The Preparatory Study on The Dhaka Mass Rapid Transit Development Project (Line 1) In Bangladesh

Draft Final Report 2

November 2018

Japan International Cooperation Agency (JICA)

ALMEC CORPORATION
Oriental Consultants Global Co., Ltd.
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Katahira & Engineers International

Exchange Rate (April 2018)

1USD=107JPY

1USD=83BDT

1BDT=1.29JPY

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ABBREVIATIONS

ADB	Asian Development Bank
AFD	Agence Francaise de Developpement
BBA	Bangladesh Bridge Authority
BIWTA	Bangladesh Inland Water Transport Authority
BIWTC	Bangladesh Inland Water Transport Corporation
BR	Bangladesh Railway
BRT	Bus Rapid Transit
BRTA	Bangladesh Road Transport Authority
BRTC	Bangladesh Road Transport Corporation
BUET	Bangladesh University of Engineering and Technology
C&B	Construction & Building
CASE	Clean Air and Sustainable Environment
CNG	Compressed Natural Gas
DAP	Detail Area Plan
DCC	Dhaka City Corporation
DF/R	Draft Final Report
DFID	Department for International Development
DHUTS	Dhaka Urban Transportation Network Development Study
DMA	Dhaka Metropolitan Area
DMDP	Dhaka Metropolitan Development Plan
DMP	Dhaka Metropolitan Police
DMTA	Dhaka Metropolitan Transport Authority
DMTC	Dhaka Mass Transit Company
DNCC	Dhaka North City Corporation
DPP	Department of Printing and Publications
DRTM	Directorate of Road Transport Maintenance
DSCC	Dhaka South City Corporation
DTCA	Dhaka Transport Coordination Authority
DTCB	Dhaka Transport Coordination Board
ECNEC	Executive Committee of the National Economic Council
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
F/R	Final Report
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GIBR	Government Inspector of the Bangladesh Railways
GOB	Government of Bangladesh
GOJ	Government of Japan
GPS	Global Positioning System
HIS	Household Interview Survey
IC/R	Inception Report
IT/R	Interim Report
JICA	Japan International Cooperation Agency
LDC	Least Developed Country
LGD	Local Government Division
LGED	Local Government Engineering Department

MOC	Ministry of Communication
MOHPW	Ministry of Housing and Public Works
MOR	Ministry of Railways
MRT	Mass Rapid Transit
NGO	Non-Governmental Organizations
OD	Origin and Destination
ODA	Official Development Assistance
PPPO	Public Private Partnership Office
PT	Project Team
RAJUK	Rajdhani Unnayan Kartripakkha
RD	Record of Discussions
RHD	Road and Highway Department
RTC	Regional Transport Committee
SC	Steering Committee
SEA	Strategic Environmental Assessment
SPA	Survey and Plan Area
STP	Strategic Transport Plan for Dhaka
TDM	Traffic Demand Management
TOR	Terms of Reference
UMRT	Urban Mass Raid Transit
WB	World Bank
WG	Working Group

1 Introduction

1.1 Background

Dhaka City is the capital of the +People's Republic of Bangladesh. The Dhaka Metropolitan Area (DMA) has a population of 9.3 million in 2011. Currently, urban transportation in the DMA relies mostly on road transport, where car, bus, auto-rickshaw, rickshaw, etc. coexist. This creates serious traffic congestion in addition to health hazards caused by traffic pollution including air pollution. With the rapid national economic growth, the urban population is expected to increase and so will the number of privately owned automobiles. Therefore, improving the urban (public) transportation system in the DMA has become a critical issue to ease traffic congestion and arrest environmental deterioration.

With this situation, the government of Bangladesh (GOB) formulated the "Strategic Transport Plan for Dhaka" (STP) in 2005 in cooperation with the World Bank (WB). Since the STP was officially approved by the GOB, it is expected that each donor will hereafter provide the assistance based on this STP to improve the urban transportation situation. And the Japan International Cooperation Agency (JICA) conducted the Dhaka Urban Transportation Network Development Study (DHUTS) Phase 1 from March 2009 with the DTCA as its counterpart agency. The study's objectives were to conceptualize the basic urban development scenario for the DMA by 2025 and to select priority projects that would help build such a scenario. That study recommended the MRT Line 6 as a priority project. As a result, JICA conducted the feasibility study on MRT Line 6 under DHUTS Phase 2. Following these studies, the GOB and JICA concluded the loan agreement on the "Dhaka Mass Rapid Transit Development Project" on February 2013 to construct MRT Line 6. Meanwhile, the World Bank finished the feasibility study and basic design of BRT Line 3 and is now preparing the project's detailed design. On the other hand, the Asian Development Bank (ADB) already completed the basic design of the BRT Line 3 extension project (from the airport to Gazipur) and since April 2013 has conducted the activities for the detailed design stage.

As for the transportation network plan, the STP, which was formulated in 2005, identified three BRT lines (i.e., BRT Lines 1, 2, and 3) that were supposed to commence before 2010. But except for MRT Line 6 and BRT Line 3 above, other projects stated in the STP have not started yet and so the STP needed to be reviewed and updated. And JICA conducted the Project on the Revision and Updating of the Strategic Transport Plan for Dhaka (RSTP) from May 2014 with the DTCA as its counterpart agency.

It is thus under these circumstances that the GOB and JICA have made several preliminary discussions in order to identify priority projects in the field of transport sector, and agreed to make preparation for Dhaka Mass Rapid Transit Development Project (Line 1 and Line 5). Accordingly, JICA dispatched a mission on the project to GOB from March 7, 2016 in order to develop scope and implementing arrangements of a further survey which would study feasibility of the project.

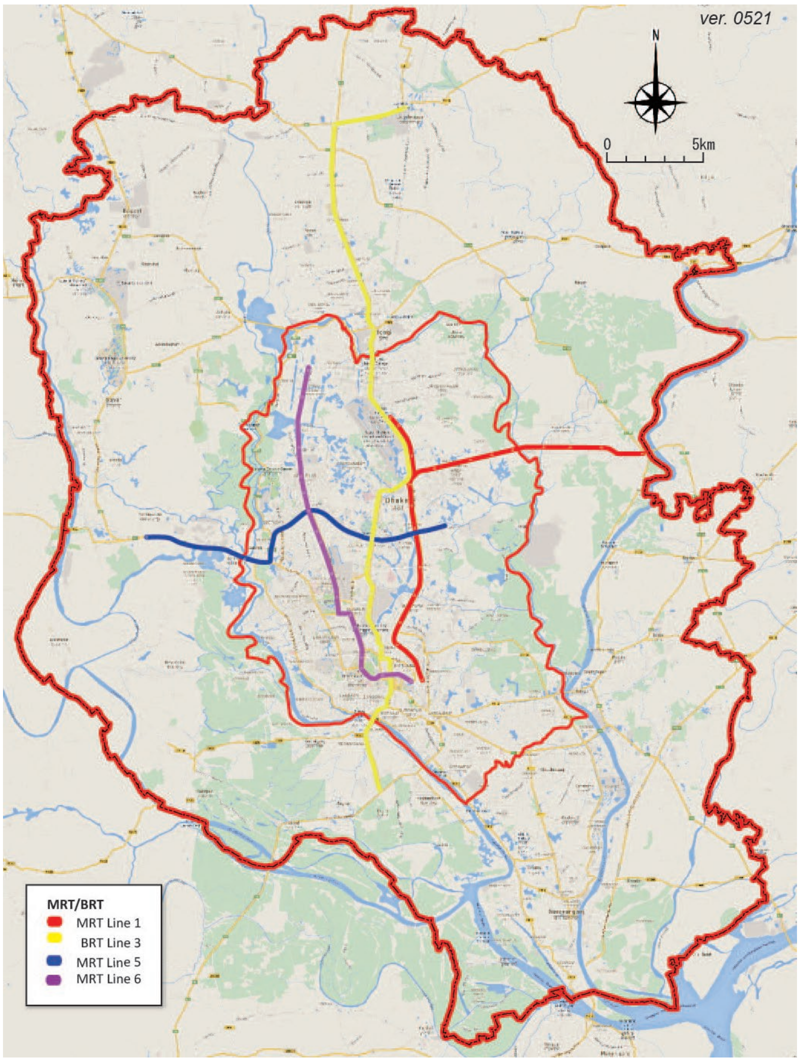
1.2 Objectives of the Project

The objectives of the Project are to alleviate traffic congestion and improve air pollution in the Dhaka City by constructing mass rapid transit system, thereby contributing to the economic and social development of Greater Dhaka Region and improvement of urban environment.

MRT Line 1 (1st phase) and MRT Line 5 (1st phase) were prioritized as the high priority projects by RSTP. In this project, feasibility study of MRT Line 1 (1st phase) and MRT Line 5 (1st phase) supposed to be implemented and set up feasible project plan and project implementation plan considering of technical, economic and budgeting, and environment and social aspects.

1.3 Scope of the Project

As mentioned in the objectives of the study, when MRT Line 1 and Line 5 will be nominated as an ODA project such as Yen-loan project, the project implementation plan and consultation plan will be required to appraise by international-financing agencies. In the appraisal, the appraisal, the following these issues are essentials.

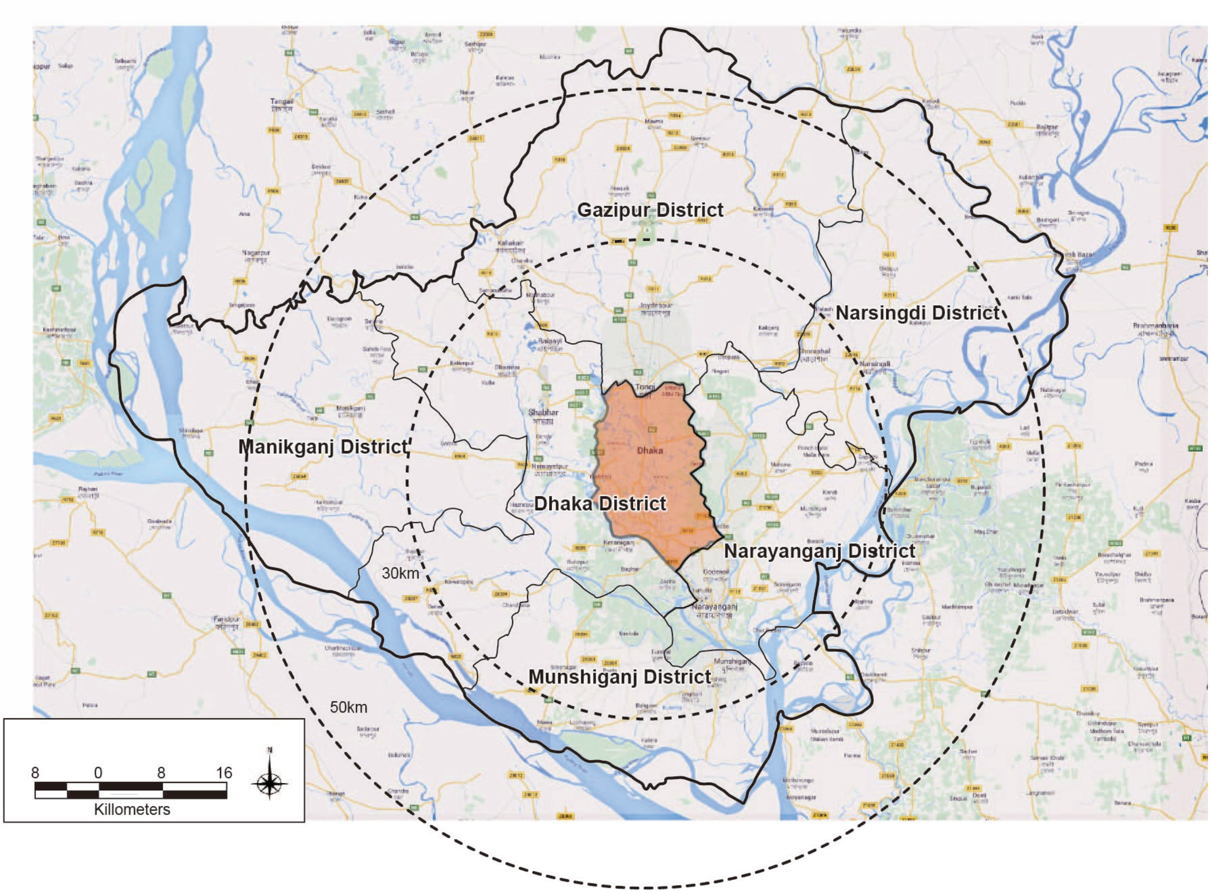


Source: JICA Study Team

Figure 1.3.1 MRT and BRT Routes in RAJUK Area

1) **Project Site**

Districts of Dhaka, Gazipur, Manikganj, Narayanganj, Munshiganj and Narsingdi.



Source: JICA Study Team

Figure 1.3.2 Project Site

2) **Executing Agencies**

Dhaka Transport Coordination Authority (DTCA)

Dhaka Mass Transit Company Limited (DMTC)

1.4 Basic Policy and Points of the Study

1) Key Points of the Study

Outputs of this study will be the basic information to evaluate the MRT projects as Japan's yean load project. So, the following issues need to be considered with JICA's guidelines when compiling the results.

1. Methods of procurements and constructions (including TORs of BD and DD)
2. Project Costs (including MM of consultant services)
3. Capacity of Implementation and O&M
4. Indicators of Operation and Evaluation

2) Schedule of ECC

This project is the feasibility study of MRT Line 1 and Line 5, and the environmental Impact Assessment (EIA) and the Resettlement Action Plan (RAP) will be made for each MRT Lines.

3) Consistencies with the MRT Line 6

Standardisation of MRT system needs to be required to improve their quality and make them safer, and also in RSTP proposed MRT Lines should be networked each other. Therefore, some system of MRT Line 1 and Line 5 should be installed same with MRT Line 6.

(1) Integration of System, Regulations and Standard

MRT Line 1, Line 5 and Line 6 will be shared tracks and station in the future, so MRT systems, regulations and standards need to be integrated.

(2) Integration of Automated Fare Collection System

Automated fare collection system of MRT Line 1 and Line 5 will be installed same system with MRT Line 6. In order to adopt connected ride discount system with MRT lines and other public transports.

(3) Connectivity of MRT Line 1 with MRT Line 6 at Motijheel Area

At the current situation, planned Motijheel station of MRT Line 6 will be far from proposed Kamalapur station of MRT Line 1. In this project, connectivity between those stations need to be considered.

4) Development around the station

A transit-oriented development (TOD) typically includes a central MRT station surrounded by a high-density mixed-use area, with lower-density areas spreading out from this centre. A TOD is also typically designed to be more walkable than other built-up areas, through using smaller block sizes and reducing the land area dedicated to automobiles.

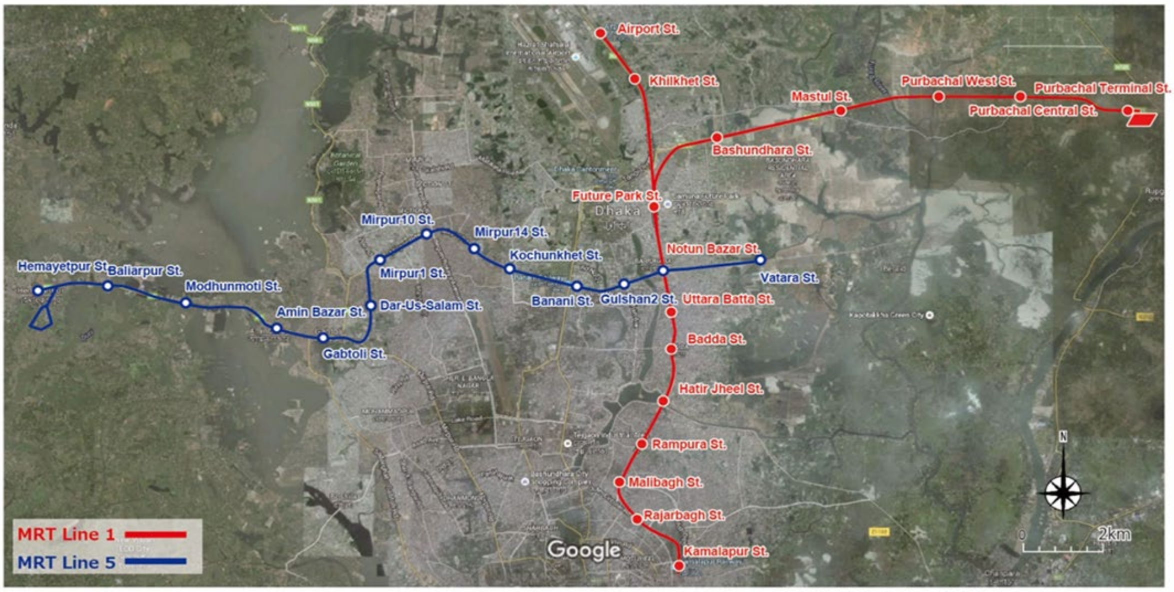
TOD allows the transport operator to benefit from alternative revenue, and increased ridership. In turn, this provides opportunity for better services to be offered to the public.

2 Characteristics of the Project Area

2.1 Location of the Project Area and Spatial Structure

2.1.1 Location

MRT Lines 1 and 5 were prioritized as high priority projects by RSTP. In this project, the feasibility study of MRT Lines 1 and 5 are supposed to be implemented. The location of Lines 1 and 5 is shown in Figure 2.1.1. The location and depo area are tentative and will be determined in this study.



Imagery ©2016 DigitalGlobe, Map data ©2016 Google

Figure 2.1.1 Location of MRT Line 1 and Line 5

2.1.2 Administrative Units and Land Areas

MRT Lines 1 and 5 are located in Greater Dhaka Area (GDA). The survey area covers the whole GDA that consists of Dhaka, Gazipur, Manikganj, Munshiganj, Narayanganj, and Narshingdi districts. The total area is 7,500 sq. km with 24.4 million or more residents since 2011. The more developed 1,500-km^2 Rajdhani Unnayan Kartripakkha (RAJUK) has 14.8 million residents. In contrast to the low population density of the entire GDA (31 person/ha), RAJUK has a very high density at 111 person/ha. The center of RAJUK can also be expected to have a much higher population density than that of the entire RAJUK.

The project area is generally low, flat, fertile, and flood-prone. While most of the developed area within RAJUK is at an elevation of 6–8 m above sea level, the elevation of Dhaka City Corporation (DCC) varies from 2 to 13 m above sea level. Due to the topographical and geological characteristics of GDA, it is inevitable to experience floods and overflow during the rainy season. There were water channels, natural drainages, and low land areas in and around Dhaka in the past, which contributes to the retention and discharge of rain water. However, the acceleration of urban sprawl has interrupted those water retention areas.

As of 2005, 25% of the national gross domestic product (GDP) was contributed by the gross regional domestic product (GRDP) of GDA. The GRDP of Dhaka City contributes 15% to the national GDP as it is a capital and economic centre of Bangladesh. The agricultural sector is still dominant outside RAJUK, while industrialization has been promoted within it.

There are also two export processing zones (EPZs) in Savar in Dhaka District and Narayanganj City in Narayanganj District. Moreover, the informal economic sector provides significant number of job opportunities in Dhaka.

Like other parts of Bangladesh, GDA is largely dominated by agricultural land use; whilst residential areas spread along the main road and river networks. The large industrial areas and commercial/business areas can be found only in RAJUK. The residential or housing development in RAJUK mainly focus on rich households; therefore, many immigrants from outside RAJUK and low-income households are forced to live in slums where there is no access to the required basic infrastructures. One of the many reasons of urban development delay outside RAJUK area is because of the lack of transport infrastructures. Without transport networks, people and goods cannot be mobilized.

The provision of basic infrastructures varies by GDA district. The electrification rate of GDA, however, is only 63% while 97% of the households in Dhaka district has access to electricity. Coverage of piped drinking water varies between 37–95%. Narayanganj district has the highest coverage in GDA. Provision of sanitary water (with water seal) is very low with only 38% are provided in GDA.

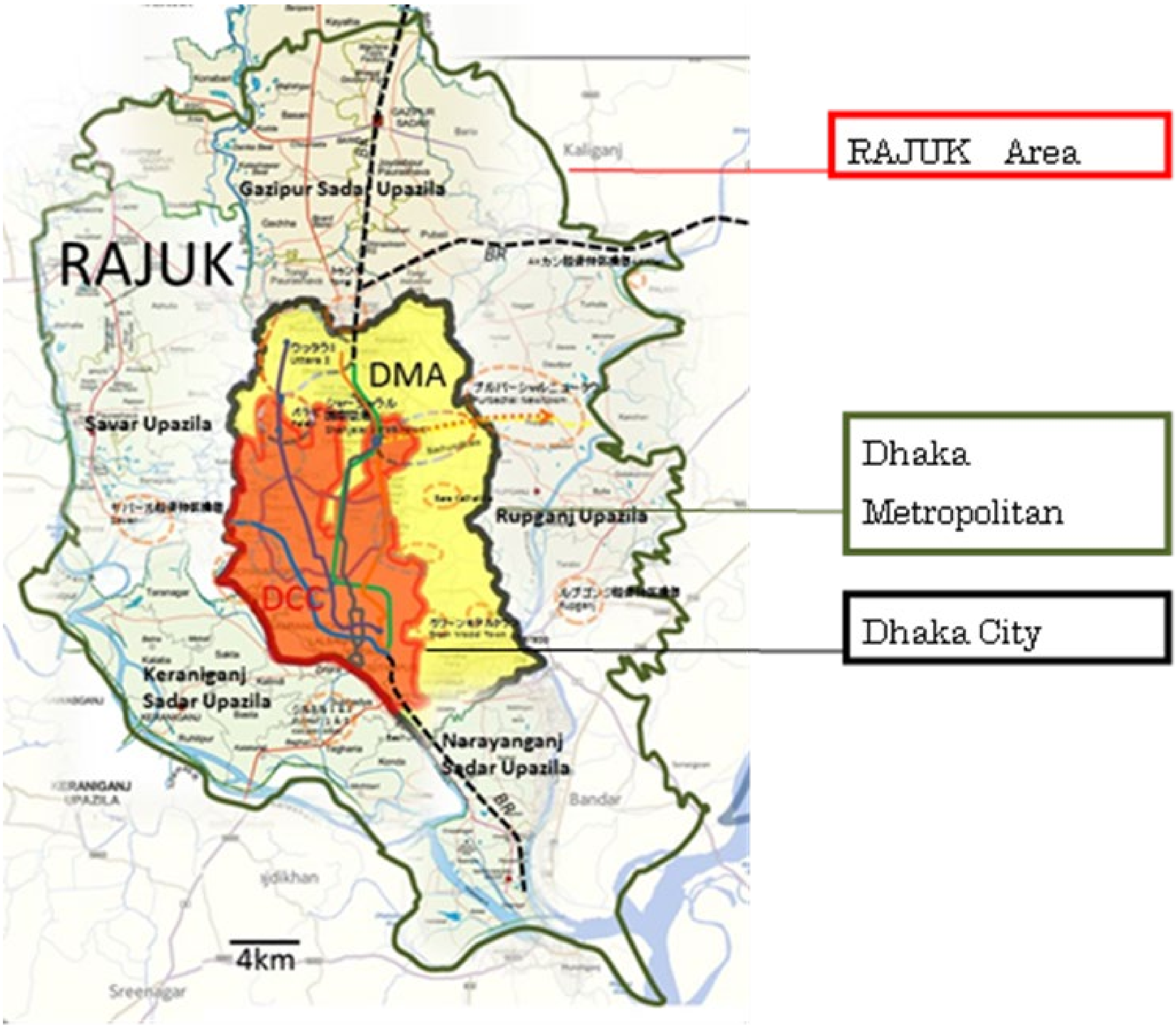


Figure 2.1.2 Study Area

2.2 Socio-Economic Profile

2.2.1 Population

1) Population

The total population of GDA in 2011 was approximately 23.5 million, which was 15.6% of the national population. Among the districts, Dhaka has the largest population with 51.3% of GDA; however, Gazipur showed the most rapid increase of population in the period of 2001–2011 and has the second largest population among all the districts. On the other hand, the populations of Manikganj, Munshiganj, and Narsingdi grew slowly compared to GDA, which suggests centralization of population (see Table 2.2.1).

Table 2.2.1 Population and Area of GDA District

District		Area (sq.km)1)	Population		AGR (%/year)
			2001	2011	
GDA	Dhaka	1,463.6	9,036,647	12,043,977	2.91
	Gazipur	1,806.4	2,143,200	3,403,912	4.73
	Manikganj	1,384.7	1,343,749	1,392,867	0.35
	Munshiganj	1,004.3	1,353,483	1,445,660	0.66
	Narayanganj	684.4	2,300,514	2,948,217	2.51
	Narsingdi	1,150.1	1,983,449	2,224,944	1.15
	TOTAL	7,492,5	18,161,042	23,459,577	2.59
% to National		5.1	13.9	15.6	-
National		147,568.9	124,355,263	149,772,364	

1) Area data from Statistical Year Book Bangladesh 2015
Source: Population and Housing Census 2011

RAJUK planning area covers some parts of Dhaka and Gazipur Districts as well as Narayanganj with 20.1% of the GDA. As per population, RAJUK area has 14.9 million in 2011, and the share of its share to GDA increased from 55.3% in 2001 to 60.7% in 2011 due to its rapid population increase (see Table 2.2.2).

