

9. TRAIN OPERATION PLAN

9.1 TRAIN OPERATION PHILOSOPHY

Train operation plan for proposed corridors of Varanasi Metro viz. BHU to BHEL Corridor (19.4 Km) and Benia Bagh to Sarnath (9.9 Km) has been envisaged based on the ridership assessment. The peak hour peak direction trips (PHPDT) is 24000 passengers for BHU to BHEL corridor and 18000 passengers for Benia Bagh to Sarnath corridor in the design year. This chapter includes headway/frequency, hourly train operation plan, rolling stock requirement etc.

The underlying operation philosophy is to provide mass rapid transit services at economical cost with fixed Infrastructure and rolling stock planning.

- The frequency of train services shall be optimized to provide sectional capacity commensurate with the peak direction traffic demand during peak hours.
- A minimum train service frequency shall be provided during lean period so as to keep the option of this service attractive during lean period as well
- The frequency of services shall be regulated to meet the growing traffic demand in horizon years
- Basic unit selected is two motor car and one trailer car

The train operation plan for the proposed corridors will be based on the following salient features:

- Train operation for the proposed corridors of Varanasi metro is planned between BHU to BHEL Corridor (19.4 km, 4 Elevated & 13 Underground stations) and between Benia Bagh to Sarnath Corridor (9.9 km, 2 Elevated & 7 Underground stations) respectively.
- Though the track connectivity is planned between the two corridors at Benia Bagh, the train operation is proposed independently for each corridor considering the section wise traffic of the corridors.
- Running of normal services for 16 hours of the day (6 AM to 10 PM) with average station dwell time of 30 seconds,
- Make up time of 5-10% (on the tangent track) with 10-15% coasting.

- Scheduled average speed for corridor 1 and corridor 2 shall be 35 km/h and 34 km/h respectively.

9.2 TRAFFIC DEMAND

9.2.1 Peak Direction Traffic

The PHPDT for purpose of planning of services for the proposed corridors in the years 2023, 2031, 2041 and design year are indicated in **Table 9.1**.

TABLE 9.1: YEAR WISE MAXIMUM PEAK HOUR PEAK DIRECTION TRIPS (PHPDT)

S.N.	Corridor	Maximum PHPDT			
		2023	2031	2041	Design
1	BHU to BHEL	13000	15500	20000	24000
2	Benia Bagh to Sarnath	10000	13500	15500	18000

9.2.2 Section Wise Traffic

Section wise traffic for the proposed corridors for different horizon years is shown in **Annexure 9.1**.

9.3 TRAIN FORMATION

To meet the above projected traffic demand, the train operation plan has been formulated considering the rolling stock of 2.9 m wide coaches. The train composition, capacity and headway required for the operation.

9.3.1 Composition

The car composition to be adopted is given below-

DMC : Driving Motor Coach

TC : Non Driving Trailer Coach

3-Car Rake Composition: **DMC-TC-DMC**

Every coach shall be fully interchangeable with any other coach of same type.

9.3.2 Capacity

For the purpose of calculating rake requirement of rolling stock, passenger carrying capacity is considered as below in Table 9.2.

TABLE 9.2: CARRYING CAPACITY OF COACHES

Description	Driving Trailer Car (DTC)			Trailer Car (TC)/ Motor Car (MC)			3 Car Train		
	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush
Seated	43	43	43	50	50	50	136	136	136
Standing	102	204	272	110	220	293	314	630	839
Total	145	247	315	160	270	343	450	766	975

Normal - 3 Per/sqm, Crush- 6 Per/Sqm a, Dense Crush – 8 Per/Sqm of standee area

9.3.3 Headway

To meet the projected traffic demand, running trains with 3 car composition at different headways has been envisaged. The traffic capacity and demand have been matched by suitable regulation of headways.

The infrastructure and train operation plan for the two corridors of Varanasi Metro are proposed to be designed for 3 car rake composition for the ultimate/design year.

Based on above, the headway and capacity provided for different corridors for the various horizon years is presented in **Table 9.3**.

