydrological, and socio-economic data. Accordingly, a 250 to 500 m buffer range around the BSR line shall be determined to represent the BSR system's flood risk. Waterlogging points shall be identified in the risk assessment process.

Based on the severity of risks of flood, following prevention measures are required to be undertaken at stations and depots :

- Evacuating people from the vicinity of flood areas of BSR lines, stations or depots and providing proper secured alternative entry and exits
- Providing signals and alarms to alert people to not to enter into the vicinity of risky areas
- Providing Water stop plate and high steps;
- Opting for Floodwater harvesting system and pumping out to proper channels of the drainage system.
- Planting vegetation near affected BSR corridors to retain excess water, Terrace slopes to reduce slope flow, and building alluviums (man-made channels to divert water from flooding),
- Construction of dykes, dams, reservoirs or holding tanks to store extra water during flood periods.
- Construction of Embankments, flood walls and Natural detention basins.
- Implementing Channel improvement.
- Providing required PPE to ensure workers' Safety and providing health facilities to workers and arranging for health check-up for workers, as per requirement

Residual Impacts: No adverse impact on surrounding ecosystem is anticipated.

8.7.10. Soil Erosion at Closed Borrow Areas and Embankments

Accidental soil erosion may occur at closed borrow areas and embankments due to climatic change or any other local activities nearby.

Mitigation Measures: Visual Monitoring and inspection of borrow areas in case operated (if closed and rehabilitated), embankments and other places expected to be affected, shall be carried out once in every three months as per monitoring plan, to check soil erosion if any. And measures shall be necessitated to avoid residual impacts such as soil erosion and mosquito breeding at stagnated water. This will comply with WB ESS 3 and EIB Standards 3.

Residual Impacts: No negative impacts are predicted on ecosystem.

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8.7.11. Pedestrian & Road Traffic Congestion around Stations

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

Mitigation Measures: This passenger and road traffic congestion can be controlled by proper implementation of inter modal integration with other modes of transport to and fro source to destination.

Residual Impacts: No negative impacts are predicted on ecosystem.

8.7.12. Risks & Impacts on Operational and Community Safety

The most significant safety issue potentially affecting both crew and passengers is the threat of serious injury or the potential loss of life due to train collisions with other trains or with road vehicles, as well as the possibility of derailment due to these or other operational causes. Recommended management actions include the following :

- Implementation of rail operational safety procedures aimed at reducing the likelihood of train collisions such as a positive train control (PTC) system. If a full PTC system is not practical, automatic rail switches should be installed or, where manual switches remain, documenting when a manually operated switch in non-signalled territory is changed from the main track to a siding, and returned back to the normal position for main track movements. This information should be communicated to all crew members and the train dispatcher.
- Regular inspection and maintenance of the rail lines and facilities to ensure track stability and integrity in accordance with national and international track safety standards;
- Implementation of an overall safety management program that is equivalent to internationally recognized railway safety programs.

Residual Impacts: There will be insignificant impact to the environment. No adverse impact on surrounding ecosystem is anticipated.

8.7.13. Risks & Impacts on Community Health

Community health and safety impacts during operations include noise and dust, road and train accidents along the railway corridor. During construction, communities adjacent to the works and tracks may be exposed to risks of noise and dust, traffic disruptions, accidents, general construction hazards and personal safety, including sexual harassment. The COVID-19 pandemic also introduces potential risks of community exposure through contagion pathways such as meetings, stakeholder engagement sessions and construction sites, and from train travel in general. Emergency-response planning and monitoring for prevention and control of pollution or other risk incidents during operation shall be established.

During operation stage Safety Measures such as general rail operational safety, transport of dangerous goods, pedestrian safety, fire risk due to failure to manage vegetation in RoW, etc. shall be followed as per Indian Railways, as given in the **Annexure 10.18**.

During operation stage, as far as possible government security personnel shall be deployed at stations and depot and in running trains, as applicable.

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Corporate Social Responsibility: Public shall be advised to construct the noise barriers such as walls, double glazed windows and tree plantation between the roads and their property. The public awareness is necessary regarding the human health through the newspapers and consultations and distribution of pamphlets during the operation stage.

Residual Impacts: No negative impacts are predicted on ecosystem.

8.8. Cumulative Impact Assessment

Cumulative Impacts are the overall effects caused by the totality of past, present and foreseeable future actions. Cumulative effects can result from incremental changes caused by the interactions between effects within a project and/or the interaction with the effects from other developments. With regard to railway schemes, cumulative effects are considered in the following ways:

- Multiple effects from the scheme, and from different schemes of the same or similar type, upon the same resource; such as the effect on a single community of noise from several transport sources.
- Different multiple effects from the scheme, and from other schemes, upon the same resource; such as land take and damage due to hydrological change, affecting several sites of the same habitat.
- Incremental effects arising from a number of small actions, including ongoing maintenance operations, having developed or developing over time

8.8.1.1. Project under Discussion

The budget announcement of BBMP, BDA and BMRCL as well as through the discussions with the officials of these agencies the consultants understand that there are few projects that are often discussed in several meetings with the stakeholder agencies and that are planned in the project region. Few of those projects are

- Bengaluru Metro Rail Phase 2A (Outer Ring Road) - Expected to complete by 2025
- Bengaluru Metro Rail Phase 2B (KR Puram to Kempegowda International- Expected to complete by 2025
- Satellite Town Ring Road (STRR)
- Peripheral Ring Road (PRR)

These projects are considered during the formulation of alternatives and relevant projects are integrated with the proposals of this study thus minimizing the cumulative Impacts.

During the study, it was understood that, small stretch of Metro Rail line – 2A and 2B are runs parallel to proposed BSRP railway alignment (Corridor 1 & 4) at Doddanekkundi , Benniganahalli, near Yelahanka and Doddajala areas. However, as per the information gathered, metro rail construction activities are almost nearing to completion at Benniganahalli, Yelahanka and Doddajala areas. In Doddanekkundi, the construction activities are just started. As per the Metro Annual plan, BMRCL is targeted to complete the construction by March 2025. The satellite town ring road and peripheral ring road alignments are not falling near BSRP corridors. Further, construction and project completion timelines of the remaining projects listed above are not announced till date.