On the contrary, the exterior of RAJUK area recorded lower growth ratio of population, except Gazipur District. RAJUK area which does not fall within the DCC South and North has been developing intensively for urbanization and population. The shape of expanding urbanized area becomes elongated from the north to south.

Table 2.2.2 Population and Area of RAJUK Area

	Area (km^2)	Population		AGR (%/year)
		2001	2011	
RAJUK Area	1502.3	10,037,120	14,819,160	3.99
Outside RAJUK Area	5,990.2	8,123,970	9,585,030	1.39
TOTAL	7,493	18,161	24,404	3.00

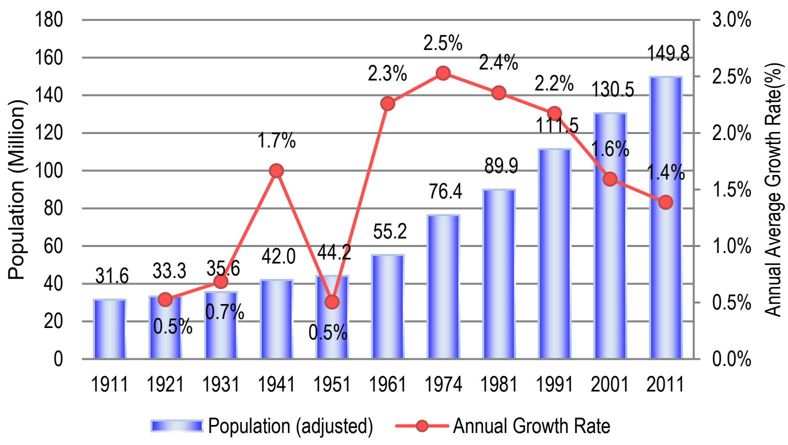
Source: Population and Housing Census 2011

2) Population Growth

The Bangladesh Bureau of Statistics has been carrying out the Population and Housing Census since 1872. As shown in Figure 2.2.1, the average annual population growth rate (population AAGR) increased from 0.5% in 1921 to 2.5% in 1974 except between 1941 to 1951 due to World War II and starvation. More than 3 million people was assumed to have died due to starvation and malnutrition. However, after 1974, the population AAGR decreased from 2.5% to 1.4% in 2011.

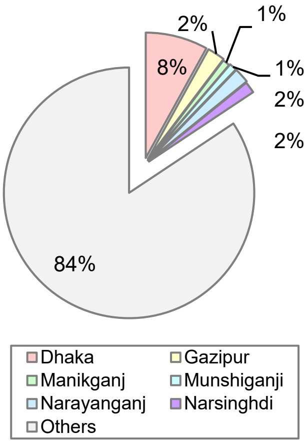
In 2011, the population of GDA is 15.7% of the population of Bangladesh and has a population AAGR of 3.2% against a large number of social growth where only covers 5%

land area of Bangladesh as shown in Table 2.4. Among the GDA districts, the population of Dhaka covers more than half the GDA population. While Gazipur and Narayanganj's population are lower than Dhaka's, their population AAGRs are higher than convenient locations, which makes commute to Dhaka easy and they have a relatively lower land value.



Note: Adjusted population.
Source: Statistical Yearbook of Bangladesh 2012, BBS

Figure 2.2.1 Population and Average Annual Growth Rate



Source: Population and Housing Census 2011, BBS

Figure 2.2.2 Population Distribution in GDA (2011)

Table 2.2.3 Population Growth Rate in the Study Area

	Area (sq. km.)	Population ('000)		Population Share (%)		Growth Rate (%)	Population Density ('000 person/sq.km)	
		2001	2011	2001	2011	2001-2011	2001	2011
Bangladesh	147,570	130,523	149,772	100.0%	100.0%	1.4%	884	1,015
GDA	7,492	17,112	23,460	13.1%	15.7%	3.2%	2,284	3,131
- Dhaka	1,464	8,511	12,044	6.5%	8.0%	3.5%	5,814	8,227
- Gazipur	1,806	2,032	3,404	1.6%	2.3%	5.3%	1,125	1,885
- Manikganj	1,384	1,205	1,393	0.9%	0.9%	1.5%	871	1,007
- Munshiganji	1,004	1,294	1,446	1.0%	1.0%	1.1%	1,289	1,440
- Narayanganj	684	2,174	2,948	1.7%	2.0%	3.1%	3,178	4,310
- Narsinghdi	1,150	1,896	2,225	1.5%	1.5%	1.6%	1,649	1,935
Rajuk Area	1,429	10,804	15,853	8.3%	10.6%	3.9%	7,561	11,094

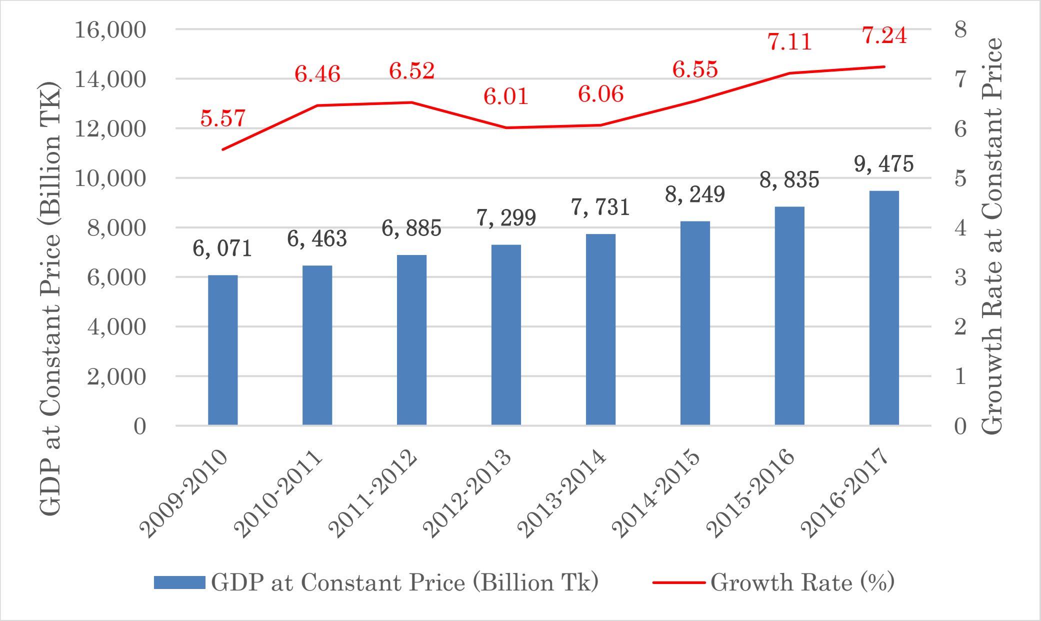
Source: Population and Housing Census 2011, BBS

2.2.2 GDP

1) National GDP and GDP Growth

Since 2009, Bangladesh has been consistent in continuing to achieve high GDP with almost more than 6% growth rate despite the impact of world recession, the European financial crisis in 2007–2008, and especially the growth rate at constant price since 2015 has been more than 7%.

The International Monetary Fund (IMF) published in the "World Economic Outlook, September 2014" the forecasted GDP growth rate of Bangladesh that will increase up to 7.0% by year 2017 based on economic development and potential. The GDP in Bangladesh has even exceeded the forecast in the report. Bangladesh has a high evaluation from international finance institutions that, in 2005, it was regarded as one of the Goldman Sach's Next11 recognizing its potential of becoming one of the world's larger economies after the BRICs (Brazil, Russia, India, and China) and JP Morgan's Frontier in 2007.



Source: GDP of Bangladesh 2013-2014, 2014-2015, 2015-2016,2016-2017, BBS

Figure 2.2.3 GDP Growth of Bangladesh (2009–2017)

Table 2.2.4 GDP Growth of Bangladesh (2009–2017)

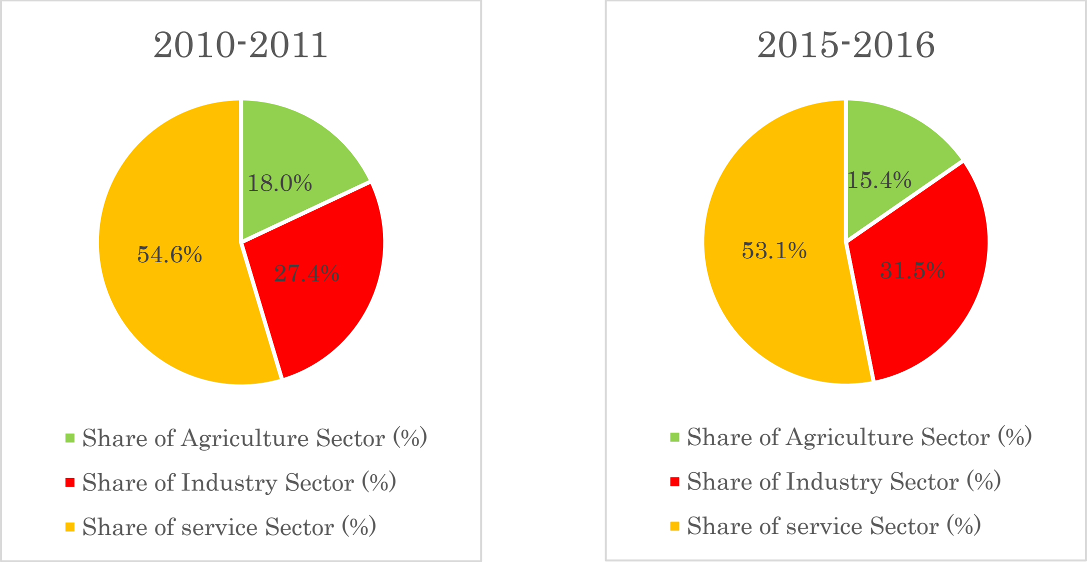
	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015	2015–2016	2016–2017
GDP at Constant Price (billion Tk)	6,071	6,463	6,885	7,299	7,731	8,249	8,835	9,475
Growth Rate (%)	5.57	6.46	6.52	6.01	6.06	6.55	7.11	7.24
Population (million)	147.8	148.7	151.6	153.7	155.8	157.9	159.89	161.75

Note: Constant Price base year is 2005–2006.
Source: GDP of Bangladesh 2013–2014, 2014–2015, 2015–2016,2016–2017, BBS

2) Sectoral Share of GDP

Figure 2.2.4 and Table 2.2.5 shows the proportion of each sector from years 2009 to 2017. During this period, the share of agriculture in GDP has gradually decreased from 18.0% to 15.4%. Contrary to the decrease, the share of industry has changed from 27.4% to 31.5%.

With the underlying “Perspective Plan of Bangladesh 2010–2021 (Vision 21), 2012”, the Government of Bangladesh has set a goal to become a middle-income country by year 2021. Accordingly, the target total GDP growth rate was set to 8% in 2015 and gradually increase to 10% by 2021. In addition, the government aims to increase the industrial sector GDP up to 37% in 2021, which is being assessed through the yearly achievement report.



Note: * Provisional Constant Price base year: 2005-2006
Agriculture: Agriculture, Forestry, Fishing
Industry: Mining, Quarrying, Manufacturing, Electricity, Gas, Water supply, Construction
Service: Wholesale, retail trade, repair of motor, hotel, restaurant, transport, storage, communication, financial intermediations, real estate, renting and business activities, public administration, defence, education, health, social works, etc.
Source: GDP of Bangladesh 2013-2014, 2014-2015, 2015-2016,2016-2017, BBS

Figure 2.2.4 Comparison of GDP between 2010-2011 and 2015-2016

Table 2.2.5 GDP by Industry Sector at Constant Price of Bangladesh (2009–2017)

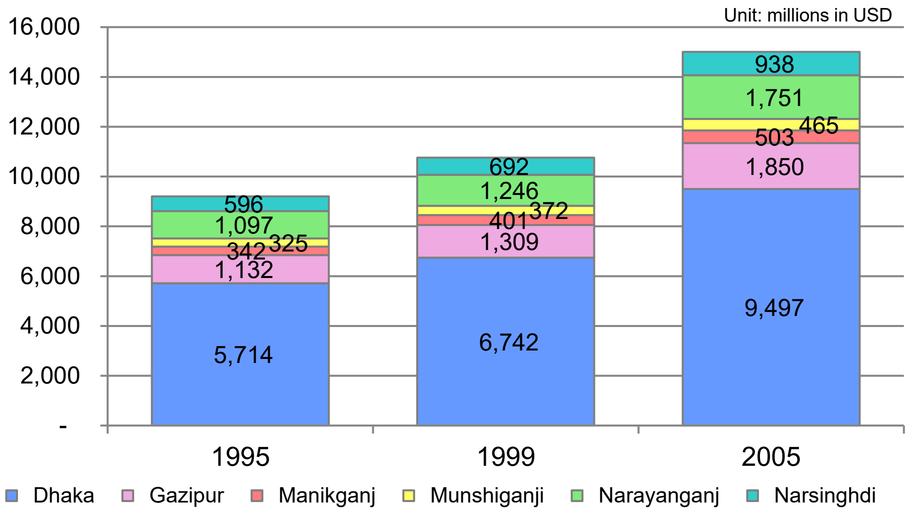
	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015	2015–2016	2016–2017 (p)
GDP of Agriculture Sector (billion TK)	1,065	1,113	1,146	1,174	1,226	1,266	1,302	1,346
GDP of Industry Sector (billion TK)	1,551	1,692	1,852	2,030	2,196	2,408	2,675	2,956
GDP of Service Sector (billion TK)	3,177	3,375	3,597	3,795	4,008	4,241	4,505	4,799
Share of Agriculture Sector (%)	18.4	18.0	17.4	16.8	16.5	16.0	15.4	14.8
Share of Industry Sector (%)	26.8	27.4	28.1	29.0	29.6	30.4	31.5	32.5
Share of service Sector (%)	54.8	54.6	54.5	54.2	53.9	53.6	53.1	52.7

Notes: * Provisional
Constant price base year in 2005–2006
Source: GDP of Bangladesh 2013–2014, 2014–2015, 2015–2016,2016–2017, BBS

3) GRDP in Study Area

The study area (GDA) is known to be the most developed and urbanized area in Bangladesh. As shown in Figure 2.2.5 and Table 2.2.6, the GRDP of the study area has taken 25% of the national GDP. Dhaka, which is the center of Bangladesh economy, contributes about 15% of national GDP and with the highest growth rate (AAGR = 5.9). Subsequently, Gazipur, Narayanganj, and Narsinghdi have a high growth rate of more than 5% per year.

According to Cambridge University survey (2014), the GRDP of Dhaka reached to US$37 billion, accounting for 35% of Bangladesh's economy.



Source: Growth, Income Inequality and Poverty Trends in Bangladesh: Implications for Development Strategy by Center for Policy Dialogue (CPD)

Figure 2.2.5 GRDP in the Study Area

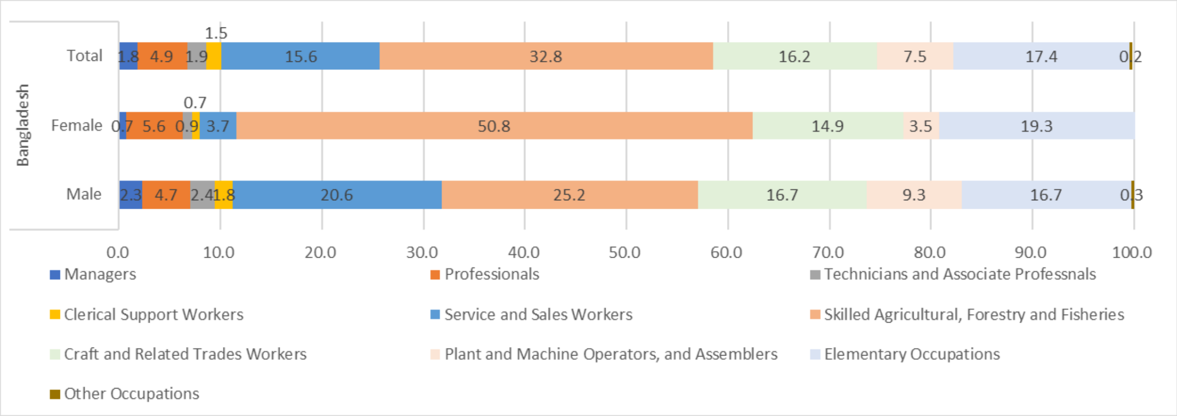
Table 2.2.6 GRDP in the Study Area

	GDP at Current Market Price (Million $US)						AAGR (%)	
	1995		1999		2005		1995-1999	1999-2005
	Million $US	National %	Million $US	National %	Million $US	National %	AAGR (%)	AAGR (%)
Bangladesh	39,065	100.0%	45,447	100.0%	59,748	100.0%	3.9%	4.7%
Study Area	9,206	23.6%	10,762	23.7%	15,004	25.1%	4.0%	5.7%
- Dhaka	5,714	14.6%	6,742	14.8%	9,497	15.9%	4.2%	5.9%
- Gazipur	1,132	2.9%	1,309	2.9%	1,850	3.1%	3.7%	5.9%
- Manikganj	342	0.9%	401	0.9%	503	0.8%	4.1%	3.8%
- Munshiganji	325	0.8%	372	0.8%	465	0.8%	3.4%	3.8%
- Narayanganj	1,097	2.8%	1,246	2.7%	1,751	2.9%	3.2%	5.8%
- Narsinghdi	596	1.5%	692	1.5%	938	1.6%	3.8%	5.2%

Source: Growth, Income Inequality and Poverty Trends in Bangladesh: Implications for Development Strategy by CPD

2.2.3 Labour and Employment

The share of employed population records are available in the Labor Force Survey. Though one-third of employment in Bangladesh engage in skilled agriculture, forestry, and fisheries, their proportion of employment in the urban area accounts for only 9.9%. On the other hand, the rate of manager, professionals, service, and sales workers in the urban area is higher than that in rural area (see Tables 2.2.6 and 2.2.7). There is a great difference between urban and rural areas in terms of distribution of employed persons (see Figure 2.2.7 and Table 2.2.8).



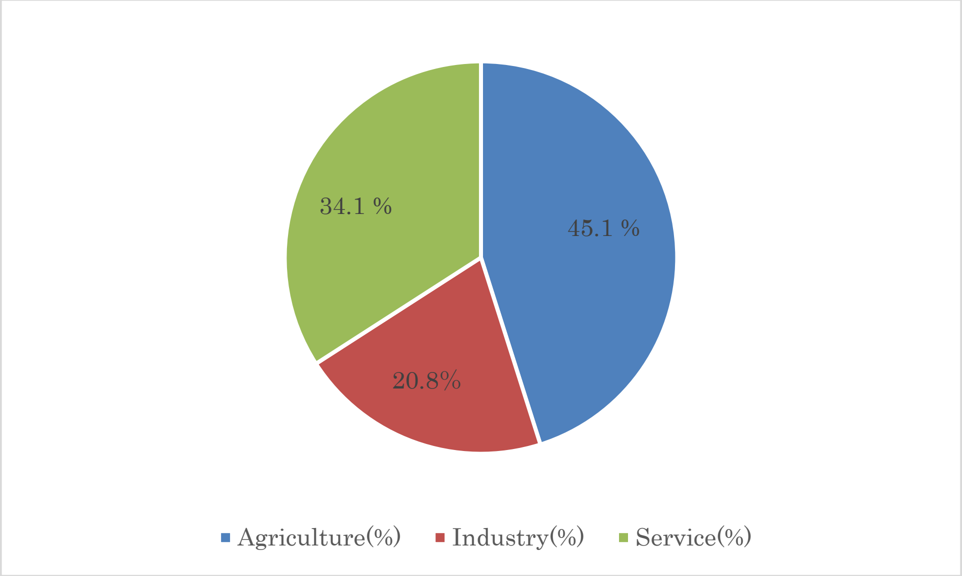
Source: Quarterly Labor Force Survey Report 2015–2016, BBS

Figure 2.2.6 Employment by Occupation and Industry (Age 15 or Older)

Table 2.2.7 Employment by Occupation and Industry (Age 15 or Older)

Occupation	Rural			Urban			Bangladesh		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Managers	1.1	0.3	0.8	5.4	2.1	4.5	2.3	0.7	1.8
Professionals	3.8	3.3	3.7	6.9	12.3	8.3	4.7	5.6	4.9
Technicians and Associate Professionals	1.7	0.6	1.3	4.1	1.8	3.5	2.4	0.9	1.9
Clerical Support Workers	1.3	0.4	1.0	3.1	1.6	2.7	1.8	0.7	1.5
Service and Sales Workers	17.4	2.5	12.7	28.6	7.3	22.9	20.6	3.7	15.6
Skilled Agricultural, Forestry, and Fisheries	32.5	62.0	41.6	7.4	16.9	9.9	25.2	50.8	32.8
Craft and Related Trades Workers	15.2	10.8	13.8	20.5	27.5	22.3	16.7	14.9	16.2
Plant and Machine Operators, and Assemblers	8.3	1.9	6.3	11.6	8.2	10.7	9.3	3.5	7.5
Elementary Occupations	18.6	18.3	18.5	11.9	22.3	14.7	16.7	19.3	17.4
Other Occupations	0.3	0.0	0.2	0.5	0.0	0.4	0.3	0.0	0.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Quarterly Labor Force Survey Report 2015–2016, BBS



Source: Quarterly Labor Force Survey Report 2015–2016, BBS

Figure 2.2.7 Distribution of Employed Persons by Broad Economic Sectors

Table 2.2.8 Distribution of Employed Persons by Broad Economic Sectors

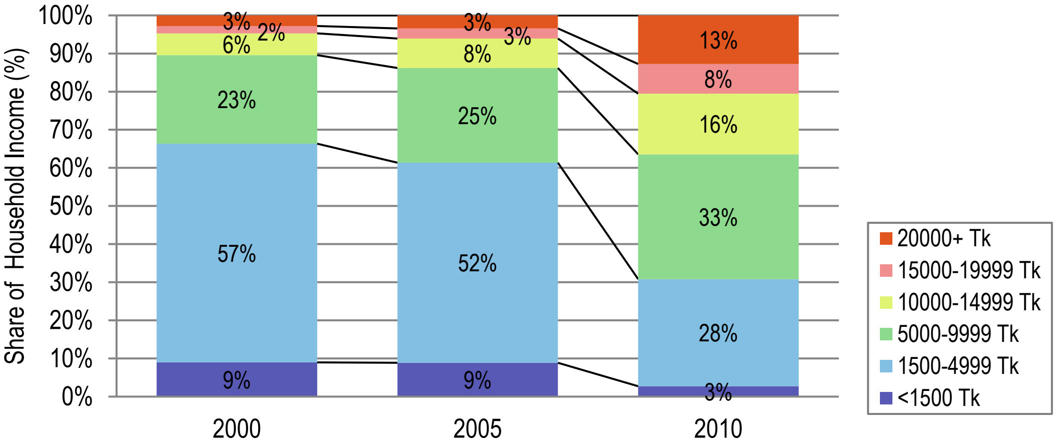
Economic Sector	Rural			Urban			Bangladesh		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Agriculture (000)	15,650	7,920	23,570	1,532	1,088	2,620	17,182	9,008	16,190
Industry (000)	4,880	2,598	7,477	3,201	1,395	4,596	8,081	3,993	12,073
Service (000)	9,088	1,783	10,870	6,876	2,063	8,939	15,964	3,846	19,809
Total (000)	29,618	12,300	41,918	11,609	4,546	16,155	41,227	16,846	58,073
Agriculture (%)	52.8	64.4	56.2	13.2	23.9	16.2	41.7	53.5	45.1
Industry (%)	16.5	21.1	17.8	27.6	30.7	28.5	19.6	23.7	20.8
Service (%)	30.7	14.5	25.9	59.2	45.4	55.3	38.7	22.8	34.1
Total (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Quarterly Labor Force Survey Report 2015–2016, BBS

2.2.4 Income Levels and Poverty

1) Distribution of Household Income and Expenditure

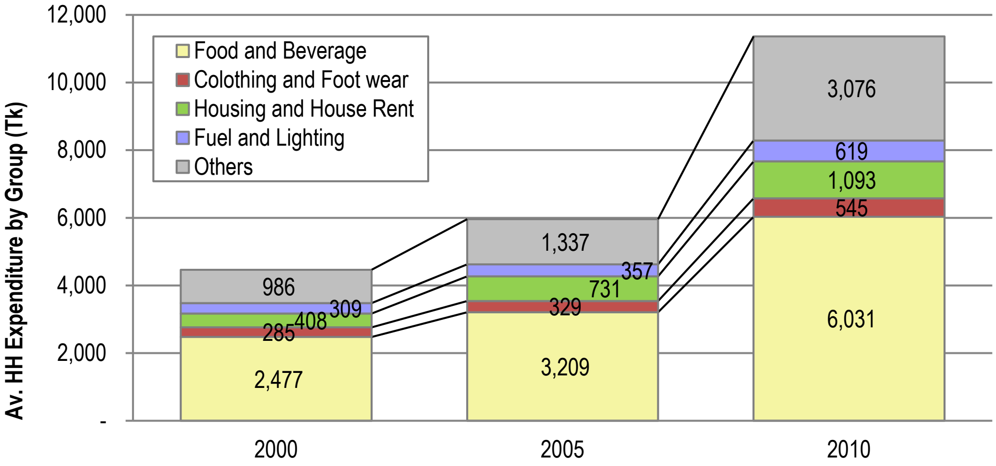
Household income and expenditure in Bangladesh have also increased in 2000–2010 against economic development. As per the Household Income and Expenditure Survey, the average household income was almost BDT12,000 in 2010. As shown in Figure 2.2.8, the share of low-income households (with monthly household income of less than BDT5000) was decreasing while high monthly income households (with monthly household income of more than BDT5000) was increasing every year.