TABLE 9.3: TRAIN OPERATION PLAN, HEADWAY AND CAPACITY PROVIDED

Train Operation/ Corridors	Items	Year				
		2023	2031	2041	Design	
BHU to BHEL (19.4 km)	Cars/ Train	3	3	3	3	
	Headway (Sec.)	276	228	174	144	
	Trains/hr	13	16	21	25	
	Capacity Provided	@6p/m ²	9958	12256	16086	19150
		@8p/m ²	12675	15600	20475	24375
PHPDT Demand		13000	15500	20000	24000	
Beniabagh to Sarnath (9.9 km)	Cars/ Train	3	3	3	3	
	Headway (Sec.)	360	258	228	192	
	Trains/hr	10	14	16	19	
	Capacity @6p/m ²	7660	10724	12256	14554	

Train Operation/ Corridors	Items	Year			
		2023	2031	2041	Design
	Provided @8p/m ²	9750	13650	15600	18525
	PHPDT Demand	10000	13500	15500	18000

Keeping in view the traffic demand, it is proposed to operate 3-car trains. Subsequently, the passenger carrying capacity will be increased varying by regulating the headway to meet the growing traffic demand in horizon years.

9.4 TRAIN OPERATION PLAN

9.4.1 Corridor 1 – BHU to BHEL

Train operation for the different horizon years for BHU to BHEL Corridor has been formulated such that there is optimum utilization of the rolling stock and the empty running of trains is reduced. The year wise train operation plan is described as below:

- **Year 2023**

Train operation plan for the corridor in year 2023 is planned with 3 car rake composition and 276 seconds headway during peak period. The planned peak hour peak direction trips (PHPDT) capacity is 9958 @ 6 passengers/m² of standee area (Capacity of 12675 @ 8 passengers/m² of standee area under dense loading conditions). The capacity has been planned considering the design PHPDT of 13000 passengers. However, in the sections where the planned capacity is less than the section load i.e. in the section between Benia bagh and Kashi Vidyapeeth, capacity can be met by carrying standees @ 8 passengers/ m² which have been deliberately planned for peak hour train operation for optimum utilization of rolling stock.

- **Year 2031**

The train operation with 3 car trains at 228 seconds peak period headway has been proposed for year 2031 with PHPDT capacity of 12256 passengers with standees @ 6 persons/m² (capacity of 15600 passengers @8 persons /m²). With the proposed headway, the planned capacity is slightly less than the demand in the section between Beniabagh and Kashi Vidyapeeth station. However capacity in this section can be met by carrying standees @ 8 passengers/ m².

FIGURE 9.1: PHPDT DEMAND AND CAPACITY PROVIDED (2023) FOR BHU TO BHEL CORRIDOR

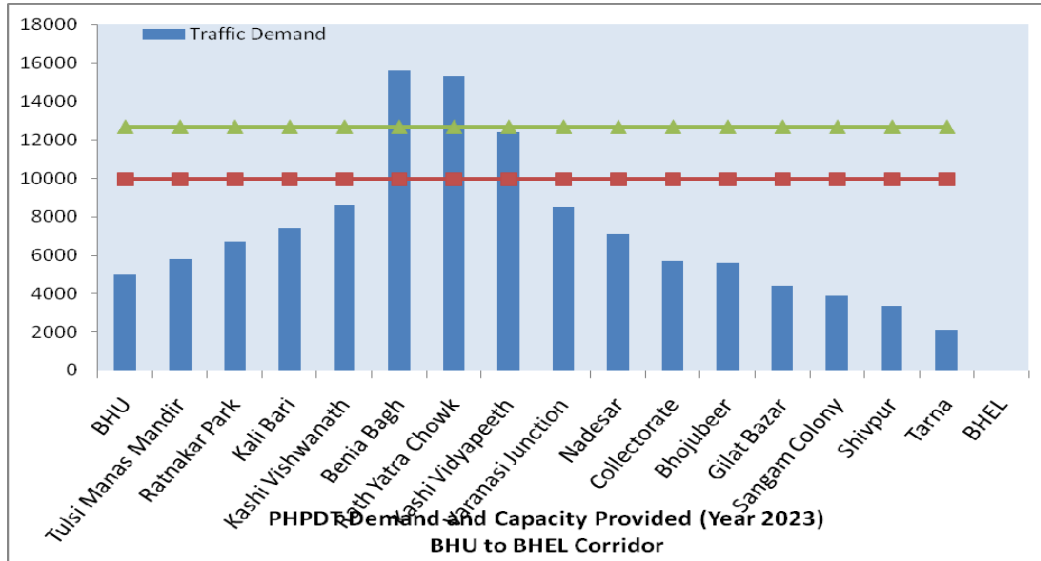
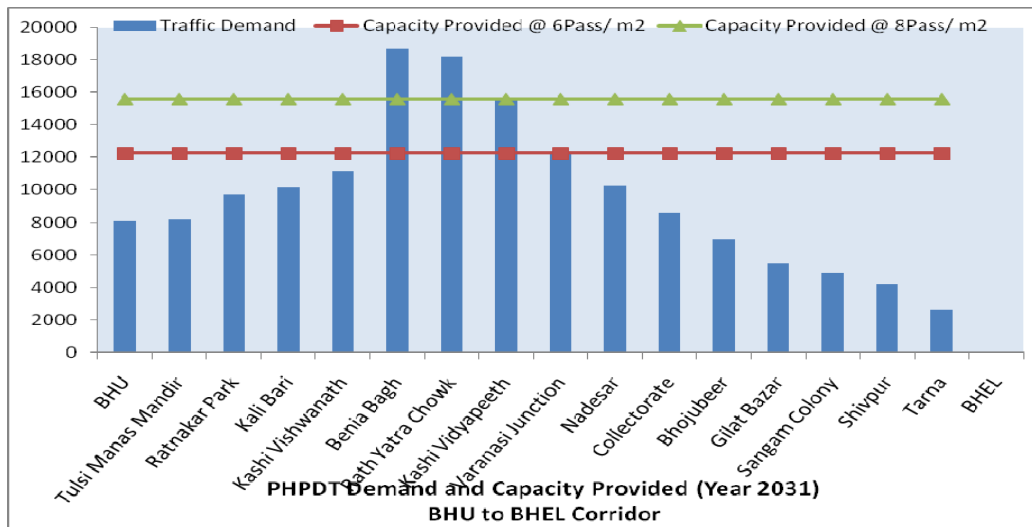


FIGURE 9.2: PHPDT DEMAND AND CAPACITY PROVIDED (2031) FOR BHU TO BHEL CORRIDOR

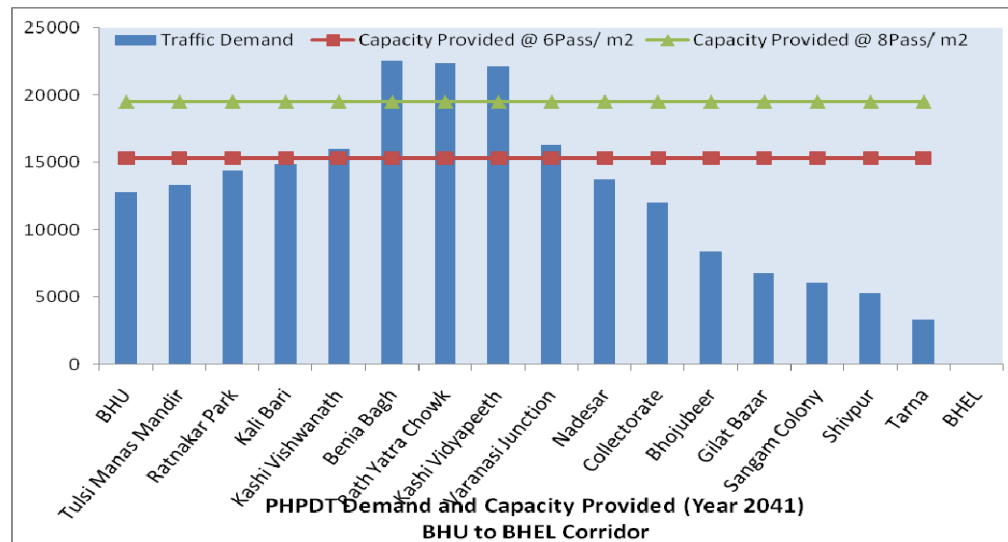


• **Year 2041**

The train operation for corridor 1 in year 2041 is planned with 3 car rake operating at 174 seconds headway during peak period. The peak hour peak direction traffic will be met by running 21 trains of 3 car during peak periods with the carrying capacity of 16086 @ 6 passengers/m² of standee area (Capacity of 20475 @ 8 passengers/m² of standee area). The planned PHPDT capacity is less than the demand in the section between Kashi Vishwanath to Varanasi Junction section. However capacity in this section can be met by

carrying standees @ 8 passengers/ m2.