Source: Household Income and Expenditure Survey, 2000, 2005, and 2010, BBS

Figure 2.2.8 Share of Household Income from 2000 to 2010

Figure 2.2.9 shows an increasing rate of average household expenditure that went up to BDT11,003 monthly in 2010 at the national level. The monthly average consumption in 2010 increased by 84.5% compared to year 2005 and by 142.5% with year 2000. Expenditure in food and beverage in particular, shows a tremendous increase.



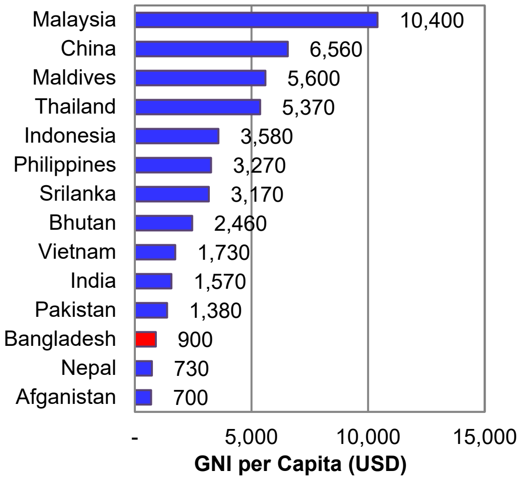
Source: Household Income and Expenditure Survey, 2010, BBS

Figure 2.2.9 Increasing Trend of Household Expenditure in Bangladesh

2) Poverty Indices

(1) Gross National Income (GNI) per Capita among Asian Countries

The Bangladesh economy recently shows a rapid growth; however, the country still remains as one of the poorest in the world. According to World Bank, the GNI per capita of Bangladesh in 2013 was in the third lowest position in South Asia with almost 60% difference from India and less than 30% from Sri Lanka. In order to curb the economic condition, the Government of Bangladesh resorted to increase minimum wage. For instance, the minimum monthly wage of garment workers received an increase from BDT1,661 in 2006 to BDT3,000 in 2010, and continuously went up to BDT5,300 in 2014.



Source: World Bank

Figure 2.2.10 GNI per Capita of Asian Country (2013)

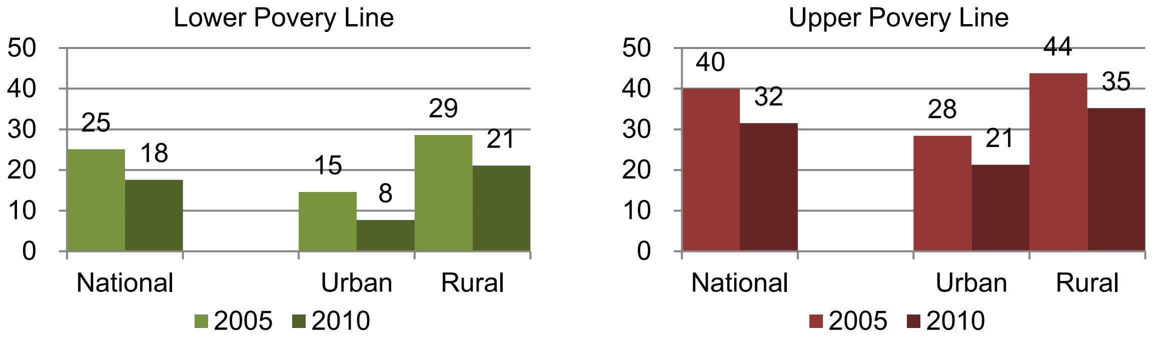
(2) Population of the Poor

The GNI of Bangladesh is quite low due to a large number of poor population. In order to estimate the number of poor people, Bangladesh Bureau of Statistics has been using the Cost of Basic Needs (CBN) method since 1995–1996. In this method, the two poverty lines estimated are lower poverty line (extreme poor) and upper poverty line (moderate poor).

Lower Poverty Line (Extreme Poor). Households with total expenditures on combined food and non-food items equal or less than the food poverty line (less than 2,122 kcal per person in a day) are considered to be under the extreme poor bracket.

Upper Poverty Line (Moderate Poor). Households with total expenditures equal to or less than the upper poverty line (summation of food and non-food poverty lines) are known as moderate poor.

As stated in the Perspective Plan, the government aims to reduce the number of upper poverty population from 32% to 13.5% by year 2021. In reference to Figure 2.2.11 data, the percentage of lower and upper poverty line people has decreased from 2005 to 2010.



Source: Upper Poverty Line: Household Income and Expenditure Survey, 2010 and Target: Perspective Plan of Bangladesh, Planning Commission Bangladesh, April 2012, BBS

Figure 2.2.11 Change of Percentage of Poor People in National Level

(3) Slum Population

People unable to afford their livelihood in the rural areas venture to Dhaka or a sub-urban area to get any job where they eventually engage into a low-skill job such as day labourer, rickshaw puller, luggage carrier, and the like. According to “Slums of Urban Bangladesh, Mapping and Census 2005,” slum is defined as a neighbourhood or residential area with a minimum of 10 households or a mess unit with at least 25 members having four of the following conditions prevailing within the area.

- Predominantly poor housing;
- Very high population density and room crowding;
- Very poor environmental services, particularly water and sanitation facilities;
- Very low socio-economic status for the majority of residents; and
- Lack of security of tenure.

According to the above assumption, the number of slum population in Dhaka Metropolitan Area doubled from 1995 to 2005 (from 1.5 to 3.4 million people), while the number of slum communities increased by roughly 70% (from 3,007 to 4,966). Also, the share of slum population increased from 20% to 37%.

2.3 Land Use

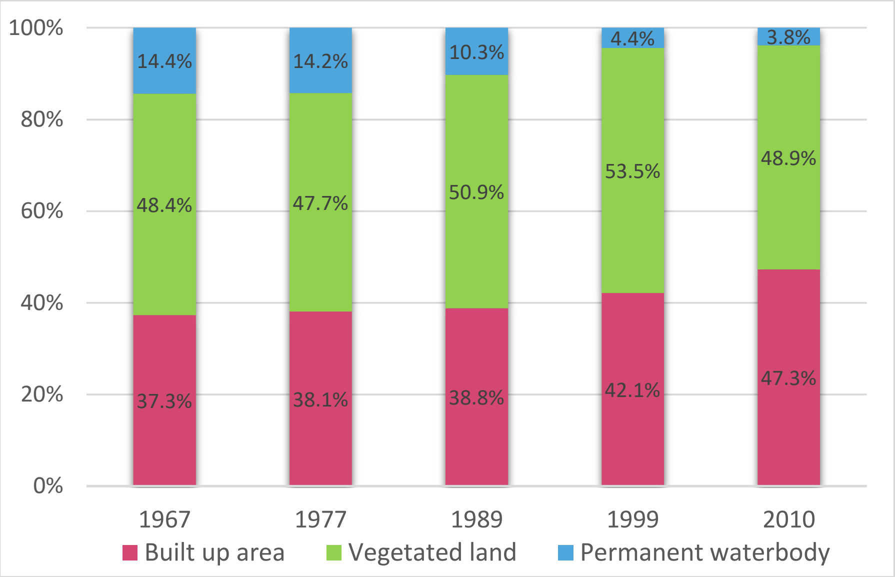
2.3.1 RAJUK Area

1) Overview

Similar with other developing cities, the growth of Dhaka's land use has been changing since 1967. While the vegetation area is almost fixed at 70,000 ha in the past 40 years, the current water body became a quarter since 1967, which is 5,520 ha in 2010 from 206,868 ha in 1967 as shown in Figure 2.3.1. Thus, the waterbody has been converted to built-up area. The lack of growth management and planned urbanization causes extensive urban poverty of low-income people who use the waterbody as domestic use and the fields for agriculture and fishery, recurrent episodes of flash flooding, substantial growth of slums, and exploitation of resources and the mismanagement of limited land resources.

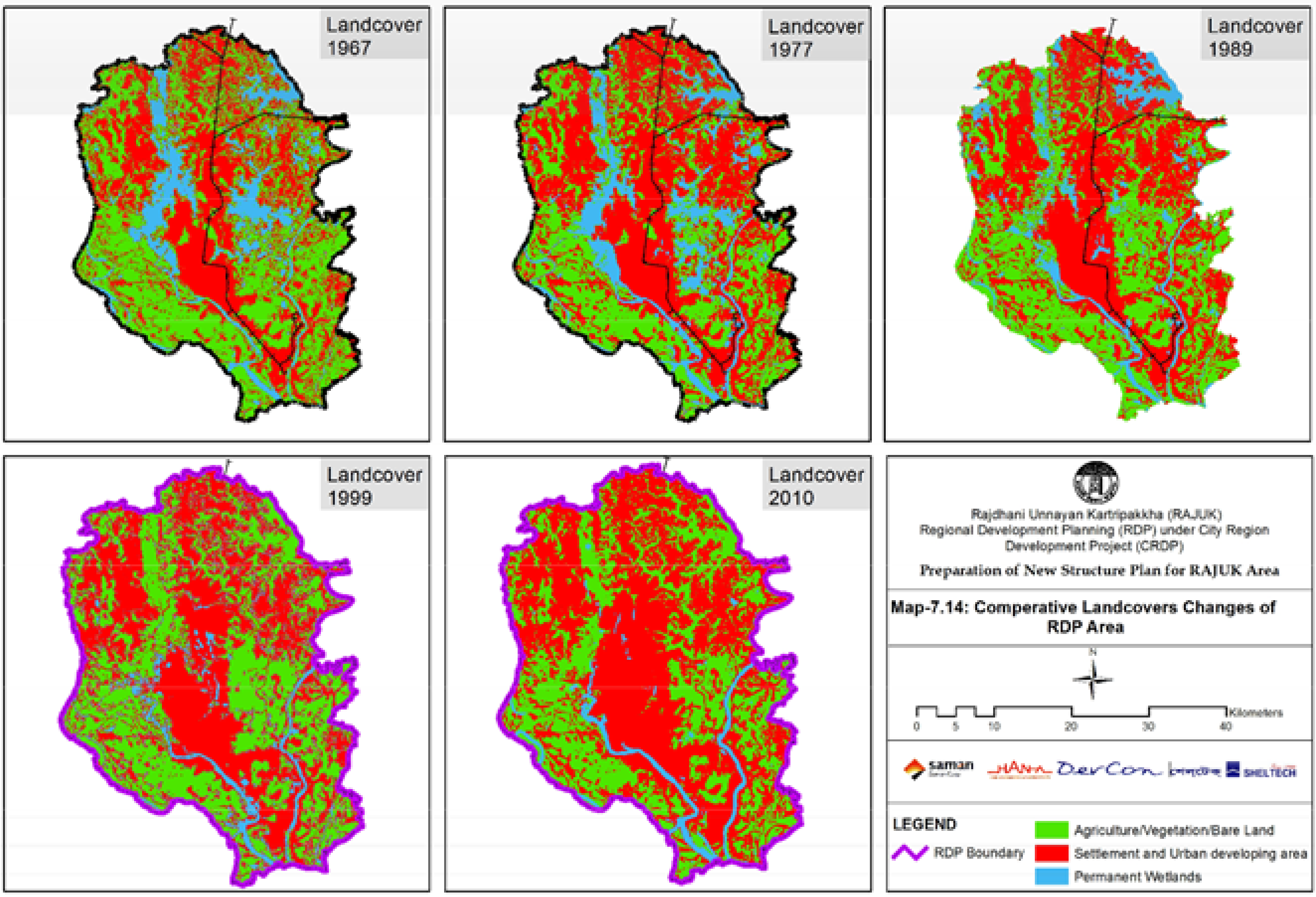
In 1967 to 1989, the built-up area increased gradually from 53,727 to 55,921 ha with 0.2% of the annual increase rate. After that period, urbanization has accelerated. The built-up area increased by about 5,000 ha in 1989–1999 and by 7,500 ha in the period of 1999–2010.

Figure 2.3.2 indicates the speedy expansion of built up area within RAJUK area through transformation of permanent water bodies and vegetation areas. The expansion of built up area mainly occurred to the northern region of RAJUK area specifically towards Savar, Ashulia and Uttara areas.



Source: Japan International Cooperation Agency (JICA) Study Team worked out based on Regional Development Planning (RDP) Survey Report (RAJUK, 2014)

Figure 2.3.1 Land Cover Changes between 1967 and 2010



Source: RDP Survey Report (RAJUK, 2014)

Figure 2.3.2 Land Cover in 1967, 1977, 1989, 1999 and 2010

RAJUK area is further divided into six regions, namely Dhaka Central Region, Northern Region, Eastern Region, Western Region, Southern Region, and South-Western Region. Below is the coverage of each region.

Dhaka Central Region. The existing Dhaka City consisting of 41 Thanas of DMA.

Northern region. All the unions (except Mirzapur union) of Gazipur Sadar Upazila and the entire area of Gazipur City Corporation.

Eastern region. Two Parushava (Kanchan and Tarabo) and six union of Rupjanj Upazila, and one Parushava (Kaliganj) and two unions of Kaliganj Upazila.

Western region. Savar Parushava and 11 unions of Savar Upazila.

Southern region. Two Parushavas (Narayanganj and Siddhiraganj) and seven unions of Narayanganj Sadar Upazila, one Parushava (Kadam Rasul Parushava) and five unions of Bandar Upazaila, and one Parushava (Sonargaon) and seven unions of Sonargaon Upazila (part).

South-Western region. Eleven unions of Keraniganj Upazila of Dhaka District.

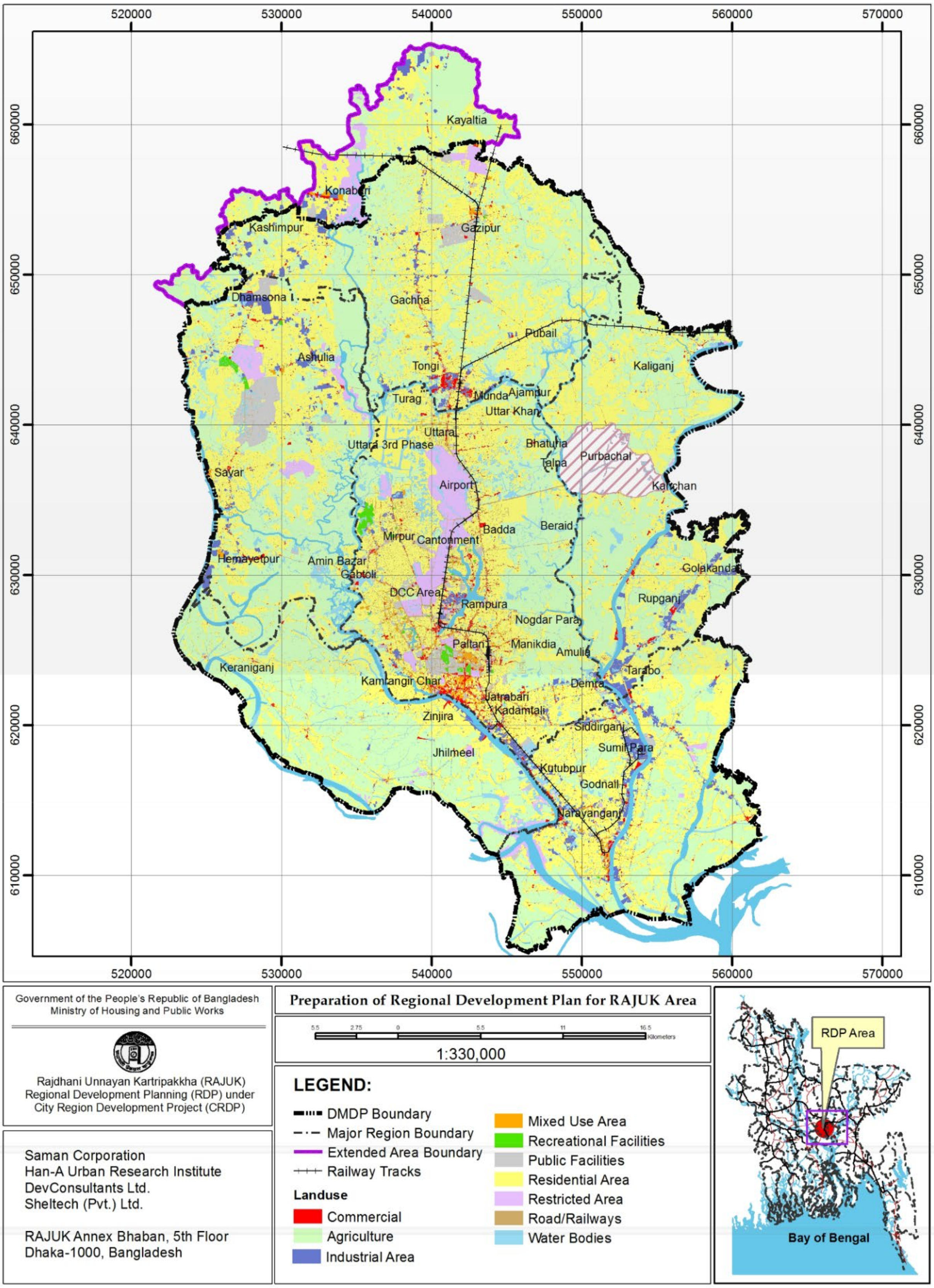
The total RAJUK area is 152,000 ha in which the northern region accounts the largest with 23.4% of the area, followed by Dhaka Central Region with 19.8%, and western region with 16.6%. In terms of land use type, the agricultural use is still dominant at more than 40% of the total area in RAJUK. These agricultural lands expand towards the north and west regions. Residential area is the second largest with 56,024 ha, which has been developed in Dhaka Central and northern regions. The development direction of the residential areas is the same as the urban expansion. Other urban land use, such as commercial and mixed-use, can also be found mainly in Dhaka Central and northern regions.

On the other hand, industrial areas are more concentrated in the northern and southern regions. The western region has relatively high share of public facilities and recreational area.

Table 2.3.1 Existing Land Use of the RDP Area

Land Use Type	Area (ha)							Share (%)						
	Region						Total	Region						Total
	DCR	NR	ER	WR	SR	SWR		DCR	NR	ER	WR	SR	SWR	
Agriculture	7,105	16,560	9,813	11,156	8,095	10,997	63,713	11.1	26.0	15.4	17.5	12.7	17.3	100.0
Industrial Area	541	864	557	727	909	144	3,810	14.5	23.1	14.9	19.4	24.3	3.9	100.0
Commercial	694	291	134	139	242	71	1,572	44.2	18.5	8.5	8.8	15.4	4.5	100.0
Mixed Use Area	612	128	4	82	124	21	971	63.0	13.1	0.4	8.5	12.7	2.2	100.0
Residential Area	12,988	14,248	7,022	8,852	8,759	4,154	56,024	23.2	25.4	12.5	15.8	15.6	7.4	100.0
Purbachal New Town	6	0	2,392	0	0	0	2,379	0.3	0.0	99.7	0.0	0.0	0.0	100.0
Public Facilities	1,294	780	90	1,178	337	89	3,767	34.3	20.7	2.4	31.3	8.9	2.4	100.0
Recreation al Area	289	4	0	87	9	0	390	74.1	1.0	0.0	22.4	2.4	0.0	100.0
Restricted Area	2,030	931	30	754	321	303	4,302	46.5	21.3	0.7	17.3	7.4	6.9	100.0
Road/Railw ays	1,859	553	212	418	423	192	3,657	50.8	15.1	5.8	11.4	11.6	5.3	100.0
Waterbody	2,643	1,203	1,273	1,902	2,416	1,966	11,758	23.2	10.6	11.2	16.7	21.2	17.2	100.0
Total	30,061	35,562	21,528	25,296	21,635	17,937	152,343	19.8	23.4	14.2	16.6	14.2	11.8	100.0

Note: DCR = Dhaka Central Region, NR = Northern Region, ER=Eastern Region, WR = Western Region, SR = Southern Region, SWR = South-western Region
Source: JICA Study Team worked based on RDP Survey Report (RAJUK, 2014)



Source: RDP Survey Report (RAJUK, 2014)

Figure 2.3.3 Land Use of RAJUK Area, 2013

2) Dhaka Central Region

A large portion of the Dhaka Central Region is already urbanized with 60% of the area as built-up. Majority of the built-up area is residential area with 43% followed by commercial area with 2.3%, mixed use with 2.0%, and industrial area with 1.8% (see Table 2.3.2). This region also covers Motijheel, Panthapath, and Gulshan, all of which are usually referred to as the central business district (CBD) of Dhaka. The land and property prices in this region increased incredibly between the period of 2000–2010.

About 13,000 ha of residential area is occupied mainly by middle- and high-income groups, and other residential areas developed spontaneously that are occupied by the low-income group. The spontaneous or unplanned development of residential areas in the region has increased urban problems.

There are 540 ha of industrial area, which are mainly in Pallabi, Mirpur, and Hazaribag Thanas, and 690 ha of commercial area in the southern side of DCC. Main commercial area is the old part of Dhaka City, such as Kotwali, Lalbag, and Sutrapur Thanas. Other commercial areas can also be found in Motijheel, Ramna, Tejgaon, and Khilgaon Thanas in the central part of DCC, and Gulshan, Mirpur, Badda and Uttara Thanas are in the northern part of DCC. All major commercial activities are situated along the major roads.

Besides the urbanized area, the agricultural land of 7,100 ha are spread in the peripheral area near the DMA boundary. Agricultural lands are mostly located in Uttar Khan, Beraid, Starkul, Badda, Demra, Sabujbag, and Khilgaon areas. Since the urban areas of the region are highly dense, these agricultural lands and water bodies have been converted for private housing projects.

This region also has 2,030 ha of restricted area occupied by military or government establishments. Important establishments include the President's Office and Residence at Banga Bhaban, Prime Minister's Office and Residence, National Parliament Building, Hazrat Shahjlalal International Airport, Secretariat near Paltan, and Old Airport Area at Tejgaon. These restricted areas are located at a significant valuable land in an urban development aspect and became a constraint for the transport development. Besides the restricted area, large public facilities including government offices and universities also occupy prime land and cause congestions. Moreover, the share of recreational area and transport facilities are still insufficient to provide better living conditions for residents and to ensure sustainable development.

Table 2.3.2 Land Use Composition in Dhaka Central Region

Land Use Type	Ha	%
Agriculture	7,104.9	23.6
Industrial Area	541.4	1.8
Commercial	694.2	2.3
Mixed Use area	611.9	2.0
Residential Area	12,987.9	43.2
Purbachal RA	6.3	0.02
Public Facilities	1,293.6	4.3
Recreational Area	289.0	0.96
Restricted Area	2,030.0	6.8
Road/Railways	1,858.8	6.2
Waterbody	2,643.4	8.8
Total	3,0061.4	100.00

Source: RDP Survey Report (RAJUK, 2014)

3) Northern Region

Since most of the northern region is high land, the urbanization of Dhaka Central Region expanded to the north. The total 17,200 ha urbanized land is the second largest in RAJUK area. The Dhaka Central Region has 18,000 ha urbanized land. The agricultural area is still dominant in the region with 47% of the total area, but the residential area is also more than 40% (see Table 2.3.3).

About 14,000 ha of residential area is a mix of urbanized housing areas in Gazipur and Tongi Pourashava and rural homestead areas around the agricultural land. In general, urbanized housing areas have been developed for middle-income group, and the rural homestead areas are for low-income group. New planned residential areas are also being developed as private housing projects.

This region is known as one of the industrial cities of Bangladesh. Some industrial development can be seen along the Dhaka–Mymenshing Highway. In particular, Tongi is a major industrial area composed of many garment factories. The high land along this highway has increased in industrial development, but consequently caused disorder in residential and commercial developments that resulted with large slums. Another industrial zone is in the eastern side of the Upazila in Kashimpur Union and Konabari Union. Beximco Industrial park is situated near the Zirani Bazar. Small industrial areas are also scattered along the rivers and major roads where industrial establishments can have good accessibility for logistics.

Similarly, commercial areas were developed mainly along Dhaka–Mymenshing Highway. Gazipur and Tongi are the major commercial centers in this region. The latter, in particular, has the most commercial activity within the region.

Large part of the agricultural land is considered to be relatively of “high-value agricultural land.” In addition to the agricultural area, some seasonal crops also grow in the waterbody during dry season. The swampy areas used for agriculture are situated by the side of the Turag River in the south-eastern and eastern parts of the region.

Restricted land of 860 ha is mainly occupied by the Army Machine Tools Factory in the northern side of the region, Bangladesh Ordnance Factory (BOF), and Security Printing Press. Public facilities area has several research institute and universities.

Table 2.3.3 Land Use Composition in Northern Region

Land Use Type	Ha	%
Agriculture	16,560.0	46.6
Industrial Area	931.0	2.6
Commercial	291.5	0.8
Mixed Use area	127.7	0.4
Residential Area	14,247.8	40.1
Public Facilities	780.3	2.2
Recreational Area	4.1	0.01
Restricted Area	863.5	2.4
Road/Railways	552.8	1.6
Waterbody	1,203.1	3.4
Total	35,561.8	100.0

Source: RDP Survey Report (RAJUK, 2014)

4) Eastern Region

The eastern region is a predominantly agricultural area that occupies more than 45% of the entire region. The built-up area, which is mainly residential (see Table 2.3.4), occupies only 36%. The 9,800 ha of agricultural land is mostly the eastern fringe area with low-lying land. Part of the waterbody with 1,300 ha is also used for agriculture during the dry season.