FIGURE 9.3: PHPDT DEMAND AND CAPACITY PROVIDED (2041) FOR BHU TO BHEL CORRIDOR



- **Design Year**

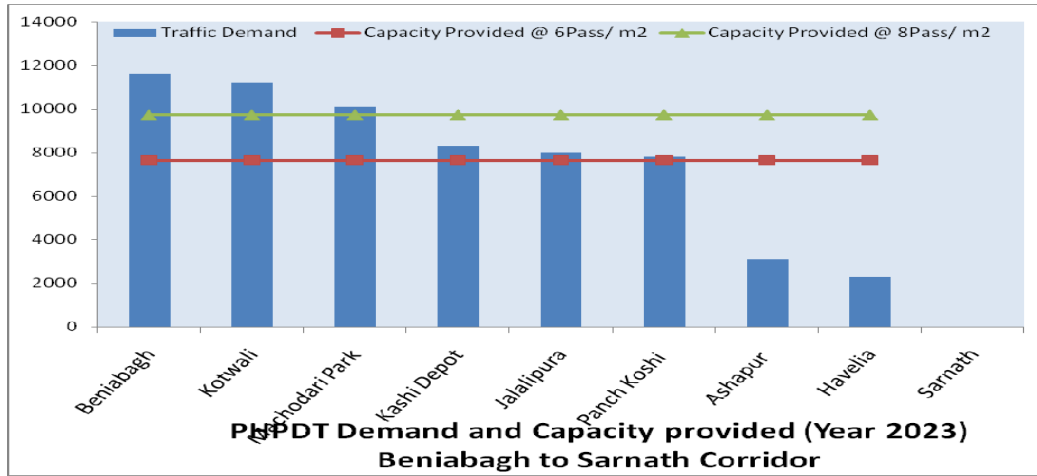
The train operation for BHU to BHEL corridor for the design year has been planned with 3 car rake operating at 144 seconds headway during peak period. The peak hour peak direction traffic of 24000 passengers will be met by running 25 trains of 3 car during peak periods with the carrying capacity of 19150 @ 6 passengers/m² of standee area (Capacity of 24375 @ 8 passengers/m² of standee area)

9.4.2 Corridor 2 – Beniabagh to Sarnath

- **Year 2023**

The train operation with 3 car trains at 360 seconds peak period headway has been proposed for year 2023 with PHPDT demand of 7660 passengers @ 6 passengers/m² of standee area (9750 passengers @8 passengers/m² of standee area). With the proposed headway, the planned capacity is slightly less than PHPDT demand in the section between Beniabagh to Machodari Park Station. However capacity in this section can be met by carrying standees @ 8 passengers/ m2.