The residential area is 7,000 ha or 33% of the total land. Since the eastern region is located at the peripheral area of DMA, sub-urban housing areas are situated on both sides of the roads within this area. Other residential areas are rural homestead area that is situated beside the agricultural land and occupied by the low-income group. Purbachal New Town, which is developed by RAJUK, is in this region as well (see Chapter 2.5). More urbanization would occur surrounding the peripheral semi-urban area of this zone being within the vicinity of the urbanized area.

Since the road network is not fully developed, the industrial development that covers less than 3% of the total area is concentrated by the river side of Balu, Shitalakhaya River, and Bhulta area. Along the national and regional highways and some important feeder roads are where the other industrial areas are. While the residential development increased, the commercial area occupied only 0.6% of the total area. Similar to the industrial area, commercial activities were developed mainly by the side of the national and regional highways and some important feeder roads. The industrial and commercial developments along the major roads also contributed to the additional unplanned development in those areas.

Table 2.3.4 Land Use Composition in Eastern Region

Land Use Type	Ha	%
Agriculture	9,813.5	45.6
Industrial Area	557.3	2.6
Commercial	134.3	0.6
Mixed Use area	3.9	0.02
Residential Area	7,022.3	32.6
Purbachal RA	2,391.5	11.1
Public Facilities	89.8	0.4
Restricted Area	30.2	0.1
Road/Railways	212.1	1.0
Waterbody	1,273.5	5.9
Total	21,528.5	100.0

Source: RDP Survey Report (RAJUK, 2014)

5) Western Region

The land use composition of the western region is similar to the eastern region (see Table 2.3.5). The main difference is that the western region has more public facilities and recreation areas, while the eastern region has a relatively large area for Purbachal New Town Development. More than 50% of the total land of the western region is agricultural land or waterbody that is considered as flood prone. In general, Keraniganj Upazila is low-lying and a flood prone area while Savar Municipality is relatively high land. Therefore, Savar Municipality has been developed as an urban center with residential, industrial, and commercial uses.

About 9,000 ha of residential area is mainly located along the roadside of Dhaka-Aricha Highway, Nabinagar-Tangail Road, Ashula Road, and Dhaka-Keraniganj Road. Urbanized residential area is generally developed for the middle-income group. The remaining rural homestead areas are for low income people.

About 700 ha of the industrial area includes the Savar Export Processing Zone located along the Nabinagar-Tangail Road. Some other industrial establishment is located along Dhaka-Aricha Highway, Hemayetpur-Singair Road, and Ashulia Road. The total area is small, but the western region has the third largest industrial area among six regions of RAJUK area.

Similarly, commercial land is also small at 140 ha. It has the smallest share of the land in the region (0.6%). The major commercial activity areas are the Hemayetpur, Savar Bazar, Nabinagar, Ganak Bari, and Zirani. There is also some commercial activity located along the river side of Buriganga and the Dhaka-Keraniganj Road.

Public facilities area includes Jahangir Nagar University, Savar Dairy Farm, Public Administration Training Center (PATC), City University, Daffodil University, BRAC Training Center, Bangladesh Atomic Energy Commission, Bangladesh Livestock Research Institute, etc. The area covers about 1,200 ha. There are also about 750 ha of restricted areas including Savar Cantonment which is a prime restricted area.

There is some high value agricultural land as well as some low-lying areas. Besides that, about 8% of the total area is waterbody, which can be used partially for growing some seasonal crops in dry season.

Table 2.3.5 Land Use Composition in Western Region

Land Use Type	Ha	%
Agriculture	11,156.2	44.1
Industrial Area	727.2	2.9
Commercial	138.8	0.6
Mixed Use area	82.4	0.3
Residential Area	8,852.0	35.0
Public Facilities	1,177.8	4.7
Recreational Area	87.3	0.4
Restricted Area	753.7	3.0
Road/Railways	418.4	1.7
Waterbody	1,901.8	7.5
Total	25,295.5	100.0

Source: RDP Survey Report (RAJUK, 2014)

6) Southern Region

Residential land use is central in the southern region as it occupies more than 40% of the total land (see Table 2.3.6). This is followed by agricultural land with 37%. Urbanized housing areas are located in Kadam Rasul, Sidhhirganj, and Narayanganj Pourashavas (NCC Area), Fatullah, Kanchpur, Madanpur, Islamia Bazar, Bandar Upazila head quarter, Mugrapara, etc. In addition, almost all are rural home stead areas for the low-income group that resulted from the lack of approved detailed plan.

The southern region has the largest industrial area of 910 ha in RAJUK, especially Narayanganj that is known as the industrial city of Bangladesh. Industrial activities have been mainly developed along the Shitalakhhaya River, Buriganga River, Old Brahmaputra River, Dhaka-Chittagong Highway, and Dhaka-Sylhet Highway. The Adamjee Export Processing Zone (EPZ), which was established in 2006, has 99.2 ha of the land and is located 15 km away from Dhaka City center. There are 61 companies with Bangladeshi main investors located in EPZ that generate more than 36,000 jobs. Other industries are located eastern side of Shitalokhhaya River in Bandar Upazila by the Brahmaputra River on Sonargaon Upazila and by the Buri Ganga River on Keraniganj Upazila.

The commercial area of 240 ha is all located in the City Corporation area along the Buriganga and Shitalakhhaya Rivers. Mugrapara, Islamia Bazar, Katchpur, Ekuria Bazar, Fatulla, Kutubpur, Shimulpara, Narayanganj, Kadam Rashul, and Siddhirganj are the main commercial activity centers in this zone.

About 8,800 ha of agricultural land and 2,400 ha of waterbody contribute to the agricultural activities of the region. The agricultural area is spread around the southern portion of Narayanganj Sadar Upazila, Bandar, and Sonargaon Upazila with low-lying parts.

Table 2.3.6 Land Use Composition in Southern Region

Land Use Type	Ha	%
Agriculture	8,094.6	37.4
Industrial Area	909.1	4.2
Commercial	242.1	1.1
Mixed Use area	123.7	0.6
Residential Area	8,758.8	40.5
Public Facilities	336.9	1.6
Recreational Area	9.4	0.04
Restricted Area	321.1	1.5
Road/Railways	423.1	2.0
Waterbody	2,416.5	11.2
Total	21,635.4	100.0

Source: RDP Survey Report (RAJUK, 2014)

7) South-Western Region

Although the south-western region is bounded by the urbanized area of the Dhaka Central Region, agriculture is its dominant land use. More than 60% of the total area is occupied by agricultural land and about 10% are waterbody. In addition, some parts of the region were converted into brick field.

Residential area shares the second highest with 23% of the total area. RAJUK's Jheelmil New Town and the urbanized residential area for the middle-income group has been developed by the roadside of Dhaka-Keraniganj and Dhaka-Mawa roads. The remaining area is the scattered and unplanned rural homestead for low-income group.

Other urban land uses in this region, such as industrial and commercial, are insignificant since they only occupy 0.8% (145 ha) and 0.4% (71 ha) of the total area, respectively. Moreover, commercial area is located along the side of Buriganga River and Shitalakhhaya Rivers.

Table 2.3.7 Land Use Composition in South-Western Region

Land Use Type	Area(ha)	%
Agriculture	10,996.9	61.3
Industrial Area	144.5	0.8
Commercial	71.4	0.4
Mixed Use area	21.2	0.1
Residential Area	4,153.8	23.2
Public Facilities	88.6	0.5
Recreational Area	0.0	0.0
Restricted Area	302.9	1.7
Road/Railways	192.4	1.1
Waterbody	1,965.6	11.0
Total	17,937.3	100.0

Source: RDP Survey Report (RAJUK, 2014)

2.3.2 Hazards

1) Flood and Inundation Characteristics

Basic inundation process that occur in Dhaka is when water levels rise in the three major rivers that cause back flows in the tributaries which, in turn, make it difficult to drain the surface water. Thus, this results in inundation in the wetlands and surrounding areas in the surroundings.

A major inundation (called *banna* in Bengali) that causes damages to human lives, properties, agriculture, etc. is when discharge from the three major rivers increase and river water of rising level flows into parts of the city with lower elevation; thus, inundating an extended area.

In recent years, major inundations occurred in 1988 and 1998 that brought about significant damages. During these inundations, water level of Buringanga River in the western part of Dhaka exceeded 7.0 m.

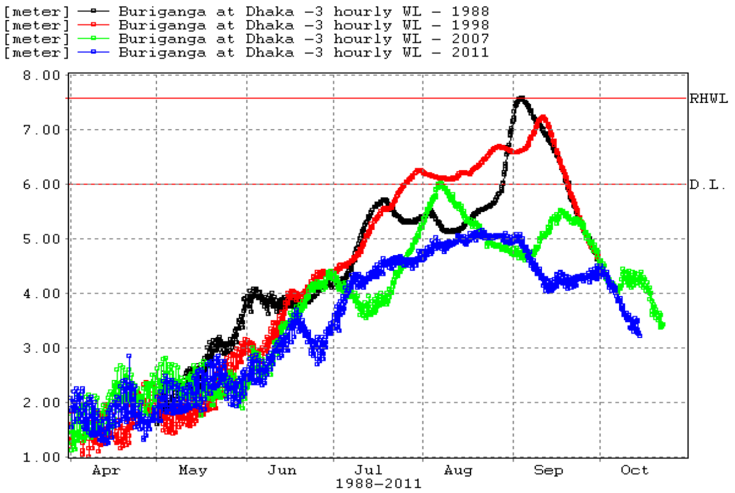


Figure 3. 6 : Comparison of Hydrograph on Buriganga at Dhaka(Milbarak)

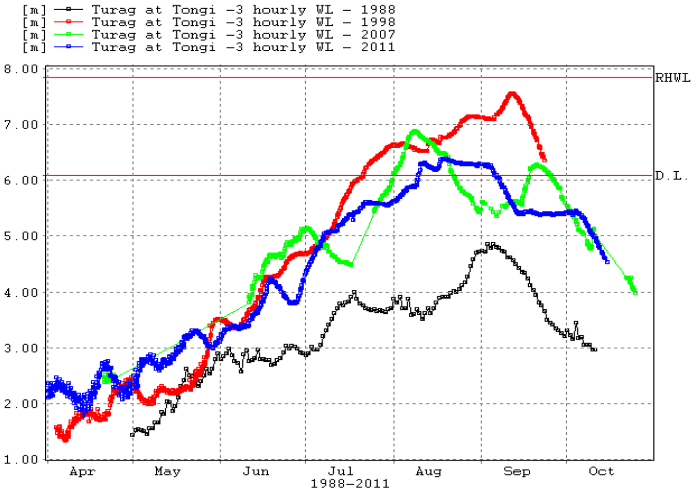


Figure 3. 7 : Comparison of Hydrograph on Tongi Khal at Tongi

Source: Annual Flood Report 2011, FFWC, BWDB

Figure 2.3.4 Water Levels in Rivers around Dhaka during Major Inundations in Recent Years

Dhaka City was built on a delta formed by rivers. Its ground is believed to be formed almost solely from silt and fine sand. As a result, river banks are subjected to erosion because of fluctuating water level and flowing river water.

Inundation by river water in Dhaka is characterized by a very slow process of flood water to recede, resulting in an elongated period of inundation. Typical duration of inundation in the last 50 years is from 15 to 45 days, during which the residents suffer directly and indirectly.

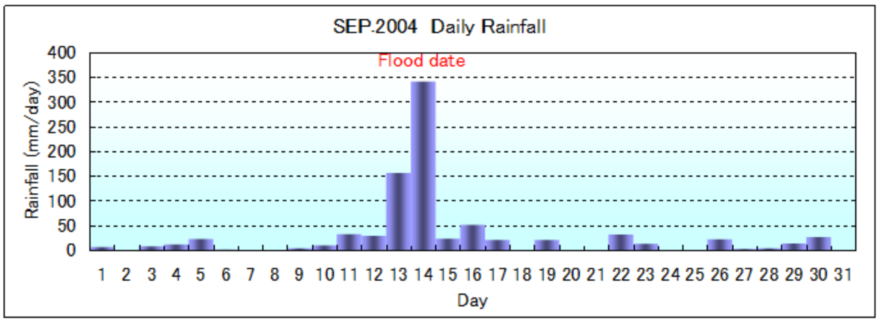
Another form of inundation that affects Dhaka is inundation by inside water. In case water levels in rivers rise when there has been a torrential rain, inundation damage by inside water occurs because the flood water cannot be drained into rivers. Flood caused by inside water is usually shallow and there is no risk of losing many lives. The 2006 Halcrow Report 2006 claims that an inundation due to drainage failure that causes damage to properties is brought about by a deluge having probability of occurrence once in ten years.

A recent case of inundation by inside water affected a large part of urban Dhaka in 2004.

This occurred when rising water levels in the rivers caused Balu River in the eastern Dhaka to overflow and then flooding the lowland areas of the city. In western Dhaka, overflow from Turag River flooded the inside land through culverts and opened regulators.

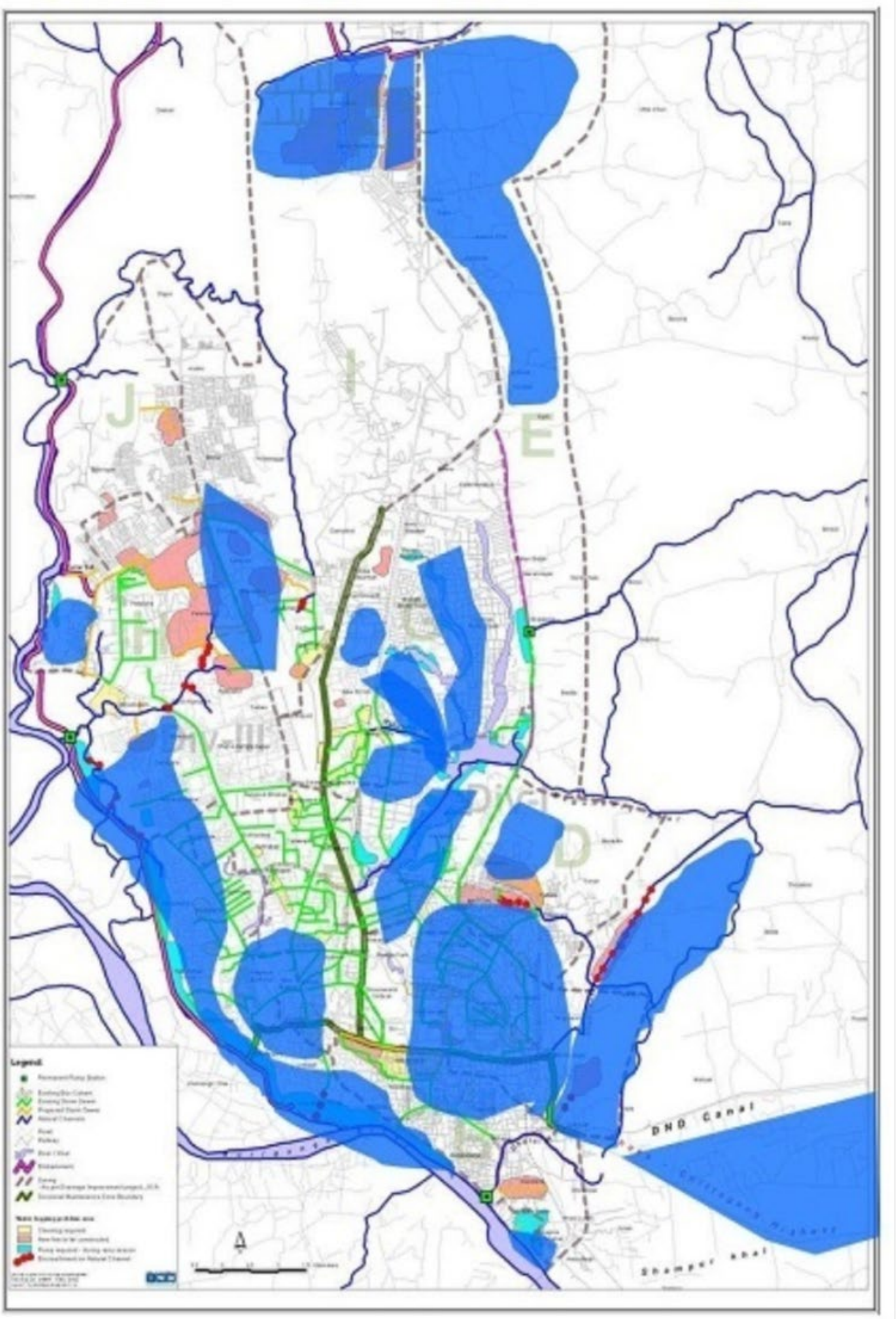
The inundation damage by inside water was caused by an intense rainfall in Dhaka when the regulator was closed so as to protect the urban Dhaka from the flooding river water.

Daily rainfall recorded in Dhaka in September 2004 when the inundation occurred was 341 mm. This means that such amount of rainfall occurred in one day exceeded the mean monthly precipitation of 284 mm recorded during rainy season (June to September) in the recent five years, and the large amount of rainwater remained in the urban area without being drained. An estimated 40% of the urbanized area in the western Dhaka was waterlogged by the inside water.



Source: Halcrow Report

Figure 2.3.5 Daily Rainfall in September 2004



Source: Survey Report (RAJUK 2014)

Figure 2.3.6 The Inundation map of Greater Dhaka, 2004

There were water channels, natural drainages, and lowland areas in and around Dhaka in the past that contributed to the retention and discharge of rain water. However, rapid sprawl of the urban district in recent years has decreased the water retention areas, leading to a loss of water-retaining capability of the urban district. In addition, haphazard urban development carried out in disregard of the topography coupled with the failure of timely building storm water drainages and negligence of maintenance services has been aggravating the problem of rainwater remaining in the urban district.

Rain water that remains over an extended period of time not only causes inconvenience to the residents' lives, traffic, and other activities, but also environmental and hygienic problems such as odor and health hazards.

Source: Survey Report (RAJUK 2014)

Figure 2.3.7 Water Logging Condition (Purba Jurain of Dhaka City)

Source: JICA Study Team

Figure 2.3.8 Street without Drainage (left) and Drainage Clogged with Garbage (right)

2) Flood control policy of Dhaka City

The flood control policy of Dhaka City was established as part of FAP in 1990s with the idea of preventing inundation by river water through building an embankment and draining rain water from the urban area by pumping. The flood control policy is intended to prepare for disasters with a probability of occurring once in one hundred years. Construction of the storm water drainage system in the city, on the other hand, was planned for disasters with a probability of occurring once in five years.

Under this policy, the western embankment (with a crown height from 7.5 to 10 m) and three pump stations (with a total discharge capacity 44.5 m^3/s) are now under construction. In the existing urban district, there are retarding basins, such as Gulshan Lake, and a new one was built in Tejgaon district to receive and retain drained rain water.

With regard to the embankment and the pump stations on the eastern edge, revision and F/S of the plan were completed, but the prospect to commence construction has not been obtained. Currently, DIT Road serves as a flood protection line and functions as an embankment that prevents overflows from rivers in the east from infiltrating the city (height of road surface is said to be around 8 m). For this reason, channels that cross the DIT Road are equipped with gates while two have pumping stations built alongside.

In the central part of the city, a project is now being implemented to construct a multipurpose waterfront that includes flood control.

3) Challenges facing the flood control policy in the eastern Dhaka development project

Dhaka is one of the most densely populated cities in the world. The trend toward nuclear families also makes it increasingly difficult to meet the demands for housing within the existing urban district. To tackle this problem, projects to develop housing lands have been carried out by the public and private sectors, making the urban district continue to sprawl. There has been a restriction on housing development in the eastern part of Dhaka because it is a lowland with elevation of 5 to 6 m. However, demands for housing development in this district have been growing because it is located near the urban district.

The most challenging about the housing development in the eastern part of Dhaka is the need for flood control measures. As described above, a project to construct embankment and reservoirs to keep inside water and pumping stations was put into place in the eastern Dhaka under the revised Eastern Bypass Study (2006). The following problems have been pointed out for this project.

(1) Setting the embankment crown height

In the past inundations, water levels in the three major rivers rose to 15 m or higher and Buriganga and Balu Rivers that surround Dhaka rose to almost 8 m. Since the ground height in eastern Dhaka is about 5 to 6 m, it was feared that building the embankment with a crown height of 8 m would lead to increased flooding energy in the event of dyke break, resulting in significant damages.

(2) Timing of embankment construction

Risk of inundation damage increases if building of an embankment lags the urban development works, If building of embankment in the downstream proceeds ahead of building in the upstream, overflow from the upstream would be prevented by the downstream embankment from returning to the river, so as to be retained in the inside over an extended period of time.

(3) Protection against bank erosion

The embankment should be protected with revetment installed over the height range of the varying water level. River sand will be used as embankment material when the actual conditions surrounding the project are considered. If this is the case, the surface behind the revetment must be installed with a soil draw-out prevention material to prevent the sand behind the revetment from being drawn out, giving rise to the danger of collapsing revetment and fragile embankment.

(4) Drainage of inside water

Building an embankment makes it difficult to drain the inside water. To drain the inside water, it is necessary to install pumps, sluice gates, and other facilities. Well-defined rules for operating these facilities and a reliable system must be put in place that can ensure correct operation and management of the facilities.

(5) Loss of wetlands

Eastern Dhaka has wetlands scattered that are valuable, not only for flood control as buffer and water retention in case of river overflow, but also for their contribution to the preservation of diversity in the natural environment. Water in the wetlands comes mainly from the overflow from rivers, ground water, and rain water. Construction of embankment would stop the harmless, ordinary flooding (barsha) from occurring; thus, causing wetlands to diminish and weaken their functions with the supply of water and fishes from rivers interrupted.

4) Development in eastern district by landfill

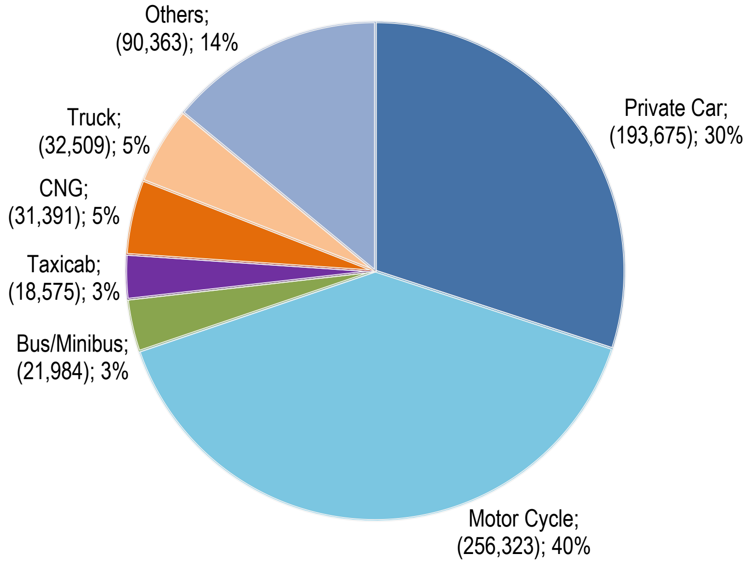
First Dhaka Eastern Bypass study was undertaken in 1998 under World Bank Technical Assistance. The study was updated in June 2006 with a new name “Updating/Upgrading the Feasibility Study of Dhaka Integrated Flood Control Embankment cum Eastern Bypass Road Multipurpose Project.”

Its main objective is to provide flood protection for the eastern part of Dhaka to mitigate damage and loss as a result of flooding by the Balu River and from internal flood water. The project will also deliver transport benefits, but they are secondary to flood defense. Total project cost in 2005 constant prices and excluding physical contingencies was estimated at BDT19 billion ($233 million) in the report.

2.4 CURRENT URBAN TRANSPORT SYSTEM

2.4.1 Introduction

At present, major modes of transport in GDA are motorcycles, private cars, microbuses, trucks, minibuses, and taxis. The number of registered public transport is quite less compared to private transport. In this section, various types of existing transports and performance as well as issues on public transport system in GDA are described.



Source: BRTA

Figure 2.4.1 Share of Total Newly Registered (2001–2013) Vehicles in GDA

2.4.2 Pedestrian & Non-Motorized Transports

1) Pedestrian

Walking is the common mode of transportation of the majority of people in Dhaka City. According to DHUTS in 2009, almost 20% of the people in the city walk. One of the reasons to some of the people is the financial incapability to use public transport. Also, quite a lot of garment workers commute to factories in the morning and by foot in the evening. Some people walk to access public transport like buses.

Even though a large share of people are pedestrians, facilities for pedestrians are not properly ensured. Convenience is not considered for the pedestrians whenever a road or an intersection is constructed or renovated in Dhaka City. There are around 66 pedestrian foot-over bridges and 4 underground pedestrian crossings in the city to ensure safe crossing of the users. In some locations, pedestrians attempt to cross the road with many motorized vehicles due to insufficient facilities for crossing. However, it has been also observed that some pedestrian foot-over bridges are not being used by pedestrians.

There are several on-going projects under DCC that focus on pedestrian walkway improvement. As a matter of fact, construction of footpath already start before construction works for drainage pipe installation, internet cable installation, etc. However, some of the re-constructed footpath are improperly done like unlevel construction with rough surface where children and elderly people find difficult to walk on. In Bangladesh, there is hardly any consideration for the handicapped in their footpath designs. This calls for a development of barrier-free walkways or crossing facilities. Moreover, footpath's height practically varies from 15 to 60 cm as there is no predetermined height of the walkway. In March 2014, Dhaka North City Corporation (DNCC) inaugurated the construction of the first ever foot-over bridge with escalator (upward direction only) in Bangladesh located at the intersection of Banani Road Number 11 and Airport Road. DNCC has a plan of constructing seven more of this bridge type if they get a positive outcome.

2) Bicycle

Bicycle is a useful and environment-friendly transport, which plays an important role as access for commuting in developed countries. However, only 2% bicycle trips were found on arterial roads in Dhaka City. In the past, bicycle was used mostly in rural areas to commute to school and to office. Due to religious conservativeness, many women still do not use a bicycle.

Some problems of using bicycles in Dhaka City are:

- Absence of dedicated bicycle lane that makes biking quite dangerous.
- No parking facilities for bicycle that makes it difficult to use even to access other modes of transport.
- Possibility of theft due to lack of parking facilities.
- Due to high initial cost of a good quality bicycle (approximately BDT15,000), it is an unaffordable to low-income people.

3) Rickshaw

Dhaka City is known to be a city of rickshaws. The registered number of rickshaws in the city, according to DNCC and Dhaka South City Corporation (DSCC), is around 100,000.[1] In many reports, it has been published that quite a number of unregistered rickshaws operate in Dhaka. Nobody actually knows the exact number of rickshaws that run in the city. The total number of registered rickshaws from 2004 to 2011 in the urban area of GDA is 330,143.[2] Out of all the districts of GDA, Dhaka holds 88% of the rickshaws while Narayanganj and Gazipur districts come in second and third, respectively.

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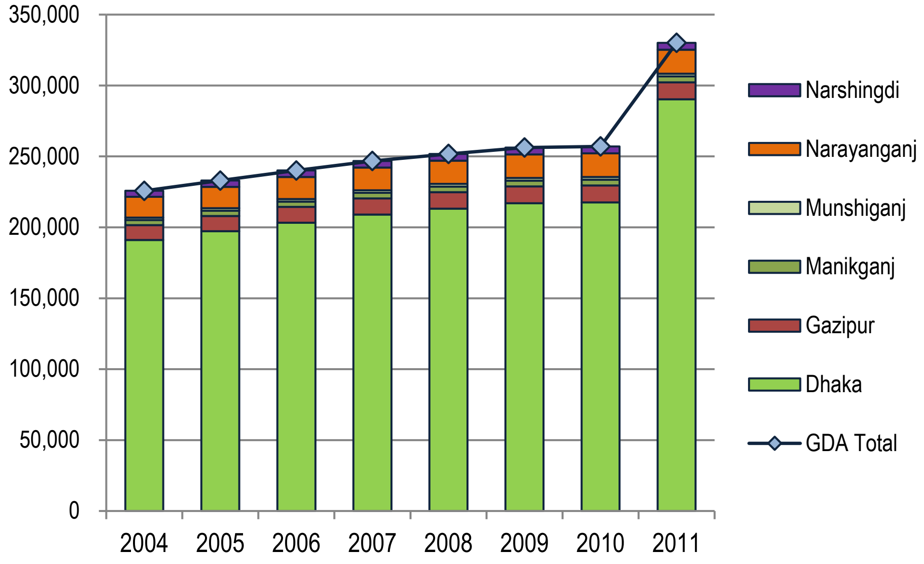
[1] DHUTS.

[2] Statistical Yearbook of Bangladesh 2010 and 2012.



Source: Statistical Year Book of Bangladesh 2010 and 2012, BBS

Figure 2.4.2 Trend of Registered Rickshaws in the Urban GDA

People in Dhaka City mostly use rickshaw for travelling short distances of 1–3 km, and students and businessmen use more than 90% of these rickshaw trips.[3] The share of trips made by rickshaw was 38% in 2009.

4) Others (Rickshaw van, Thela etc.)

In GDA, many people use rickshaw van and *thela* to transport goods due to low fare charges. Rickshaw van or *thela* is a better option for people if they need to transport small amount of commodities; however, Dhaka Metropolitan Police restricted their use. According to DCC, there are around 8,000 registered rickshaw vans in Dhaka City.[4] The number of *thela* is not available as there is no registration system for this transport. It has also been observed that rickshaw vans were used as a temporary vendor shop for vegetables, chickens, etc.

2.4.3 Private Car, Motorcycle& Truck

1) Private Car

In GDA, private cars are mainly classified into three types: sedan car, four-wheeled jeep, and 6- to 10-seater microbus. Basically, private cars are used by middle- and high-income people with some families that own more than one vehicle. Although private cars were accounted for about 30% of vehicle share in Dhaka in 2010, the occupation rate of private cars has decreased by about 23% in 2016. However, the number of private cars has increased, and one of the increase is the low operating cost by using compressed natural gas (CNG). Since CNG is being produced locally, its cost is quite low compared to other types of fuel like octane that needs to be imported. According to Navana CNG, a renowned CNG conversion company in Bangladesh, 1 m^3 CNG is equivalent to 1.23 L of octane. Considering the over-all cost, (assuming yearly travelling distance of 60,000 km) a 1800 CC CNG driven-sedan car can save around BDT0.30 million every year.

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[3] DHUTS

[4] Rickshaw Cycle Drivers in Dhaka: Assessing Working Conditions and Livelihoods.

Table 2.4.1 Number of Registered Motor Vehicles in Dhaka by Year

Type of Vehicles	Up to 2010	2011	2012	2013	2014	2015	2016	Grand Total
Ambulance	1,374	137	114	190	254	358	321	2,661
Auto Rickshaw	7,664	112	111	60	56	428	721	8,972
Auto Tempo	1,662	1	1	0	0	0	0	1,664
Bus	16,783	1,501	1,218	971	1,364	2,221	3597	26,756
Cargo van	3,231	477	278	676	603	398	908	6,344
Covered Van	4,277	1,910	1,170	1,850	2,352	1,855	2,485	15,278
Delivery Van	11,990	839	577	709	901	1,464	1,902	17,907
Human Hauler	2,718	569	145	115	109	502	870	4,811
Jeep(Hard/Soft)	19,520	1,698	1,241	1,107	1,582	3,109	4,457	31,600
Microbus	46,202	3,540	2,643	2,227	3,842	4,569	5,433	67,098
Minibus	9,490	136	103	83	135	103	153	10,165
Motor Cycle	210,081	34,708	32,810	26,331	32,894	46,764	52,178	422,722
Pick Up (double/single cabin)	20,481	7,258	5,149	4,908	7,295	7,916	8,176	59,139
Private Passenger Car	163,004	11,423	8,187	9,231	12,972	18,422	18,588	237,180
Special Purpose Vehicle	759	60	28	78	50	66	217	1,204
Tanker	817	152	90	136	163	146	173	1,634
Taxicab	36,011	52	43	4	302	54	1	36,467
Tractor	9,923	4,169	2,841	1,634	1,443	1,637	2,528	23,543
Truck	26,922	4,205	2,824	3,522	5,767	4,424	4,370	50,942
Others	168	0	0	660	967	1307	2233	47
TOTAL	**593,077**	**72,947**	**59,573**	**54,492**	**73,051**	**95,743**	**109,311**	**1,030,864**

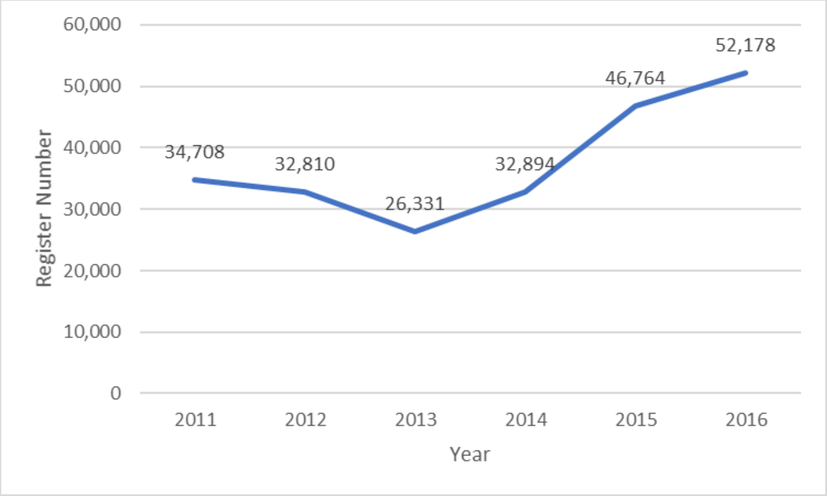
Source: BRTA(2017)

The government is trying to control the number of these types of vehicles by imposing different types of duties and taxes since 2009. There was a restriction on importing reconditioned cars of that are more than 5 years old. Importing reconditioned car duties are applicable depending on its age. To import a car in Bangladesh, several types of taxes are imposed such as import duty (5%), value added tax (15%), advance income tax (5%) and advance trade vat (3%). Aside from these, a supplementary duty is also applied that varies from 30% to 500% depending on vehicle type, engine capacity, etc. Therefore, over-all tax burden in importing a private car may vary from around 100% to 600% that is the reason of the sudden decline in the number of newly registered private cars since 2010.

2) Motorcycle

Motorcycle is becoming a popular mode of transport in Dhaka City as it can be driven through a narrow space and considered a useful transport to reach the destination in the midst of the city's traffic congestion. Its fuel consumption is quite low compared to other private vehicles.

The number of registered motorcycles has increased from 2013 to 2016 sharply. Bangladesh used to import motorcycles like Honda, Yamaha, etc. from Japan, but most of the motorcycles recently are imported from India and China. There are few local companies like Walton and Runner that assemble motorcycle parts and sell at lower price. In 2011, the government increased up to 45% the supplementary duty of importing a complete unit of motorcycle that resulted to a decreasing number of new motorcycles. The government initiated a policy to encourage motorcycle assembly industry, but most people prefer an imported motorcycle.

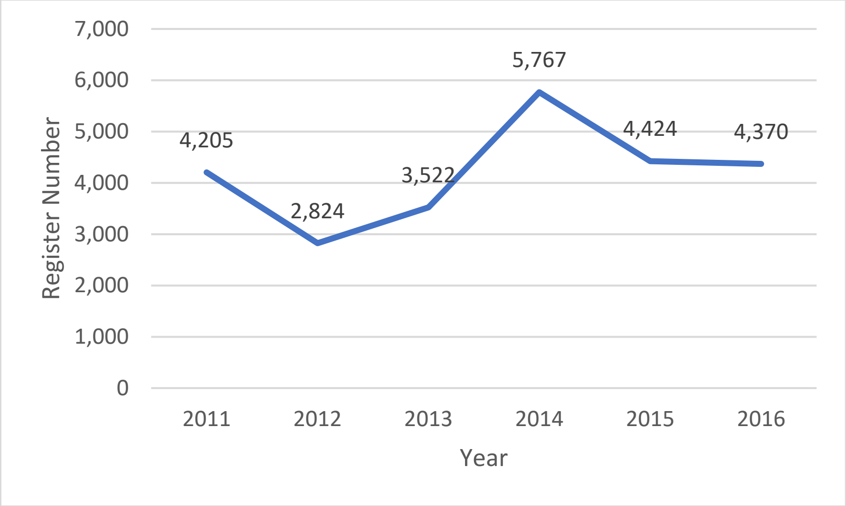


Source: BRTA

Figure 2.4.3 Trend of Yearly Newly Registered Motor Cycles in Dhaka

3) Truck

Truck is an important mode to transport goods within the districts of Bangladesh. In 2004–2005, modal split of freight transportation was around 90% by road whereas only 3.7% by rail and 6.5% by water between two most important districts of Bangladesh: Dhaka and Chittagong (Source: DHUTS). There are different types of trucks in Bangladesh depending on carrying capacity: 1.5 ton, 3 ton, 5 ton and 10 ton. Aside from these trucks there are also covered van and trailer truck which are used for carrying containers. These vehicles are operating within Dhaka, Chittagong and other major districts to transport goods.



Source: BRTA

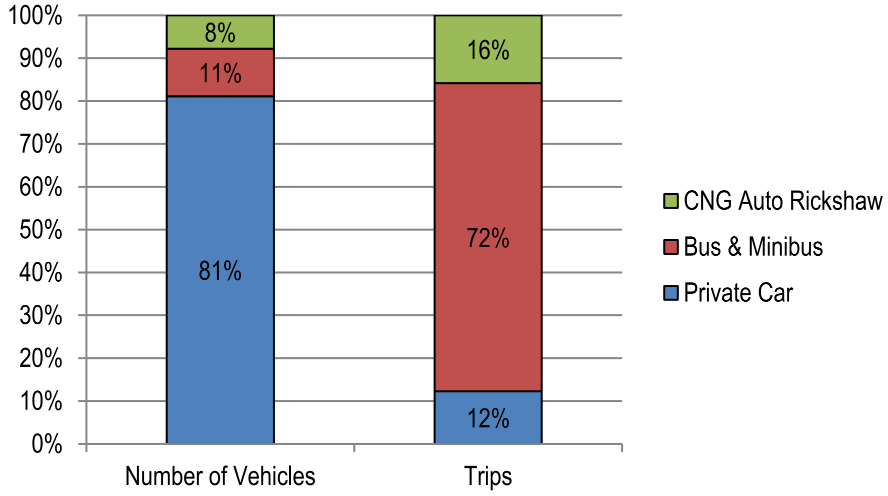
Figure 2.4.4 Trend of Yearly Newly Registered Tracks

The number of truck trips within Dhaka city is increasing every year. In 2009, a total of 28,706 trips were calculated within 24 hours (Source: DHUTS). Due to traffic congestion, Dhaka Metropolitan Police issued an order last July 2012, restricting trucks from entering

Dhaka city on a specified time table, thus trucks can only enter inside DMP area between 21:30 and 8:00. Meanwhile, DMP provides special permission to some trucks considering national importance like carrying government products. Trucks involved in construction work for government infrastructure projects are also allowed anytime inside the city. While trucks carrying export products can anytime use DIT road of Dhaka for going out and entering the city.

2.4.4 Public Transport

Main mode of public transport in GDA are bus, human hauler, train, water vessel, taxi cab, CNG and rickshaw. Recently, a new type of vehicle locally known as 'easy bike' which is basically battery operated rickshaw is also included to the public transport fleet in some areas.Trips by private cars, different types of buses and CNG in 2009 are shown with registered vehicles of each type. Buses and minibuses are generating 72% of person trips with only 11% of the share in registered vehicles.



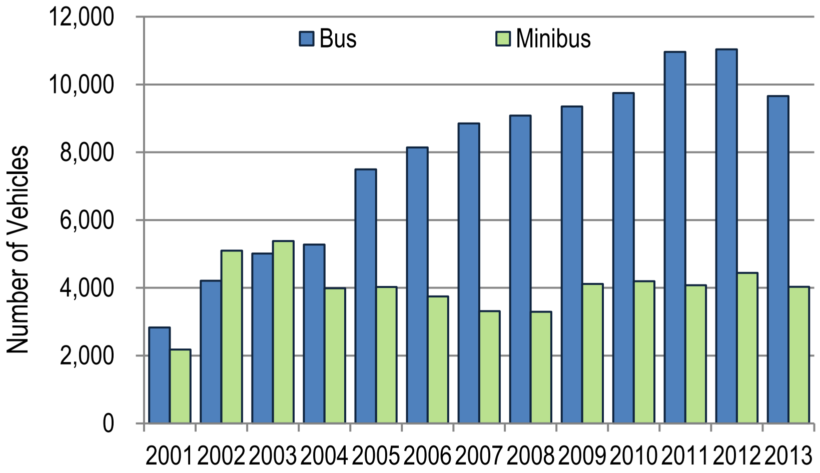
Source: DHUTS & BRTA

Figure 2.4.5 Modal Share and Generated Trips of Motorized Vehicles in 2009

1) Bus and Minibus

Currently, bus and minibus are the main mode of transport for dwellers of GDA. The number of bus routes is increasing every year to meet the travel demand of the people. However, the number of trips is still insufficient to meet the present demand. One of the reasons of low bus trips in GDA is inability to complete the planned daily trips due to traffic congestion.

According to Bangladesh law, 'Mini-bus' means any motor vehicle constructed or adapted or used to carry not more than 30 persons excluding the driver. If the number of passengers exceeds 30 persons excluding the driver then it is considered as bus. The number of registered buses is increasing than the mini-buses. In 2003, minibus has a bigger share compared with bus however the number has totally changed as the government encourages the introduction of large buses into the public transport system of Dhaka. In particular, importing of CNG driven buses has been encouraged in the national budget for the last few years.



Source: BRTA

Figure 2.4.6 Difference of Bus and Minibus

In Dhaka City, there are three inter-district bus terminals where buses depart towards different districts of Bangladesh: Sayedabad, Mohakhali, and Gabtoli. Aside from these, in Gulistan there is a bus stand where passengers can take buses towards south east direction from Dhaka. Some inter-district buses also start from Fakirapul, Kalabagan, Kallayanpur and Abdullahpur (near Uttara). Ten years ago, all inter-district buses were allowed to enter Dhaka city and take passengers from these locations. But presently bus companies provide mini-buses to carry passengers from here to main terminal. There is no designated bus terminal for city buses in Dhaka city which creates traffic hazards as most of the buses are parked along the road. Meanwhile, BRTC has five bus depots in different location of Dhaka city.

Table 2.4.2 Summary of the Inter-District Bus Terminals

Name	Area	Capacity	Daily Trips	Number of routes
Sayedabad	App. 40,500m^2	App. 500	App. 2000	87
Mohakhali	App. 36,400 m^2	App. 300	App. 800	60
Gabtoli	App. 123,400 m^2	App. 700	App. 2200	61

Source: DNCC, DSCC, & BRTA

2) Human Hauler

Human hauler, which is smaller than buses, is another type of public transport in Dhaka. Like for bus regulation, BRTA also issues route permission to human hauler services. As per BRTA records (March 2014), there are 106 planned routes for human haulers within Dhaka City and, out of these, only 34 routes currently operate with at least 1,733 human haulers on service. Different types of human haulers are Tempoo, Bondhuparibahan, Laguna, Champion, etc. Seating capacity of Tempoo and Laguna is around 10 to 12 persons while Bondhuparibahan and Champion have 14 to 20.

3) Train

Cost and safety are the two main reasons why Bangladeshi use train. Train's fare is cheaper than that of buses and it is considered as a safer mode of transport since the number of accidents and casualties is lower compared to buses. However, some people are hesitant to take the train due to sudden delay as most of the rail network in Bangladesh is single track. If any accident occurs, all train operations are affected.

Train service of Bangladesh is basically divided into categories intercity and mail. Commuter train is listed under mail train. These trains have several types of seating capacity depending on the route and train. Most exclusive one is the air-conditioned room which has sleeping arrangement and fare is almost 13 times higher than the cheapest class on the same route.

In GDA, people of Gazipur and Narayanganj use train quite often for commuting to Dhaka city. At present, a total 16 pair of commuter trains between Dhaka and Narayangonj and 4 pairs of commuter trains between Dhaka and Joydevpur are operating on weekdays. Between Dhaka and Joydevpur there are also other trains carrying passengers from Dhaka to Joydevpur. However, these trains do not stop at all the stations.

Table 2.4.3 Summary of Commuter Train Fare of RAJUK Area

Commuter Route: Dhaka (Kamalapur) –Joydevpur					
From	To	Distance	Regular Fare	Special Fare	Stations
Kamalapur	Airport	22 Km	10 Taka	BDT35; Intercity Train*	Tejgaon, Dhaka Cantonment
Kamalapur	Joydevpur	39 Km	15 Taka		Tejgaon, Dhaka Cantonment, Tongi, Dhirasram
Commuter Route: Dhaka (Kamalapur)–Narayanganj					
From	To	Distance	Regular Fare	Special Fare	Stations
Kamalapur	Cahra	14.5 Km	8 Taka	BDT15; Diesel Electric Multiple Unit (DEMU)Train	Gandaria, Fatullah
Kamalapur	Narayanganj	16.1 Km	10 Taka		Gandaria, Fatullah, Cahra

*Intercity trains do not stop at all the stoppages

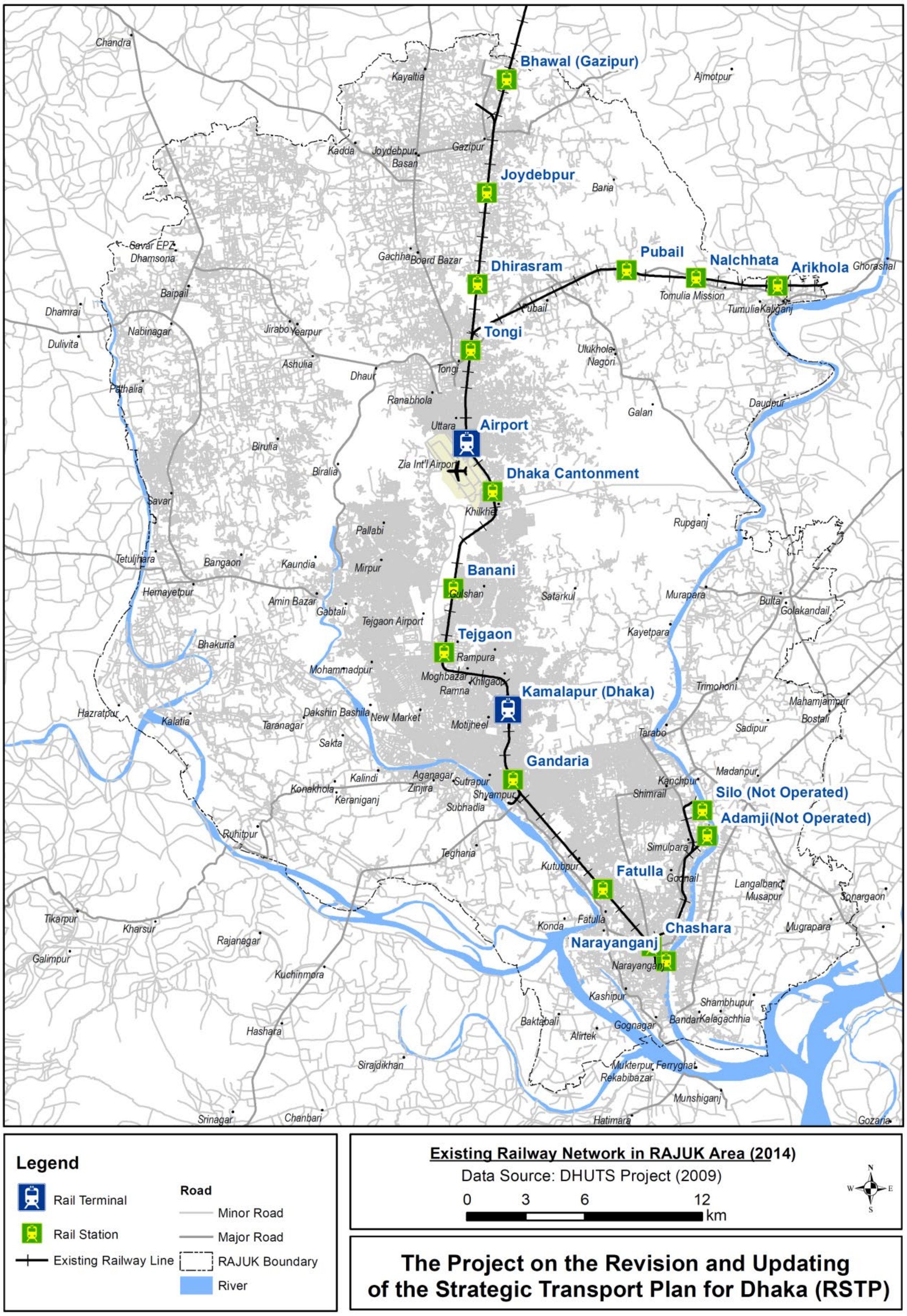


Figure 2.4.7 Existing Railway Network in RAJUK area

4) Water Transport

In Bangladesh, transport via water plays an important role, particularly for people from the southern district who uses different types of water transports like launch, ferry, steamer, etc. to come to Dhaka.

All long-distance water vessels towards Dhaka arrive at the main water terminal called Sadarghat. At present, there are 48 different long distance routes from Sadarghat to other districts in Bangladesh. Out of these 48 routes, 3 are for both private- and government-operated water vessels, 7 are only for government-operated vessels, and 38 are for private-operated water vessels. Bangladesh Island Water Transport Authority (BIWTA) is responsible for issuing the route permit and fare regulation, while Bangladesh Island Water Transport Corporation (BIWTC) is responsible for operating government-owned water vessels.

5) Taxi cab

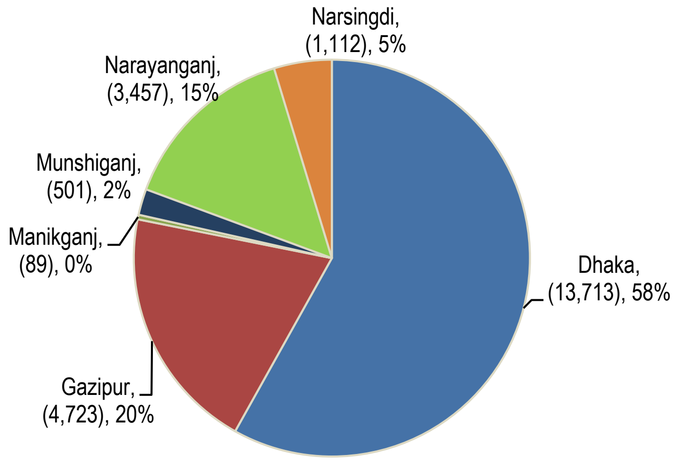
Taxi-cab service launched in Dhaka City almost 16 years ago. The two types of taxi cabs are airconditioned (A/C) and non A/C. All the A/C taxicabs are yellow-colored and the non-A/C cabs are black- or blue-colored. Most of the old taxicabs are in very poor condition, low service quality, and/or mostly are non A/C. Many of the old taxi cabs are now already off-road due to poor maintenance service. Some dilapidated cabs are still running in the roads with a pale gesture. As per BRTA, there were around 9000 taxi-cabs in Dhaka City in 2013.