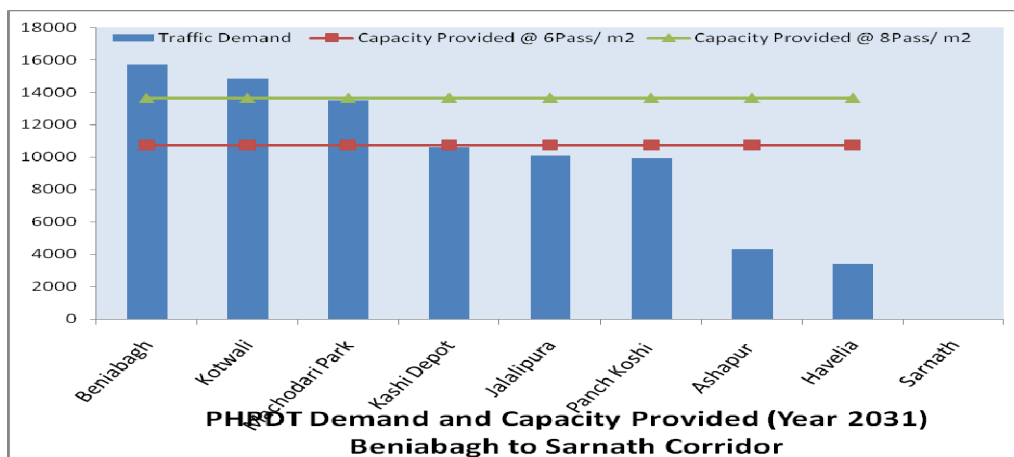
FIGURE 9.4: PHPDT DEMAND AND CAPACITY PROVIDED (2023) FOR BENIABAGH TO SARNATH



- Year 2031**

Train operation for the corridor in year 2031 is planned with 3 car train composition and 258 seconds headway during peak period. The planned peak hour peak direction traffic (PHPDT) capacity is 10724 @ 6 passengers/m² of standee area (Capacity of 13650 @ 8 passengers/m² of standee area). The planned is less than the PHPDT demand in the section between Beniabagh to Kashi Bus Depot station. However capacity in this section can be met by carrying standees @ 8 passengers/ m².

FIGURE 9.5: PHPDT DEMAND AND CAPACITY PROVIDED (2031) FOR BENIABAGH TO SARNATH CORRIDOR

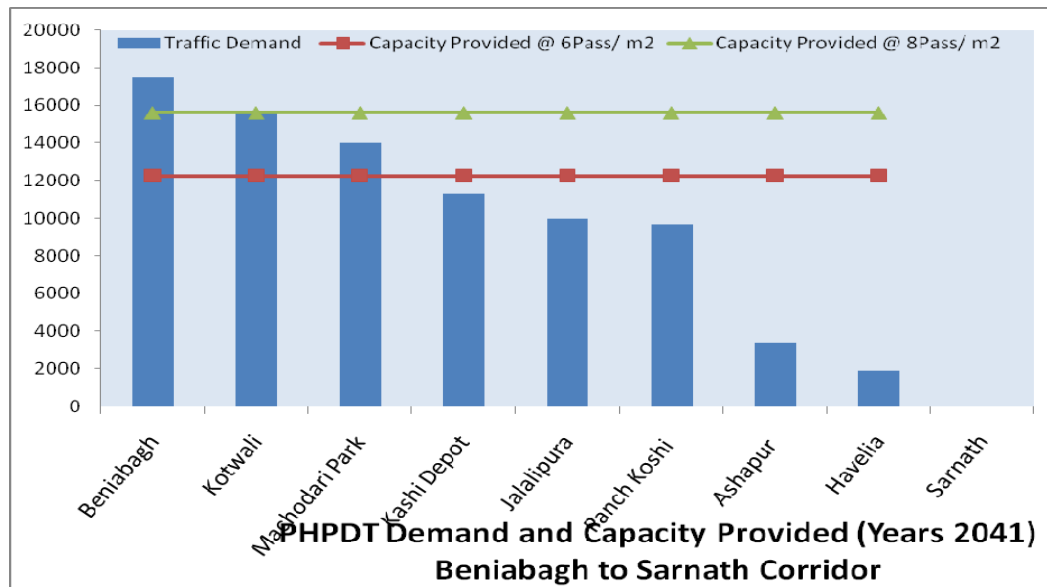


- Year 2041**

The train operation with 3 car trains at 228 seconds peak period headway has been proposed for year 2041 with PHPDT capacity of 12256 passengers with standee density @ 6 persons/m² (capacity of 15600 @8 passengers/m²). With

the proposed headway, planned capacity is slightly less than PHPDT demand in the section between Beniabagh to Machodari Park Station. However capacity in this section can be met by carrying standees @ 8 passengers/ m².

FIGURE 9.6: PHPDT DEMAND AND CAPACITY PROVIDED (2041) FOR BENIABAGH TO SARANTH



- **Design Year**

The train operation with 3 car trains at 192 seconds peak period headway has been proposed for the design with PHPDT capacity of 14554 passengers with standee density @ 6 persons/m² (capacity of 18525 @ 8 passengers/m²).