In April 2014, a new taxi-cab service was introduced in Dhaka City under Trust Transport Services and Toma Group. These taxi-cabs have different types of modern features such as: A/C, radio communications, video recording, automatic vehicle tracking, on-call service, receipts, etc. However, the fare of this service is more expensive than any other public transport services in the past.

6) ”CNG” (Three-wheeler Auto-Rickshaw)

Three-wheeler auto-rickshaw plays a vital role in the public transportation system of Dhaka. Basically, the two major types of rickshaws are compressed natural gas-powered (CNG) rickshaws and Mishuk. Mishuk is a special type of three-wheeler made in Bangladesh and driven with petrol. Nowadays, Mishuk has become very rare. A maximum two persons can sit comfortably in Mishuk while three persons can in a CNG.

Before 2002, there were around 40,000 auto-rickshaws driven by two stroke petrol engines and was known as “baby-taxi.” Due to the huge air pollution emitted by a baby-taxi, the government decided to have it replaced. In 2002, the Government of Bangladesh introduced 12,000 three-wheelers in Dhaka City that will run using CNG. The three-wheeler auto-rickshaw is now known as “CNG.” It will also be used in this report to describe this type of vehicle, since it is driven using CNG. In 2013, there are around 23,500 CNGs that operate in GDA as per BRTA. Around 14,000 units are registered in Dhaka district, while Gazipur and Narayanganj also have significant numbers of CNG among the other districts of GDA.



Source: BRTA

Figure 2.4.8 Share in CNGs (2013) among GDA Districts

The life span of CNGs was predicted 8 years from the time of introduction. However, in 2011, the government extended the life span by another 3 years and was supposed to have ended in 2013. But due to some protests from the owners and drivers, the government decided to increase the life span to 15 years unless the vehicle meets the conditions set by Bangladesh University of Engineering and Technology (BUET). These conditions are full-overhauled engine, replacement of hood cover and seats, necessary repairs of body, and suspension and break transmission.

CNGs are basically owned by an individual unlike the taxicab. The owner leases his CNG to a driver for 8 hours and can officially charge 600 takas, but most drivers complain that they have been charged 800 to 1000 takas. Another common practice by CNG owners is to lease the CNG to two different drivers in a day for an 8-hour shift that will make him earn twice from the same CNG.

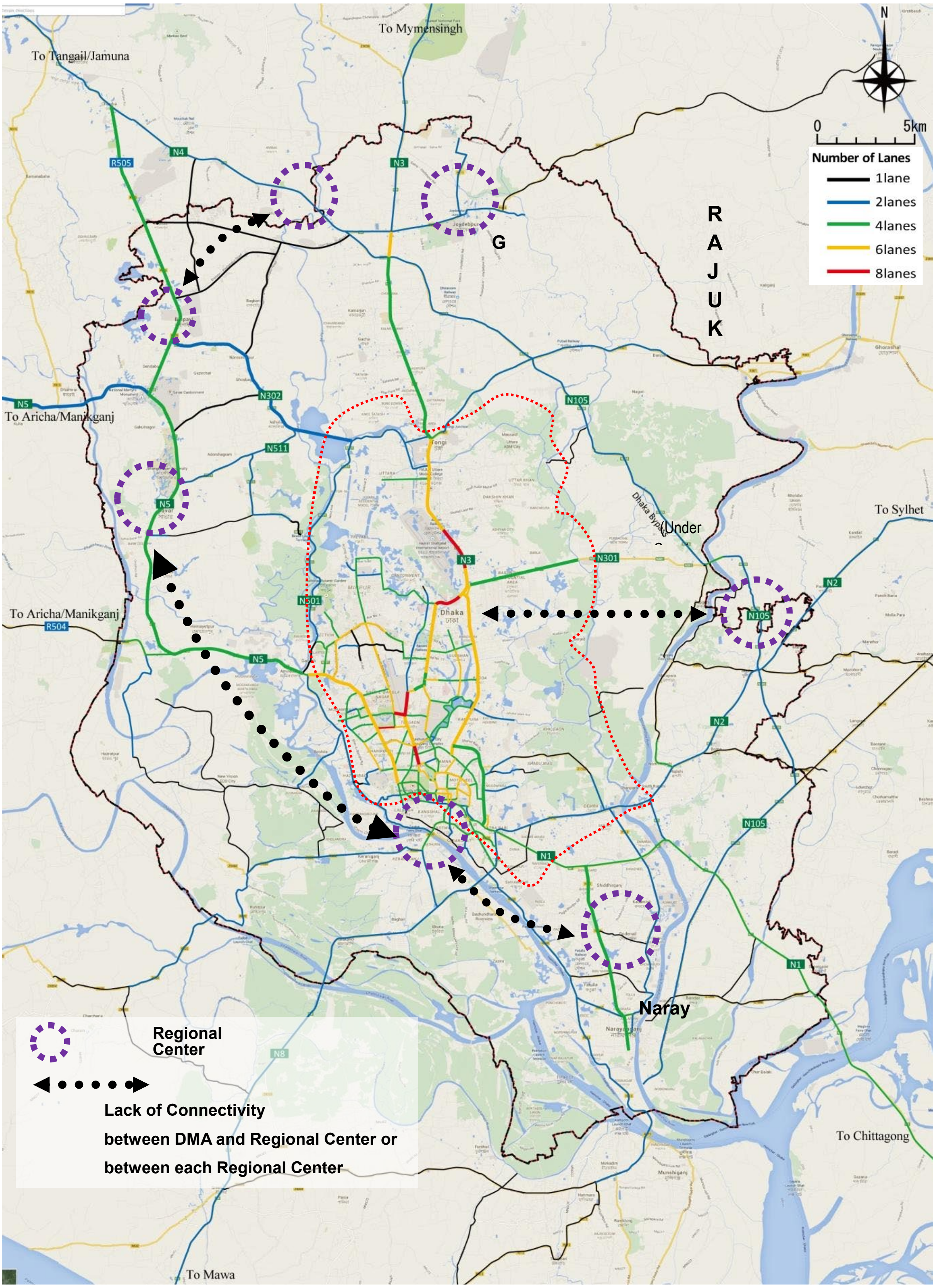
2.4.5 Urban Road Network

The road network system in the study area can be divided into two major areas as shown in Figure 2.4.10. One is the urban network that serves the traffic movement among the urban centers (DMA). The other is the regional network that serves regional traffic movement in the suburban area (RAJUK area out of DMA).

DMA is situated in the middle of RAJUK surrounded by Buriganga, Turag, and Balu Rivers. Although the major roads in DMA are multi-lane and the current pavement conditions are generally good as reported in DHUTS, there is still severe traffic congestion due to insufficiency of functional road classification, some missing links, and inadequate traffic management.

As for the road network in the suburban area, its road density is lower than in the urban area and connectivity to some adjacent regional centers is unavailable. Such situation is assumed to hamper regional partnership and to promote intense concentration of population and advanced urban functions to DMA.

Although Bangladesh governments formulated policies to resolve problems, such as exclude rickshaw from specific areas and restrict entry on cargo vehicles, the effect of policies is limited due to lack of implementation. Therefore, it is necessary to impose alternatives to road transportations.



Source: JICA Study Team

Figure 2.4.9 Major Road Network in RAJUK Area

2.4.6 MRT Line 6

1) Background

JICA conducted the Dhaka Urban Transportation Network Development Study (DHUTS) Phase 1 in March 2009 with the DTCA as its counterpart agency. The study's objectives were to conceptualize basic urban development scenarios for the DMA up to 2025 and to select priority projects that would be integrated into the scenarios. That study recommended the prioritization of constructing MRT Line 6. As a result, JICA conducted the feasibility study on MRT Line 6 under DHUTS Phase 2. Following this study, the GOB and JICA concluded in February 2013 the loan agreement on the Dhaka Mass Rapid Transit Development Project that was the blueprint for the construction of an MRT Line 6.

2) Existing Situation

Dhaka Mass Transit Company (DMTC) was established under the Ministry of Road Transport and Bridges as the MRT Company in 2013. Since September 2014, the General Consultant has been implementing the design works and has been preparing tender documents for MRT Line 6. At the same time, Institutional Development Consultant (IDC) for the Dhaka MRT Line 6 has started.

3) Progress of Construction Work (September, 2018)

There are eight kinds of bid, six packages for civil works, one package for system, and one package for locomotive.

CP-01: contract package CP-01 is for the land development of depot area which is completed and handing over to CP-02 contractor.

CP-02: contract package CP-02 is depot civil and buildings which are stabling yard, central store for maintenance and overhauled materials, space for overhaul and train maintenance, main workshop, operation control center, train inspection, generator and electrical building, train wash station, manual train washing, multi-storied building for DMTC head office, and green space. Presently, construction of retaining, sonic logging test at test pile, check boring, static load test on test pile, service pile, permanent pile and raft construction of building are going on.

CP-03 and 04: construction of viaducts and nine elevated stations between Uttara North and Agargaon and boring, construction of permanent pilling, pile cap, column and pier head, and precast segment are going on all along the corridor.

CP-05 and 06: package CP-05 is for the construction of viaducts and elevated stations from Agargaon to Karwan Bazar and package CP-06 is for the construction of viaducts and elevated stations from Karwan Bazar to Motijheel. The contractors have been taken access to and possession of the site and construction yards is under construction.

CP-07 and 08: package CP-07 is for electro-mechanical system and CP-08 is for rolling stock & depot equipment. Contractors are discussing about demarcation of communications system with PDCB, ESS dimensions and interface issues. The CP-08 contractors are discussing with CP-02 and CP-07 teams and reviewed the progress.

The periodic monitoring, reviewing, reporting of Environmental and Social Environment (WG-6) of CP-02, CP-03 & 04 is going on.

2.4.7 BRT Line 3

1) Background

The BRT Line 3 corridor project in Dhaka is under the Greater Dhaka Sustainable Urban Transport Project (GDSUTP). Asian Development Bank (ADB) sponsored the BRT route of the northern section that connects Gazipur and Uttara (international airport). World Bank sponsored the BRT route of southern section that connects Uttara (Airport)–Mohakhali–Ramna–Gulisthan–Keranigonj (Jhilmil). BRT Line 3 corridor in Dhaka has different sponsor, however. It is a single BRT route that connects the northern and southern areas. So, BRT Line 3 corridor must have a design with an equal service pattern for public transit users. The completion date should have been in 2016. Planning and joint implementation should be coordinated, and the northern and southern projects should become one BRT system upon completion.

Therefore, considering coordinated BRT system, this detail design work for BRT Line 3 corridor (Airport–Keraniganj) will have to be the service pattern with same bus fleets and same infrastructures such as bus-way, station, and etc. However, after preparation of detail design, the project was out of project list by the World Bank because of the proposed RAJUK Flyover Project. It made the BRT Line 3 Project impossible to be implemented at the same transport corridor.

2) DTCA Proposal

In this situation, DTCA made a proposal to World Bank to implement the project under phasing with the justifications. The proposed phases were as follows:

Phase 1:

Airport to Mohakhali section: Construction of 10-km BRT corridor from airport to Mohakhali including construction of five BRT stations, Mohakhali flyover, Mohakhali terminal, and Keraniganj Depot. Prepare and implement shuttle service plan from Mohakhali to Keranigaj (Jhilmil).

- Construct airport to Mohakhali.
- Construction of Mohakhali and Keraniganj Depot.
- Commence BRT service.
- Establish Shuttle service.

Phase 2:

Mohakhali to Gulistan section

- Construct Mohakhlai to Gulistan.
- Expand BRT service.

Phase 3:

Gulistan to Jhilmil section

- Construct final stage to Jhilmil.
- Operate full BRT service.

3) DTCA’s Justifications

- It is a proactive measure to manage traffic and travel demand during BRT construction that demonstrates good planning and management initiative during the traffic chaos due to BRT construction. Public opinion of the BRT project is likely to be improved.

- Provides an essential transport connection to Mohakhali and Farmgate should the ADB BRT northern section of the airport be completed earlier than the World Bank section.
- A traffic management measure during BRT construction is to offer motorists a good alternative than be stuck in traffic and introduce the use of the bus service prior to BRT.
- Allows restrictions to be placed on cars on the basis that good public transport alternatives are provided (with traffic priority for buses).
- The interim shuttlebus service will pilot key elements of the BRT such as establish system management (the BRT Co.), engage operators under contract, initiate fleet procurement, and commission the system.
- Triggers early engagement with affected bus operators and establishes the operations of the future BOC consortium of BRT Line 3, introducing them to a performance-based contract regime prior to start of BRT.
- Establishes the operations of the BRT company; giving them a trial run in bus operations, providing services and managing contractors.
- Facilitates an early introduction of e-ticketing system prior to BRT with revenue collected by the Dhaka BRT Co. (BOC is paid on km basis) giving the BRT Company time to familiarize and trial the system.

4) The Mission

In this context, a World Bank team carried out an Exploratory Mission for the proposed Dhaka BRT Line 3 on 23–27 April 2017. The main objectives were to assess the modified project proposal from the original proposal in 2013, namely on the line length and the arrangement for the implementing agencies, and to understand if the new proposal is technically sound and if an effective coordination mechanism is in place for the stakeholder agencies.

5) The Features of the Project

The mission identified the following features of the new proposed proposal:

- Corridor. The proposed project is for the Phase 1 section (10.5-km from airport to Mohakhali) of the BRT Line 3 corridor. The Line 3 Corridor was originally proposed in the Strategic Transport Plan (STP) that was developed with support through the WB-funded Dhaka Urban Transport Project (DUTP) and approved by the government in 2008. The corridor is also included in the Revised Strategic Transport Plan (RSTP), approved during the August 2016 Cabinet meeting as a part of 2 BRTs and 6 Mass Rapid Transit (MRT) networks.
- Connection with BRT Line 3 North. The Government of Bangladesh is in the implementation phase of GDSUTP that is funded by ADB, AFD, and GEF. The GDSUTP 'will contribute to developing a sustainable urban transport system in DNCC and Gazipur City Corporation (GCC) areas, which form part of north Greater Dhaka, through the delivery of a 20-km BRT corridor; BRT line 3-North will start from Gazipur BRT Line 3-North and Line 3-South is connected at the airport station. The plan is to have a single operation for the entire corridor with buses operating continuously across Airport Station, managed by the same Dhaka BRT Company.
- BRT Operation. The Line 3 Corridor will run articulated 18m-long buses on the dedicated lane by the median. The BRT lanes will have physical barrier (high-curb or

fencing) to prevent mixed traffic and pedestrians from coming in. There are seven stations (Airport, Khilkhet, Kuril, Cantonment, Kakoli, Amtali, Mohakhali Terminal), which will be on the median side and not the curve side. Stations will be accessible via foot-over-bridges or pedestrian subways with universal access or at-grade road crossing. BRT buses will run mainly at grade, but also on existing Banani Flyover (between Cantonment and Kakoli), and the proposed Mohakhali Flyover, which will be constructed in the North–South direction to the east side of the existing Mohakhali Flyover.

- Implementation Arrangement. Two project implementation units (PIUs) at RHD and DNCC were proposed and supported by project coordination unit (PCU) at DTCA. DMP will work closely with PIUs/PCU on traffic management matters and will have another PIU once its technical unit is established.
- Project Activities. Based on the request letter and preliminary discussions with the clients, the following activities were envisaged at this stage:
    - BRT Corridor Construction (implemented by RHD). At grade corridor, Mohakhali Flyover, and stations.
    - Feeder Road Construction (by DNCC). Feeder road, sidewalk, street lighting, drainage
    - Terminal and Depot Construction (by DNCC, RHD). Mohakhali Multi-story Terminal (by DNCC), Keraniganj feeder Bus Depot (by RHD)
    - Traffic Management (by DNCC for DMP, or Bangladesh Police HQ).
    - Regular Bus Restructuring (by DTCA/DNCC/RHD). Bus depot, bus stops, signs, fleet renewal -program, etc. This needs further clarification on activities and responsible agencies.
    - Studies and Technical Assistance (by DTCA).
- Project Cost: $250 million.

6) Technical Aspect

Overall, the mission found the proposed project to be technically sound and will have a significant impact in improving the traffic situation in Dhaka. While truncation into Phase 1 would pose operational challenges for the feeder bus service from Mohakhali to possible BRT passenger destinations like Farmgate and Gulistan, it is deemed feasible with the proposed number of buses and service plan. However, detailed observations of the mission on the technical aspects were as follows:

- Project Outline. The proposed construction of the RAJUK elevated road made it impossible to construct the BRT Line 3 Southern Section from airport to Keraniganj as originally planned. An alternative approach whereby the line is modified and completed in sections/phases was proposed by GOB. Funding for the first phase from airport to Mohakhali Bus Stations was requested and is the subject of this current assessment. This section is 10.5-km in length and is planned to form a single corridor with the ADB-funded Line 3 northern section that runs from Gazipur to the airport. Some of its aspects are now under construction. The original project envisaged three BRT services (S1–S3) that operate from the northern to the southern sections with two services that terminate at Gulistan and one service continue across the river to Keraniganj. A fourth service, S4, was also planned to operate between Uttara and Farmgate that joins the

BRT reserved lanes at House Building and leaving again from BG Press to travel in mixed traffic to Farmgate.

- Project Impact. The proposed project will benefit commuters that use this corridor and choose to switch to BRT. Travel time between the airport and Mohakhali by BRT is anticipated to be less than 30 minutes in contrast to the current travel time that is generally about one hour or can often be more. BRT Line 3 North and South is expected to carry about 300,000 daily passengers, most of which are likely to come from buses. As a result, bus traffic on the corridor will be greatly reduced, congestion will be reduced, and air quality will improve. The provision of safe, clean, and reliable public transport will also greatly benefit the tens of thousands of female workers at the garment factories along the corridor.
- BRT Route Truncation. As a result of the truncation of the BRT infrastructure at Mohakhali (which also has a BRT depot adjoining the BRT station at this point) all passengers on Services S1–S3 wishing to travel to Gulshan will be required to interchange to feeder buses at Mohakhali. Passengers on S4 to Farmgate will be unaffected by the truncation as the BRT ramp down from the Mohakhali elevated section will be constructed enabling the S4 to re-join the street system to travel to Farmgate. Passengers on S1–S3 who wish to go to Farmgate will interchange at Amtali to the S4 as was planned in the original design. All buses on S1–S3 will enter the Mohakhali Depot, make a turn in the depot, and re-join the BRT corridor starting again from Mohakhali Station. The S1–S3 service operates at 3-minute intervals with the S4 operating at 4-minute intervals. DCTA estimates this would require peak vehicle requirement of 66 buses on S1–S3 and 27 buses on S4. Assuming 10% spares, this suggests a fleet size for these services of 103 buses.
- Feeder Service Plan. The feeder service is expected to operate from Mohakhali, making use of the depot to turn around. Assuming separate feeder routes are used (rather than BRT buses simply continuing in mixed traffic), passengers from Gulshan would be dropped off at Mohakhali Station and the feeder buses would turn in the depot then return to Mohakhali Station to pick up southbound passengers. Current plans prepared by DTCA propose that the feeder route operates at 90 second intervals between Mohakhali and Keraniganj. That would require 106 buses in service plus 11 spares making a total of 117 buses. They are assuming the feeder buses are high-floor, 18-m long, and of140-capacity similar to the BRT buses with low-level doors on the left-hand side to enable boarding/alighting at regular bus stops.
- Importance of Phase 1 to BRT Line 3 North. If the southern section of Line 3 is not built and the northern section terminates at the airport, this will force all passengers to transfer to local buses with an estimated 10,000 passengers per hour at peak. This will not be attractive to passengers, will place huge transfer demands at the airport station, and will severely affect the viability of the northern section. Therefore, there are significant grounds to proceed with the southern section.

7) Next Steps of BRT Line3

- Operational risk assessment of Roads and Highways Department (RHD) by World Bank on 30 September 2017.
- Procurement and contract management capacity and risk assessments of DTCA, RHD, and Dhaka North City Corporation (DNCC) by World Bank on 30September 2017.
- Request WB for project preparation advance by DTCA, RHD, DNCC, and ERD on

31December 2017.

Source: BRT and Corridor Restructuring Implementation Study and Preliminary Design work for the Uttara–Mohakhali–Ramna–Sadar Ghat Corridor in Dhaka.

Figure 2.4.10 BRT Line 3 Network

8) Progress of BRT Line 3 (September, 2018)

(1) Southern Part – funded by the World Bank

As per present scope, a 10km BRT Line 3 (southern part) would be constructed along with seven stations from Airport to Mohakhali Bus Terminal rather than 22km from Airport to Keraniganj. The southern part of BRT will link with northern part BRT Line 3 at the airport. The southern BRT line will mix of at-grade and elevated. Airport to Kakoli is at-grade section and Kakoli to Mohakhali is elevated section and the bus terminal will also elevated at present Mohakhali Bus Terminal. The BRT Line 3 is renamed as “Dhaka Public Transport Improvement Project”. The project presently is preparing Technical Assistance Project Proposal (TAPP) for (i) revision of design, (ii) social safeguard and resettlement action plan, and (iii) environmental study to get the updated cost estimation. The project office will engage the TAPP consultants and will prepare Development Project Proposal (DPP) as per the costs and review findings.

(2) Northern Part – funded by Asian Development Bank

The detail design and construction supervision of the project was started since October 2013 and construction was started since July 2016.The summary of progress is up to September 2018.

Table 2.4.4 Progress of Northern Part of BRT Line 3

Work	Contract 01		Contract 02		Contract 03	Contract 04
	Required	Achieved	Required	Achieved		
Sub-soil investigation (nos. of boreholes)	92	92	200	129	24 out of 74 roads to be constructed have been taken up for works.	Gazipur bus depot with parking are and maintenance facility. 82.21% work completed
Pile (nos.)	800	87	2000	5 9test piles)	8 kitchen markets need to be developed/ constructed. No work taken up yet	
Pile cap (nos.)	105	6	287	0		
Piers (nos.)	105	0	287	0		
Drainage (m)	23,680	4,480	6,400	0		
Pavement (m)	32,000	250 (up to sub-base)	9,000	0		
Stations (nos.)	19	1 (footbridge on going)	6	0		

2.4.8 Dhaka Elevated Expressway (DEE)

1) Objective

The purpose of the expressway is to increase traffic capacity within and around the city by improving connectivity between the northern part of Dhaka City with the central, south, and south-eastern parts. In addition to providing a much-needed increase in traffic capacity, the expressway will be designed to relieve existing overloaded roads. Access and distribution to the expressway will be designed to avoid adding congestion to existing facilities.

2) Project Scope

Design, construction, operation, and maintenance of the approximately 23-km elevated expressway including construction of culverts, toll plazas, underpass and overpass, lay byes, wayside amenities; installation of computerized toll collection system, providing adequate lights and development of service areas with all required facilities.

3) Main route

The route of the DEE shall commence at Shahjalal International Airport and go along the New Airport Road and the rail alignment through the Mohakhali, Tejgaon and Moghbazar to Kamalapur Rail Station. Then the expressway shall pass through Golapbag that is south of Kamalapur Stadium and east of Jatrabari, and then connect to Dhaka–Chittagong Highway near Kutubkhali. Elevated Link 1 is Manik Mia Avenue–Holy Cross College–Tejgaon Crossing. Elevated Link 2 is Palashi–Katabon–Hatirpul–Hotel Sonargaon (backside)–Moghbazar.

4) Progress of DEE PPP Project

Progress in Land Acquisition

The project would be needed 210 acres of land to be acquired along the expressway corridor. Of them, 180 acres are under government (120 acres are under Bangladesh Railway) and 30 acres are under private land. The BBA already acquired 25 acres of land from private owners and remaining 5 acres to be acquired. In addition, demolition of structures and shifting of utilities are ongoing.

It is seen that the progress of a 7km of Tranche – 1 (Airport to Banani) is visualizing. The Trans-2 (Banani to MoghBazar, 7km) and Tranche-3 (MoghBazar to Kamlapur to Kutubkhali, 7km) are not visualizing.

Progress in Physical Works

The following table shows the major activities and program of First Dhaka Elevated Expressway up to 31st August 2018.