The rolling stock is designed for carrying higher density loading @ 8 standee passengers per square meter and in the sections where PHPDT demand exceeds the planned capacity, overloading during these periods will help in reducing the demand for increased deployment of rolling stock and the optimum utilization of rolling stock will be achieved.

9.5 HOURLY TRAIN OPERATION PLAN

The services for Varanasi Metro rail shall be operational for 16 hours of a day (6:00 hrs to 22:00 hrs). No services are proposed between 22:00 hrs to 6:00 hrs which are reserved for maintenance of infrastructure and rolling stock. The hourly distribution of daily train operation between BHU to BHEL and Beniabagh to Sarnath corridors for various horizon years is enclosed in

Annexure 9.2(a) & 9.2 (b).

9.6 VEHICLE KILOMETER

Based on the above planning and assuming 340 days service in a year (after considering maintenance period) Vehicle Kilometers have been estimated. Vehicle Kilometers for the proposed train operation for years 2023, 2031, 2041 and Design year is given below in **Tables 9.4 & 9.5**.

TABLE 9.4: VEHICLE KILOMETER: BHU TO BHEL

Year	2023	2031	2041	Design
Section Length	19.40	19.40	19.40	19.40
No of Cars per Train	3	3	3	3
No of working Days/year	340	340	340	340
Number of Trains per day each way	176	212	285	335
Daily Train –Km	3414.4	4112.8	5529	6499
Annual Train -Km (10 ⁵)	11.61	13.98	18.8	22.1
Annual Vehicle- KM (10 ⁵)	34.83	41.94	56.4	66.3

TABLE 9.5: VEHICLE KILOMETER: BENIABAGH TO SARNATH

Year	2023	2031	2041	Design
Section Length	9.90	9.90	9.90	9.90
No of Cars per Train	3	3	3	3
No of working Days/year	340	340	340	340
Number of Trains per day each way	120	176	209	257
Daily Train –Km	1188	1742.4	2069.1	2544.3
Annual Train -Km (10 ⁵)	4.04	5.92	7.03	8.65
Annual Vehicle- KM (10 ⁵)	12.12	17.76	21.09	25.95

9.7 ROLLING STOCK REQUIREMENT

Requirements of coaches for the corridor are calculated based on following;

- Coach requirement has been calculated based on headway during peak hours.
- Scheduled speed of 35 kmph for BHU to BHEL corridor and 34 kmph for Beniabagh to Sarnath corridor.
- Turn round time as **6 min** at terminal stations.
- The calculated number of rakes in fraction is rounded off to next higher number.
- Traffic reserve is taken as **5%** to cater to failure of train on line and to make up for operational time lost.
- Repair and maintenance has been estimated as **10%** of total requirement (Bare+Traffic Reserve).

Based on above assumptions and train operation plan, the rake requirement for various horizon years is indicated in **Table 9.6**.

TABLE 9.6: ROLLING STOCK REQUIREMENT

Train Operation / Corridor	Time horizon Year	Head way in sec.	Section length km	Rakes Reqd.	Bare rake Reqmt	Traffic spare @5%	Maint. Spare @10%	Total rake req.	Total coach req.
BHU to BHEL (19.4 Km)	2023	276	19.4	17.1	18	1	2	21	63
	2031	228	19.4	20.7	21	1	2	24	72
	2041	174	19.4	27.1	28	1	3	32	96
	Design	144	19.4	32.7	33	2	3	38	114
Beniabagh to Sarnath (9.9 Km)	2023	360	9.9	7.8	8	1	1	10	30
	2031	258	9.9	10.9	11	1	1	13	39
	2041	228	9.9	12.4	13	1	1	15	45
	Design	192	9.9	14.7	15	1	2	18	54