Table 2.4.5 General Features of Dhaka Elevated Expressway (DEE) Project

Items	Descriptions
Executing Agency	Bangladesh Bridge Authority (BBA)
Investor Agency	Italian Thai Development Public Company Limited
Signing of Agreement	15 December, 2013
Project Route	Shahjalal International Airport – Kuril – Banani – Mohakhali – Tejgaon – Mogbazar – Kamlapur – Sayedabad – Jatrabari – Dhaka Chittagong Highway (Kutubkhali).
Length	Mainline: 19.73 km Phasing of the Project: 1st Phase – Chain 0+000 m to 7+450 m 2nd Phase – Chain 7+450 m to 13+300 m 3rd Phase – Chain 13+300 m to 19+730 m
Ramp	31 number, length 27 km
Total length	46.73 km
Construction Costs	BDT 8940.18 Crore
Support to Dhaka Elevated Project Expenditure	BDT 3216 Crore.
Viability Gap Funding (VGF)	BDT 2413.84 Crore.
Concession Period	25 years (including 3.5 years construction period)

Source: Bangladesh Bridge Authority (BBA), June 2017

Table 2.4.6 Progress of Works by Items of Dhaka Elevated Expressway (DEE) Project

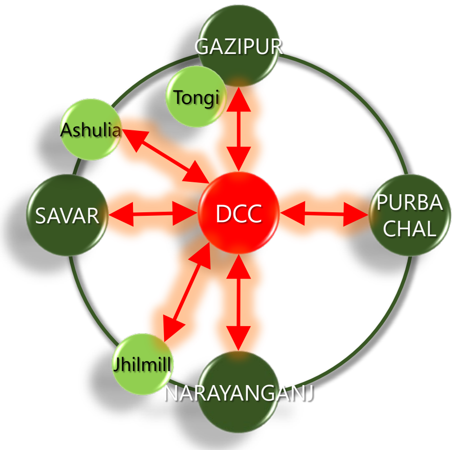
SL	Work Description	Unit	Est. Total Quantity (Tranche-1)	Total Work Done (Tranche-1)	% Work Progress (Tranche-1)
1	**Bored Pile Work**	**No.**	**1,514**	**1,127**	**74.44%**
1.1	Mainline (Dia. 1.00m & Dia. 1.2m)	No.	1,194	943	78.98%
1.2	Ramp (Dia.0.80m & Dia. 1.00m)	No.	320	184	57.50%
2	**Footing/Pile Cap Work**	**Pier**	**350**	**195**	**55.70%**
2.1	Mainline	Pier	225	169	75.11%
2.2	Ramp	Pier	125	26	20.80%
3	**Pier Column Work (Equivalent No.)**	**Pier**	**350**	**127.80**	**36.50%**
3.1	Mainline (Equivalent No.)	Pier	225	111.60	49.60%
3.2	Ramp (Equivalent No.)	Pier	125	16.20	13.00%
	- Pier Column Upper Part (Step-2) – Full Height	Pier		Mainline=84 Ramp=15	Full Height =100.2 Pier
	- Pier Column Lower Part (Step-1) – 40%	Pier		Ml. Stem-1=153 Pier	Balance Stem-1 =69 Pier
4	**Crosshead/Portal Beam**	**Pier**	**350**	**25**	**7.14%**
4.1	Mainline – Crosshead/Portal Bean	Pier	225	25	11.11%
4.2	Ramp – Pier Head for ramp	Pier	125	-	0.00%
5	**PC Yard Construction for I-Girder Production**	**LS**	**1**	**-**	**100%**
6	**PC –Girder Production**	**No.**	**3,179**	**150**	**4.53%**
6.1	PC I-Girder (Typ. Length 30m) – Mainline	No.	2,512	147	5.85%
6.2	PC Yard – (Type. Length 30m) – Ramp	No.	667	3	0.45%

Source: Bangladesh Bridge Authority (BBA), August 2018

3 Route Selection

3.1 Review of Previous Studies

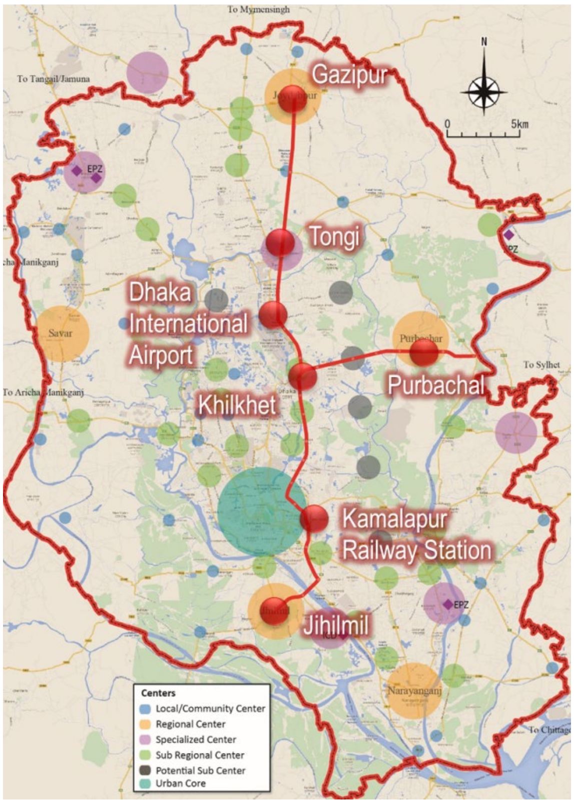
According to the Final Report of “The Project on The Revision and Updating of the Strategic Plan for Dhaka (RSTP) (2016 Nov.), Dhaka’s MRT Line 1 originating from the Gazipur Region passes Tongi, then the International Airport, and when it reaches Kuril, it divides into a southern branch and an eastern branch. The southern line is aimed to go further to the Jhilmil Region, while the eastern line aims to serve the Purbachal development area. The total length of Line 1 is 52km. The said Line 1 is expected to have the highest passenger demand among the seven corridors that was proposed by RSTP. The number of passengers is estimated at 1.9 million per day by 2035.



Source: RSTP Final Report (2016, JICA)

Figure 3.1.1 Transport Corridor in RAJUK Area

The RSTP-proposed Mass Transit System Network is shown in Figure 3.1.1, connecting the central business district (CBD) and the Suburban Regional Centre.



Source: JICA Study Team

Figure 3.1.2 Proposed MRT Line 1

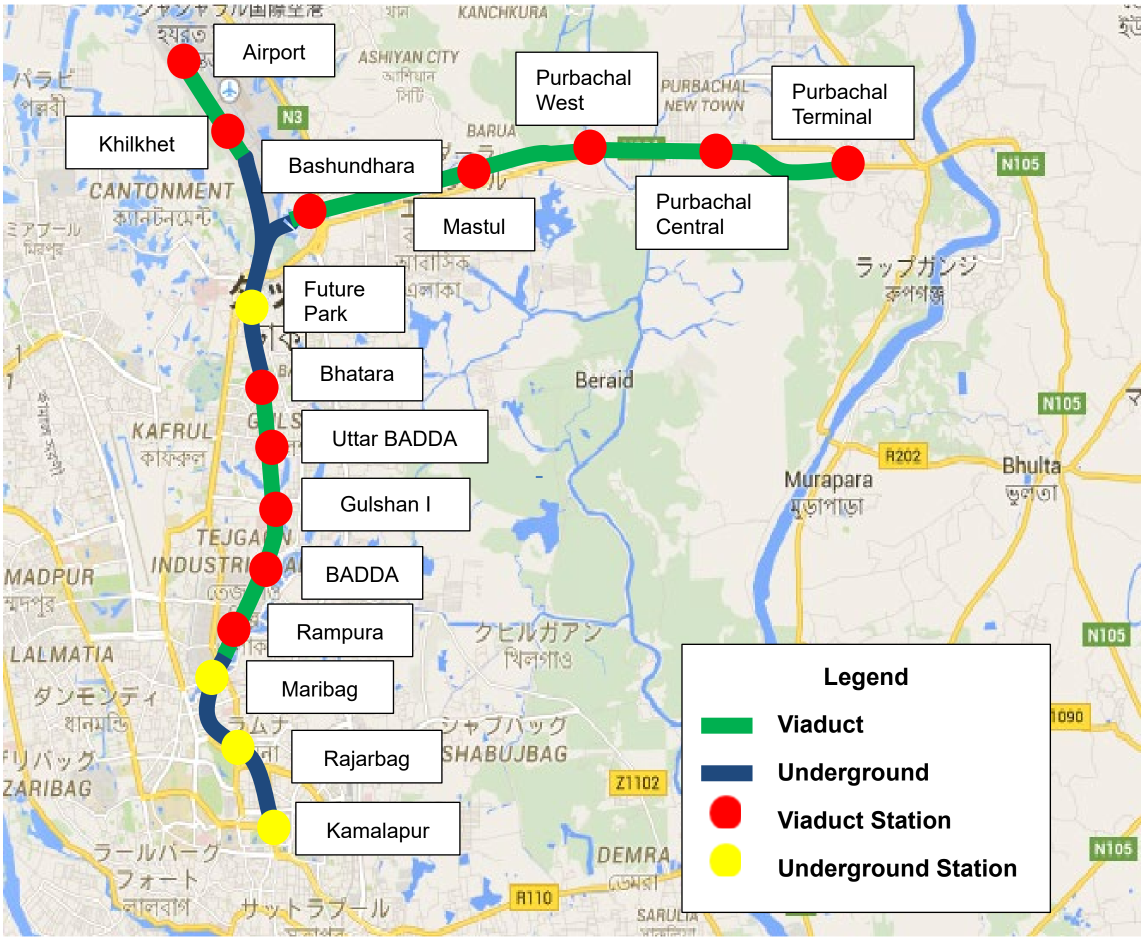
The proposed MRT Line 1 originates from the Gazipur Regional Centre and runs south toward the Tongi – International Airport and further into the CBD. While the route originating at the RAJUK Jhilmil development area in the southern part of MRT Line 1 crosses the Buriganga River and reaches the CBD via Kamalapur, the northern part of MRT Line 1 separates at the Kuril Area where it branches into the southern line and eastern line. The proposed MRT Line 1 is shown in Figure 3.1.2. MRT Line 1 Study Team assumed CBD area are comprised of Motijheel Center Ward (Thana) as commercial center, Shahbag Ward as Educational center, Paltan Ward as Government Office.

The MRT Line 1 has the most potential among the proposed seven corridors, and early project implementation was proposed. It is desirable to operate MRT Line 1 following MRT

Line 6, which is presently under construction. RSTP proposed opening the MRT Line 1 in 2025

As one element of RSTP, a preliminary feasibility study (Pre-FS) was conducted, and it recommended as Phase 1 the MRT Line 1 between the International Airport and Kamalapur, and the Purbachal Line, in order to establish the Rolling Stock Depot. There are many opinions that MRT Line 1 Phase 1 should originate at UTTARA, where high demand is expected. But in the same corridor, the BRT Line 3 Project (Bus Rapid Transit System) is under way with financial assistance from the Asian Development Bank. It was decided that it will be at the International Airport terminate that MRT Line 1 terminates pending a detailed study about the movement of people after opening BRT Line 3.

Figure 3.1.3 shows the proposed alignment of MRT Line 1 by Pre-FS.

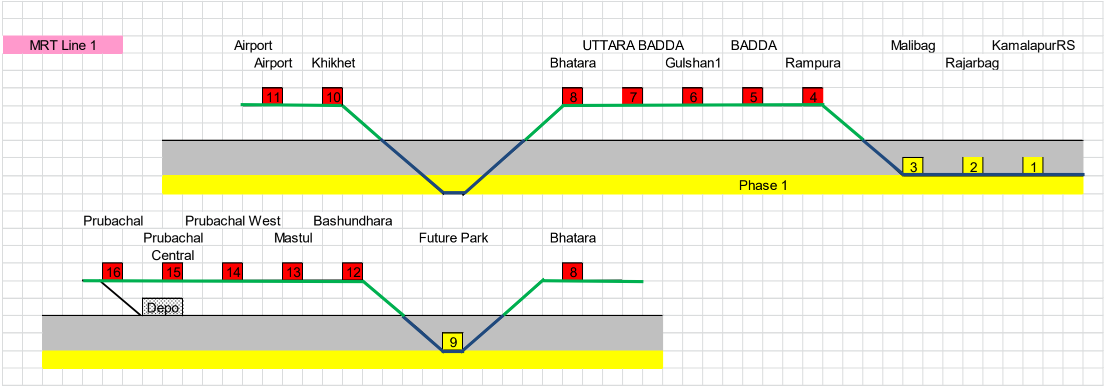


Source: JICA Study Team

Figure 3.1.3 The Proposed MRT Line 1 by Pre-FS

Though the main FS plan was supposed to be discussed more in detail based on the Pre-FS plan, the result of careful evaluation on current existing urban infrastructure showed that the space for introducing MRT needed drastic revision.

Figure 3.1.4 Shows the structures plan proposed in the Pre-FS and details are discussed in section 3.2.3.



Source: JICA Study Team

Note: Station name ofBADDA, Gulshan 1 and Bhatara were replaced by Hatir Jheel, BADDA and Nortun Bazar respectively in FS,

Figure 3.1.4 Elevated and Underground Mixed Track Proposed by Pre-FS

To construct this transferring structure, land acquisition of about 4m on both sides of the road is necessary to make room for the structure of 10m wide and the width of the original road.

In the Pre-FS plan, the underground and elevated parts have been combined, and at the transferring part from underground to ground section, a U-shaped retaining wall was planned between Malibagh and Rampura stations and between Notun Bazar and Future Park stations.

The structure plan of the “Transition” is discussed in Chapter 4, 5.2 (5) Between Stations

Between Rampura – Malibargh, for both side of the Transition Structure, a 4m wide and 50m long land is require, but there are many private houses on the land, and thus, it was concluded that this section of track should be built underground.

Source: JICA Study Team

Figure 3.1.5 The Area of Influence of the Transition Section (Between Malibagh and Rampura Stations)

On the other hand, the road width between Norton Bazar and Future Park is 29.6m including pedestrian space, and the median width is wide enough to construct the Transition Structure.

Source: JICA Study Team

Figure 3.1.6 The Area of the Transition Section (Between Notun Bazar and Future Park Stations)

Land acquisition is one of the critical issues to conduct smooth project implementation. In discussions with DTCA, there were many opinions that alignment shall avoid land acquisition as much as possible. In addition to this, since there is an elevated highway between Malibagh and Rampura stations, it is quite hard to accommodate an elevated MRT structure. JST concluded and recommended DTCA/DMTC abundance of the Underground + Viaducts Mix Scenario and adaptation the whole Underground option. Accordingly, it is necessary to build Ventilation Towers and Cooling Towers those require some land acquisition. Detailed discussion of this issue can be found in section 4.2.3.

The Pre–FS does not present alternatives regarding route selection. Between the International Airport and CBD area there is no road which has enough width to construct the MRT System except DIT Road. If the condition not to acquire land were to be followed, the only candidate would be DIT Road.

The Pre-FS proposes the opening of MRT Line 1 in 2025. In order to realize this schedule, it is necessary to implement related works such as system designing, tendering, and construction on time. This target is quite tight. In order to meet this target, land acquirement shall be minimized as much as possible. Detailed discussion of this issue can be found in section 4.15.1.

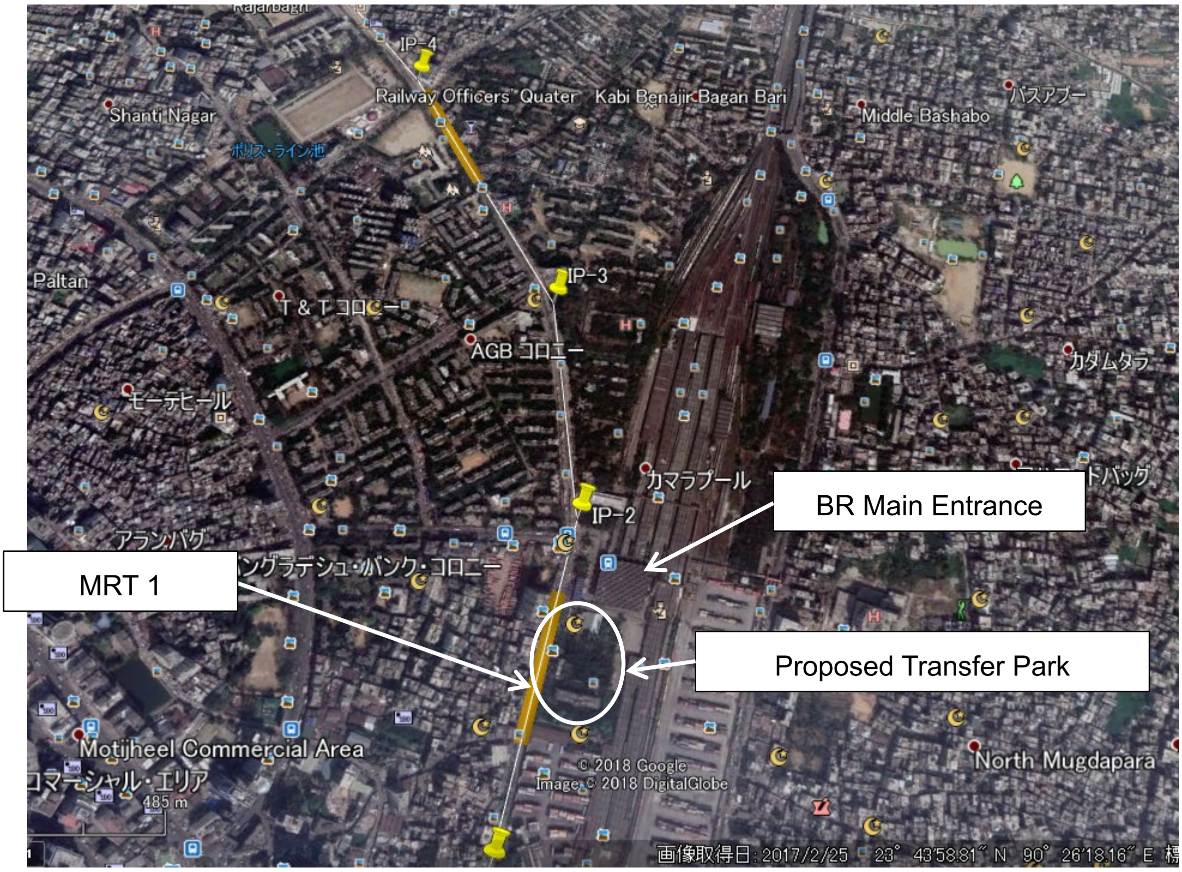
In the development of MRT, the location of the MRT has an impact on urban structure and economic activities. As discussed earlier, the MRT Line 1 connects the suburban areas such as Gazipur and the CBD. JST proposes Kamalapur BR Station as the starting point of MRT Line 1 because of the following reasons:

1. There are many passengers going to and coming from Bangladesh Railway.
2. There is the Saidabad Bus terminal near Kamalapur

3. MRT Line 6 terminates at Motijiheel near Kamalapur.

At Present, the Dhaka Elevated Expressway Project is under construction, and the BR Kamalapur Station yard will be highly commercially developed. BR has a plan to re-arrange track layout and develop the area. At present there are many BR operations.

Now there is a big Inland Container Depot adjusted to BR; furthermore, there are several maintenance depots and material stockyards. These shall be re-arranged to make more space. The redevelopment potential of BR-owned land is very high, and MRT Line 1 cannot ignore this fact. JST studied three alternatives on the location of MRT Kamalapur Station (refer to section 3.2.5). Figure 3.1.7 shows the location of the Kamalapur Station of MRT Line 1 and of BR.

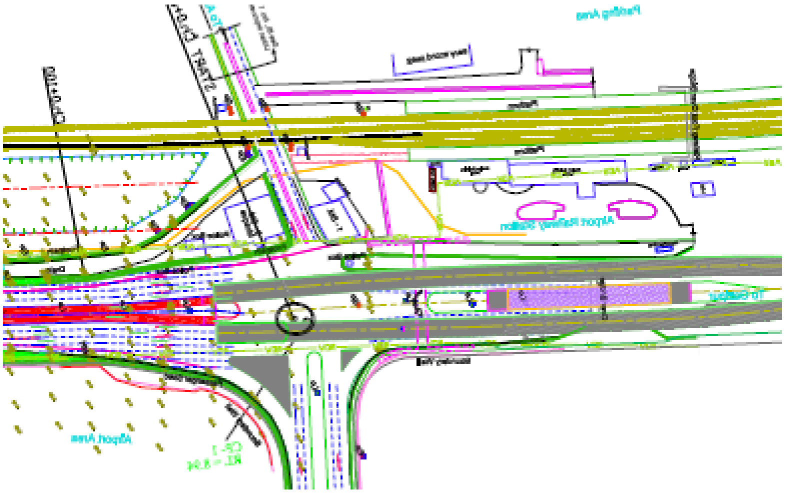


Source: JICA Study Team

Figure 3.1.7 Present BR Kamalapur Station and MRT Kamalapur Station

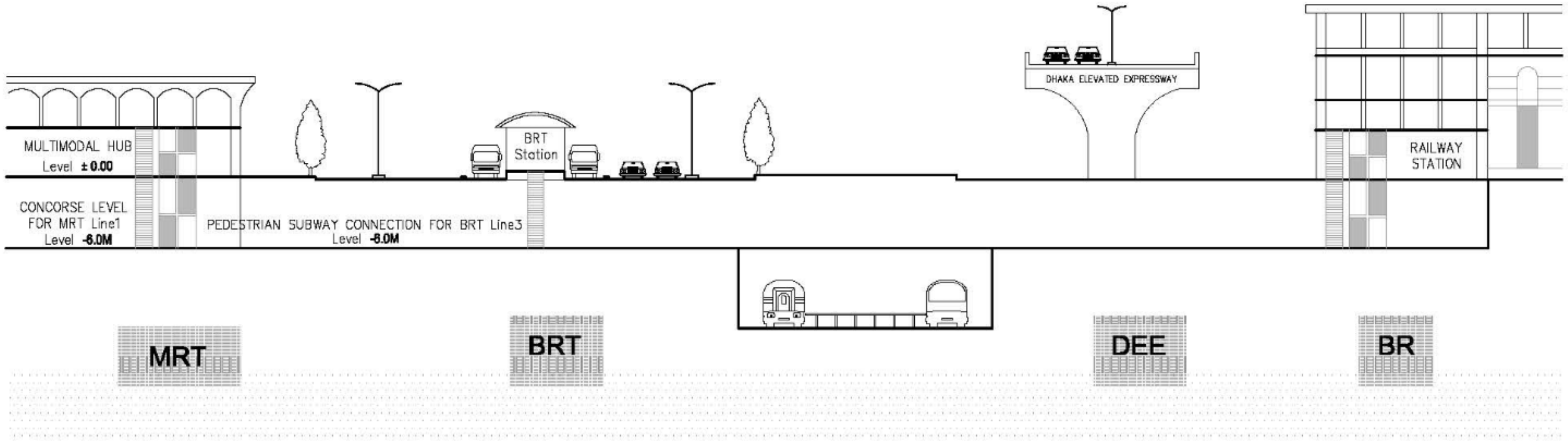
MRT Line 1 is planned aiming forward to Gazipur north of Dhaka Mega City, There is the BRTLine 3 project which is under implementation with the assistance of ADB. In addition, the southern part of BRT Line 3 is also scheduled to be implemented with World Bank assistance. From the north suburban area, passengers of BRT Line 3 have to leave the said system at the International Airport and change to other transportation modes. Therefore, MRT Line 1 has high potential.

Below is the location of BRT Line 3 Station and an image of transfer from BRT to MRT.



Source: DTCA Detailed Engineering Design Works for Bus Rapid Transit Line 3 Corridor in Dhaka

Figure 3.1.8 Image of Transferring between BRT and MRT at International Airport



Source: JICA Study Team

Figure 3.1.9 BRT Line 3 Station

With regard to Purbachal Terminal, DTCA gave JST the available location of the depot at Purbachal some 22km from Kuril. Taking into account future development, the JST accepted the candidate location and MRT Line 1 is terminated at this location. In the selection of the location of the Purbachal Terminal Station, several things were taken into account such as approach to the Depot, Line 1 Extension to over the Kanchon Bridge and people from the east who wish to reach the CBD.

3.2 Study of Location of Stations and Alternatives

3.2.1 Concept of Location of Stations

The selection criteria for the station locations are focal city activities, traffic nodes, physical conditions (elevated road, geology, groundwater, etc.), accessibility protection from flooding and escape in an emergency. Purbachal Line is within the planned development area, and for that reason the plan of the passenger coverage area of the station shall be within an 800m radius and one station set every 1.5km.

JST studied the elevated station locations in considering the followings.

Bushundara Station: Convenience for the peoples that use the Convention Center and sufficient distance between the station and transit structure, which shall be provided at the point where the track changes from underground to elevated.

Bashundhara Station～Purbachal West : JST couldn’t find any future development projects, so a standard interval of 1.5 km was adopted.

Mastul Station: Near the station, Reliance is implementing a large scale housing project.

Purbachal Wes Station: Near the station a large-scale sorts complex is planned. Furthermore there is the Purbachal New Town Plan by RAJUK. From the technical point of view, sufficient distance between the Balu River and the station shall be kept.

Purbachal Central and Purbachal East: Take the RAJUK development plan into consideration.