Annexure-9.1

SECTION WISE TRAFFIC FOR IIT BHU TO BHEL CORRIDOR

FROM	TO	2023	2031	2041
BHU	Tulsi Manas Mandir	5000	8100	12800
Tulsi Manas Mandir	Ratnakar Park	5800	8200	13300
Ratnakar Park	Kali Bari	6700	9700	14400
Kali Bari	Kashi Vishwanath	7400	10200	14900
Kashi Vishwanath	Benia Bagh	8600	11200	16000
Benia Bagh	Rath Yatra Chowk	15600	18700	22600
Rath Yatra Chowk	Kashi Vidyapeeth	15300	18200	22400
Kashi Vidyapeeth	Varanasi Junction	12400	15600	22100
Varanasi Junction	Nadesar	8500	12400	16300
Nadesar	Collectorate	7100	10300	13800
Collectorate	Bhojubeer	5700	8600	12000
Bhojubeer	Gilat Bazar	5600	7000	8400
Gilat Bazar	Sangam Colony	4400	5500	6800
Sangam Colony	Shivpur	3900	4900	6100
Shivpur	Tarna	3300	4200	5300
Tarna	BHEL	2100	2600	3300

SECTION WISE TRAFFIC FOR BENIABAGH TO SARNATH CORRIDOR

FROM	TO	2023	2031	2041
Beniabagh	Kotwali	11600	15700	17500
Kotwali	Machodari Park	11200	14800	15700
Machodari Park	Kashi Bus Depot	10100	13500	14000
Kashi Bus Depot	Jalalipura	8300	10600	11300
Jalalipura	Panch Koshi	8000	10100	10000
Panch Koshi	Ashapur	7800	9900	9700
Ashapur	Havelia	3100	4300	3400
Havelia	Sarnath	2300	3400	1900

Annexure-9.2(a)

HOURLY TRAIN OPERATION PLAN: BHU TO BHEL CORRIDOR

Time of Day	Year 2023 (3 Car)		Year 2031 (3 Car)		Year 2041 (3 Car)		Design Year (3 Car)	
	Head way (sec)	Trains /hr	Head way (min)	Trains /hr	Head way (min)	Train s/hr	Headwa y (min)	Trains /hr
6 to 7	360	10	300	12	240	15	210	17
7 to 8	300	12	258	14	192	19	162	22
8 to 9	276	13	228	16	174	21	144	25
9 to 10	276	13	228	16	174	21	144	25
10 to 11	300	12	258	14	192	19	162	22
11 to 12	300	12	258	14	192	19	162	22
12 to 13	360	10	300	12	210	17	180	20
13 to 14	450	8	360	10	240	15	210	17
14 to 15	600	6	450	8	300	12	240	15
15 to 16	450	8	360	10	240	15	210	17
16 to 17	300	12	258	14	210	17	162	22
17 to 18	276	13	228	16	174	21	144	25
18 to 19	276	13	228	16	174	21	144	25
19 to 20	300	12	258	14	192	19	162	22
20 to 21	300	12	258	14	192	19	162	22
21 to 22	360	10	300	12	240	15	210	17
Total No. of trains per direction per day		176		212		285		335

Annexure-9.2(b)

HOURLY TRAIN OPERATION PLAN: BENIABAGH TO SARNATH CORRIDOR

Time of Day	Year 2023 (3 Car)		Year 2031 (3 Car)		Year 2041 (3Car)		Design Year (3Car)	
	Head way (min)	Trains /hr	Head way (min)	Trains /hr	Head way (min)	Train s/hr	Headway (min)	Trains/ hr
5 to 6	600	6	360	10	300	12	240	15
6 to 7	450	8	300	12	258	14	210	17
7 to 8	360	10	258	14	228	16	192	19
8 to 9	360	10	258	14	228	16	192	19
9 to 10	450	8	300	12	258	14	210	17
10 to 11	600	6	360	10	276	13	240	15
11 to 12	600	6	450	8	300	12	276	13
12 to 13	720	5	450	8	360	10	276	13
13 to 14	600	6	600	6	450	8	300	12
14 to 15	600	6	450	8	360	10	276	13
15 to 16	450	8	300	12	300	12	210	17
16 to 17	360	10	258	14	228	16	192	19
17 to 18	360	10	258	14	228	16	192	19
18 to 19	450	8	300	12	258	14	210	17
19 to 20	516	7	300	12	258	14	210	17
20 to 21	600	6	360	10	300	12	240	15
21 to 22	600	6	360	10	300	12	240	15
22 to 23	450	8	300	12	258	14	210	17
Total No. of trains per direction per day		120		176		209		257