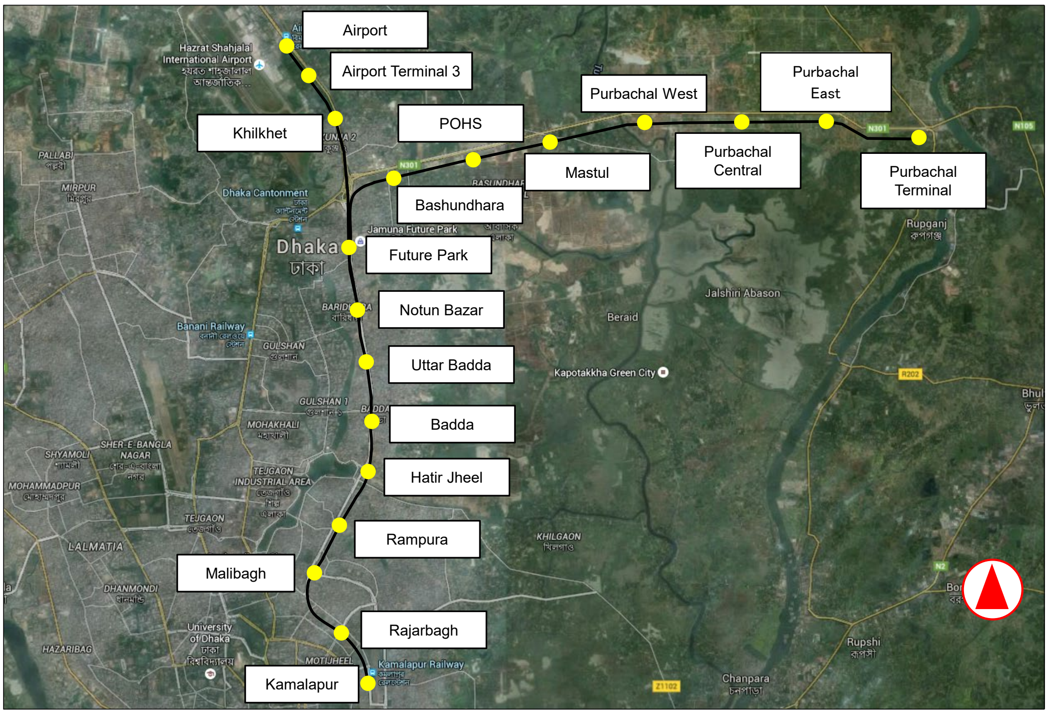
Purbachal Terminal: As discussed above

On the other hand, for the section underground, about 1km intervals between stations is the basic distance; however, according to existing condition, the distances are varied. According to suggestions of several experts, it is better to avoid locations near a river, pond or lake. In general, the MRT Line 1 runs in an area where high risk of flooding is not expected. The lowest station is provided at Hatir Jheel, where GL is some 11.0m, while as shown Table 4.4.1 the highest flooded record indicates 8.5m at Mirpur. But enough protection from flooding shall be provided. Details are discussed in section 4.5.

3.2.2 Station Location of Each Line

Figure 3.2.1 shows the location of Line 1 (Airport Line and Purbachal Line) and Table 3.2.1 shows the station list of Line 1.

With regard to the distance between Rajarbagh and Malibagh, it is some 2.1 km, which is twice that of the basic idea. At the time of Pre-FS, the location of exit of the flyover was not clear. JST found through site survey that the location of Malibagh station of Pre FS was too close to the existing flyover. Thus, the location of Malibagh station was revised and shifted north by 360 m keeping the distance between the exit and construction site of Malibagh Station at around 500 m. Consequently, the location of Malibagh station is moved to the east by 16m and required private land acquisition. In order to avoid land acquisition, a 2.1 km distance between Rajarbagh and Malibagh was adopted.



Source: JICA Study Team

Figure 3.2.1 Route Map of Line 1

Table 3.2.1 Station List of Line 1

No.	Line	Station Name	Kiropost（km）	Distance（km）
1	Airport Line	Kamalapur	0.125	1.12
2		Rajarbagh	1.249	2.11
3		Malibagh	3.355	0.95
4		Rampura	4.307	1.18
5		Hatir Jheel	5.490	1.06
6		Badda	6.551	1.03
7		Uttar Badda	7.583	0.98
8		Notun Bazar	8.568	1.58
9		Future Park	10.152	2.47
10		Khilkhet	12.617	1.43
11		Airport Terminal 3	14.044	0.85
12		Airport	14.890	
9	Purbachal Line	Future Park	10.152	2.73
13		Bashundhara	12.884	1.68
14		POHS	14.567	1.68
15		Mastul	16.521	1.67
16		Purbachal West	17.918	1.54
17		Purbachal Central	19.461	1.96
18		Purbachal East	21.418	2.18
19		Purbachal Terminal	23.594	

Source: JICA Study Team

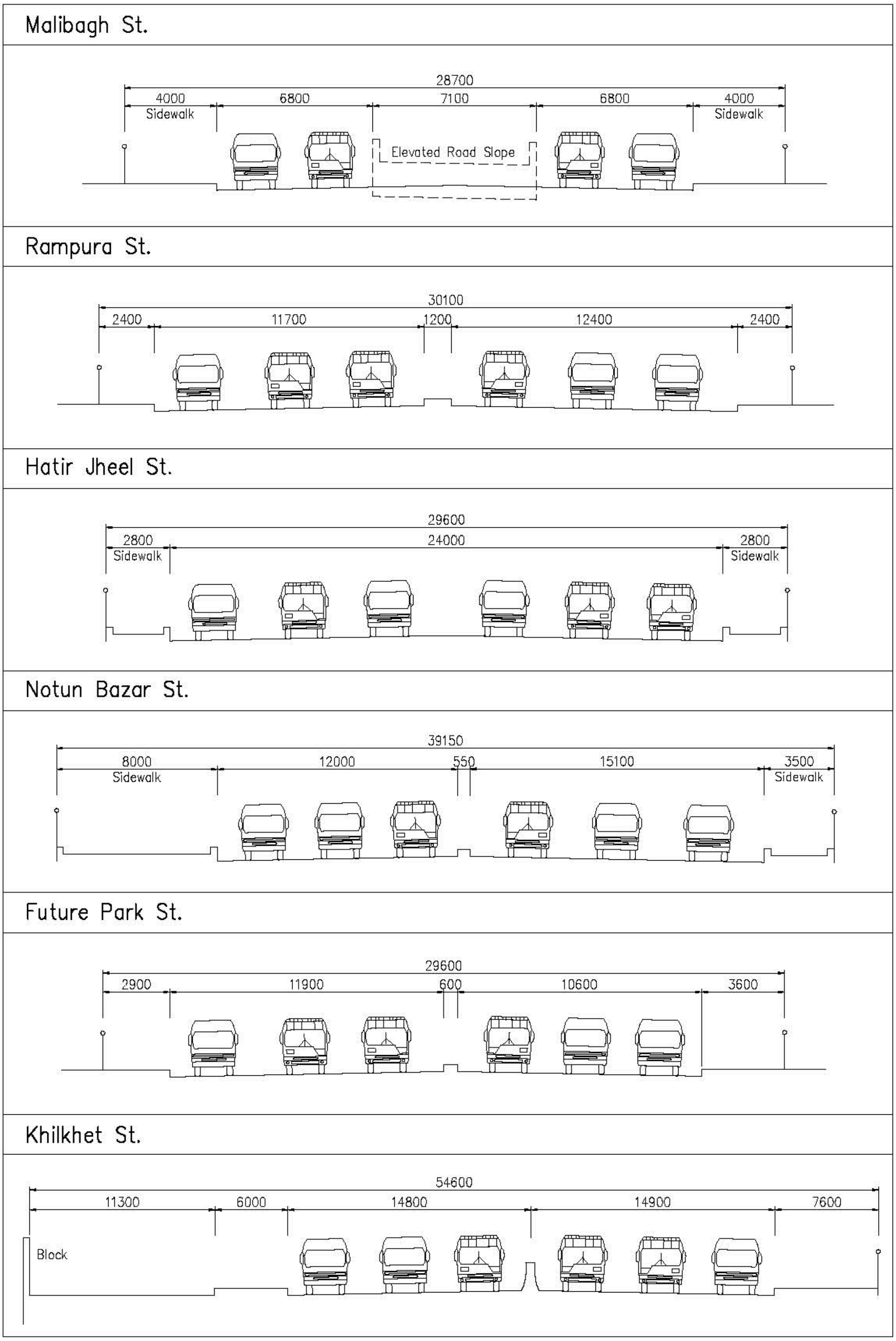
Table 3.2.2 gives a list of the station names which correspond to their locations and the type of platform to be constructed at each station.

Table 3.2.2 Location of Stations and Type of Platform

Proposed Station Location and Type of Platform				
No	**Tentative Station Name**	**Distance from Kamalapur**	**Proposed Location/Land Mark**	**Type of Station Platform**
1	Kamalapur (Origin)	0.125 km	BR Kamalapur Station West South. Within Outer Circle Road. Coordination with DEE Structure is needed	1 island platform contains SC with draw up track
2	Rajarbagh	1.249 km	South of the Rajarbagh Police Line Outer Circle Rd.	1 Island platform 2 tracks
3	Malibagh	3.355 km	North of Level Crossing East side of Existing Flyover	Stack Platform
4	Rampura	4.307 km	Rampura Bazar South Cross Ulon Rd. & DIT Rd.	1 Island platform 2 tracks
5	Hatir Jheel	5.490 km	North of Rampura Khel Bridge	1 Island platform 2 tracks
6	BADDA	6.551 km	Cross Bir Uttam AK Khandakar Rd. & DIT Rd.	1 Island platform 2 tracks
7	UTTARA BADDA	7.583 km	Dakshin Shahzacipur Cross Mashritola Rd.	1 Island platform 2 tracks
8	Notun Bazar	8.568 km	North Cross Madani Ave. & DIT Rd.	2 Island platforms 4 tracks
9	Future Park	10.152 km		
9	Khilket	12.617 km	Cross Point Airport Rd & Khilkhet Rd. Between Rd. 13 & 19	1 Island platform 2 tracks for two levels
10	Airport 3rd Terminal	14.044 km		1 Island platform 2 tracks
10	Airport	14.890 km	BR Airport Sta. In front of BR Airport Station	1 Island platform 2 tracks
11	Future Park	10.152 km	In front of the Future Park Amusement	2 Layor Island Platforms
12	Bashundhara	12.884 km	Bsashundara Residential Development Housing Block G	Lateral Platforms
	POHS	14.567km		1 Island platform 2 tracks
13	Mastul	16.251 km	Dumni (Reliance Model Town)	Lateral Platforms
14	Purbachal West	17.918 km	Sector Balu River (East side of Bridge)	Lateral Platforms
15	Purbachal Center	19.461 km	Sector 9	Lateral Platforms
	Purbachal East	21.418 km	Sector 7	Lateral Platforms
16	Purbachal Terminal	23.594 km	Sector	Lateral Platforms

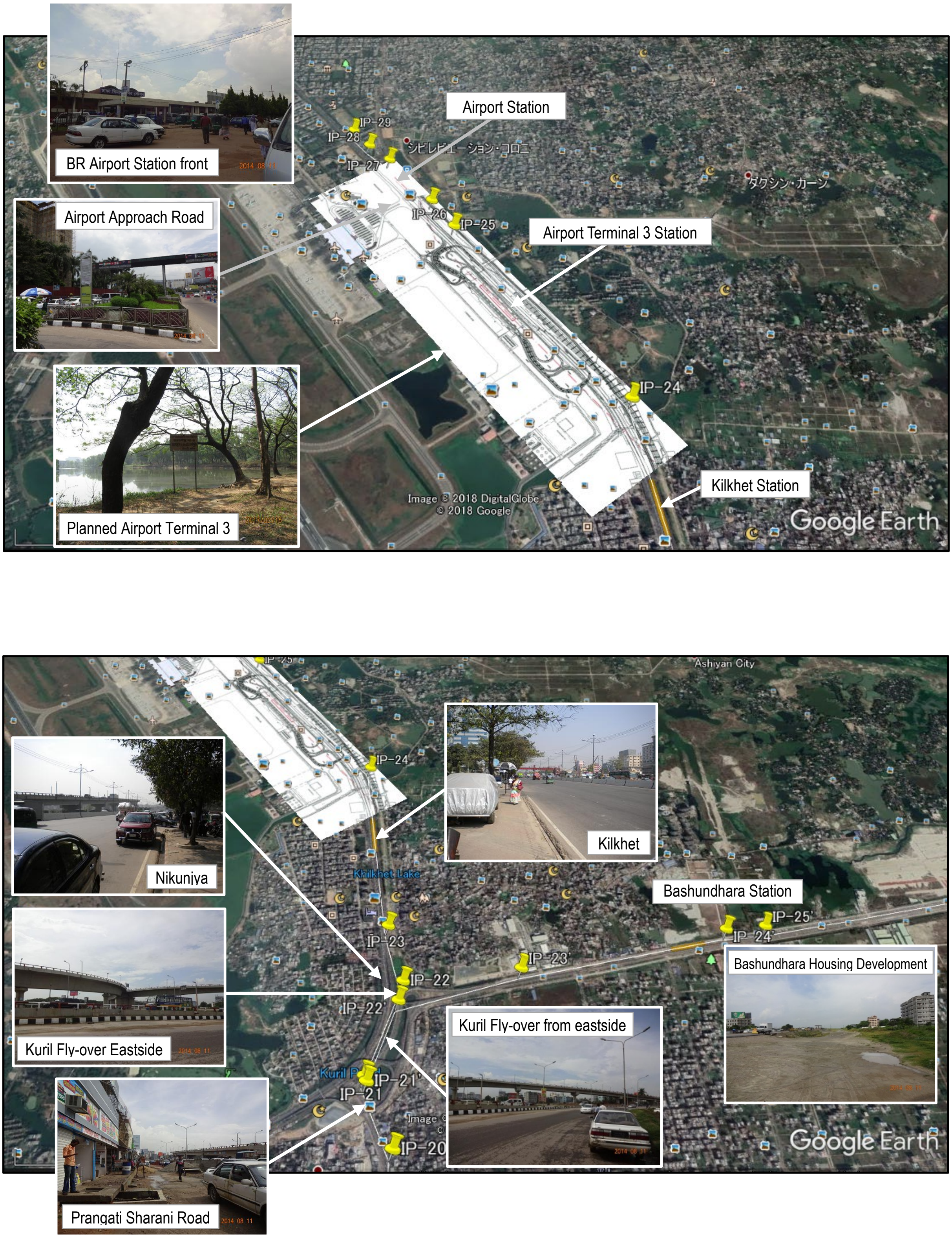
Source: JICA Study Team

The road width of on Major points of MRT Line 1 are shown in Figure 3.2.2.



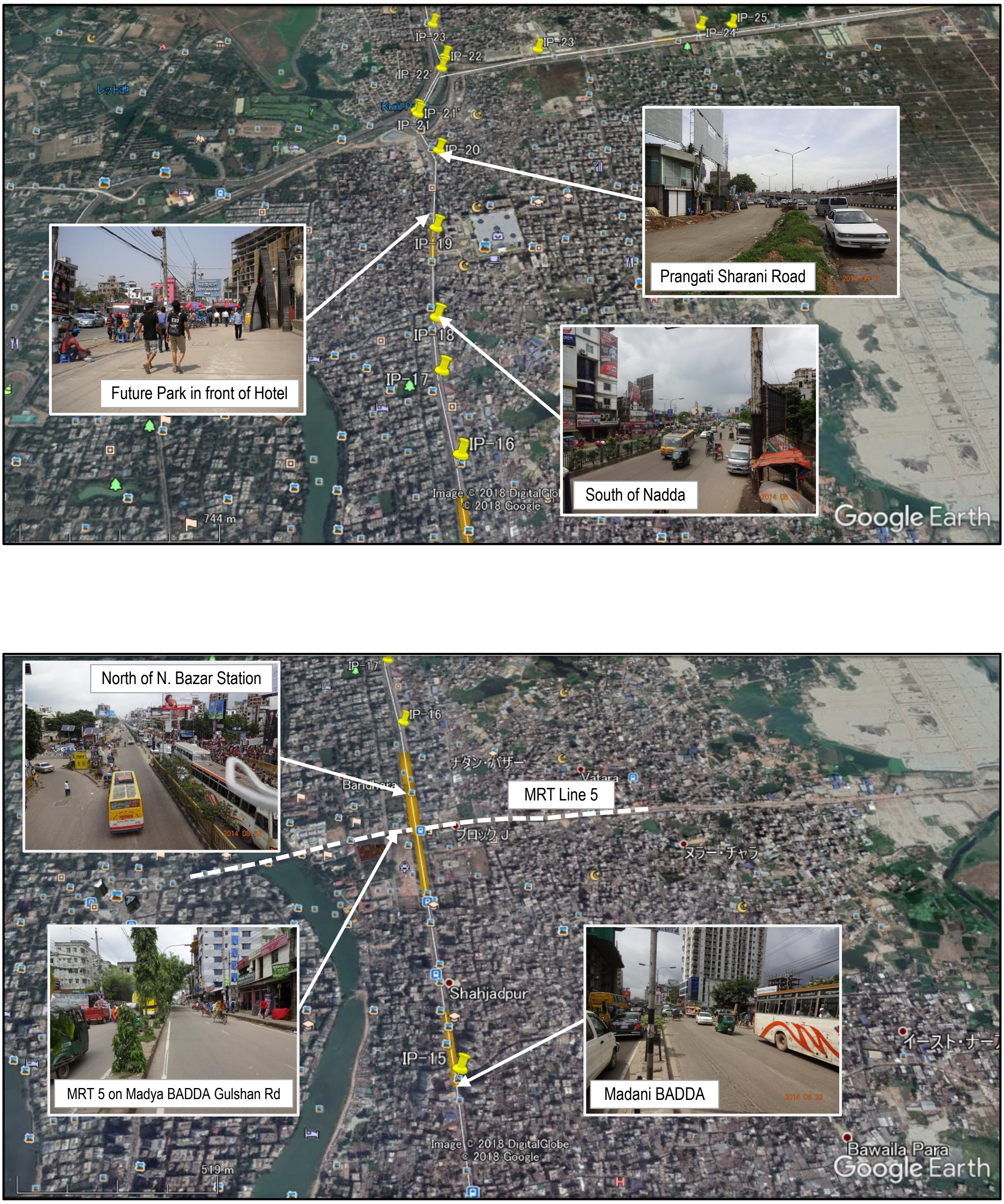
Source: JICA Study Team

Figure 3.2.2 The road width on major points of MRT Line 1



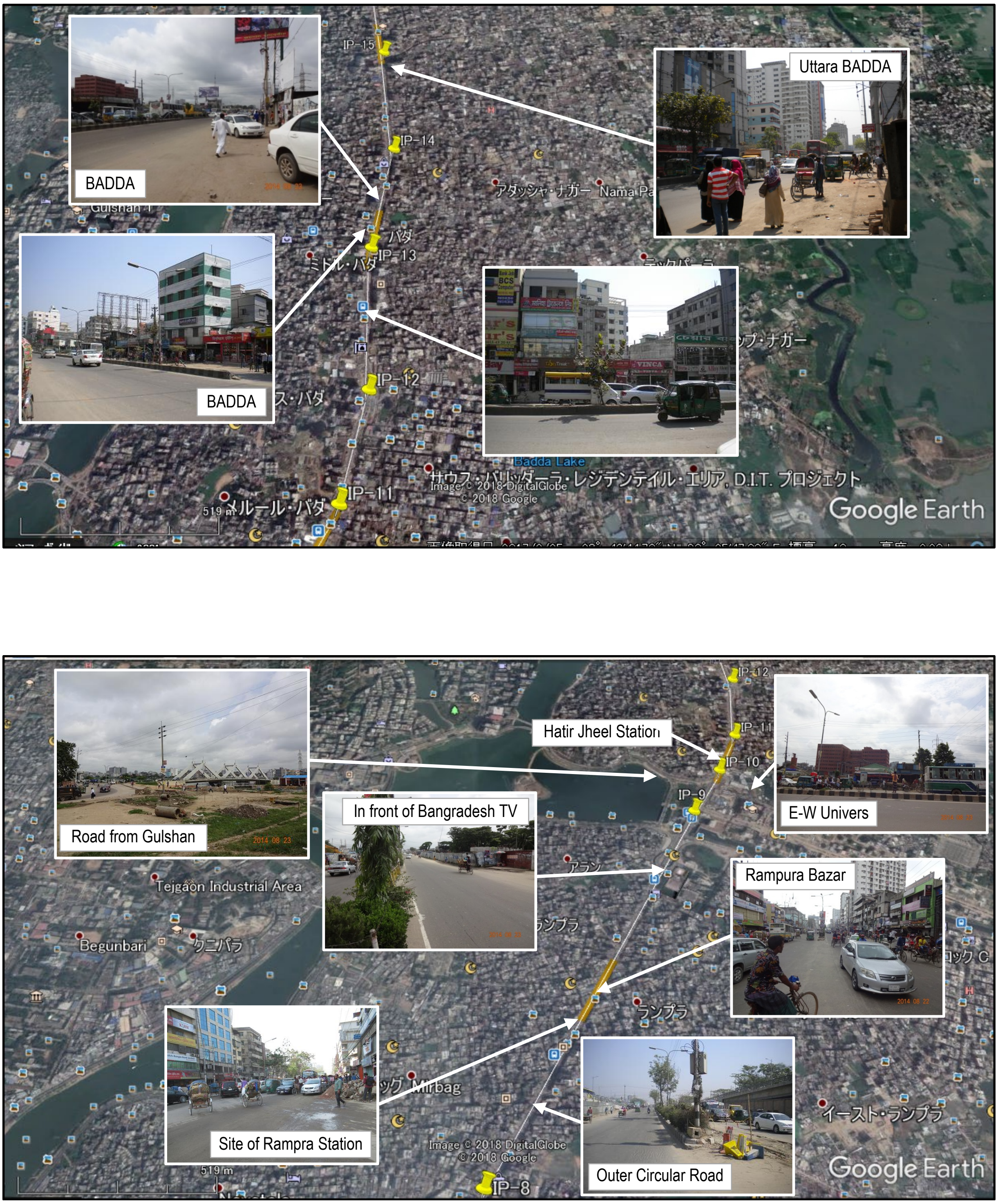
Source: JICA Study Team

Figure 3.2.3 Present Scenery of Sites for Stations (1)



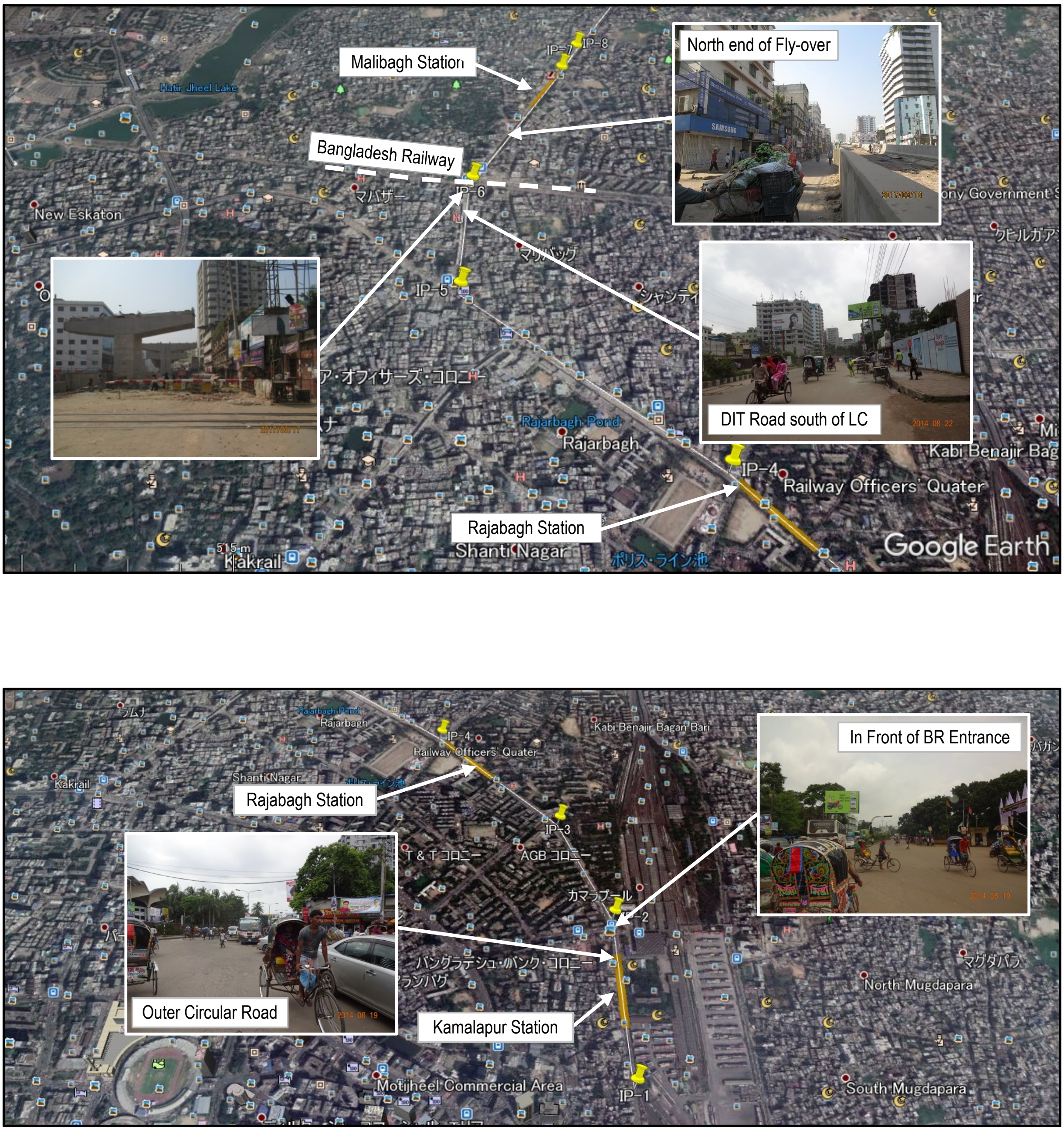
Source: JICA Study Team

Figure 3.2.3 Present Scenery of Sites for Stations (2)



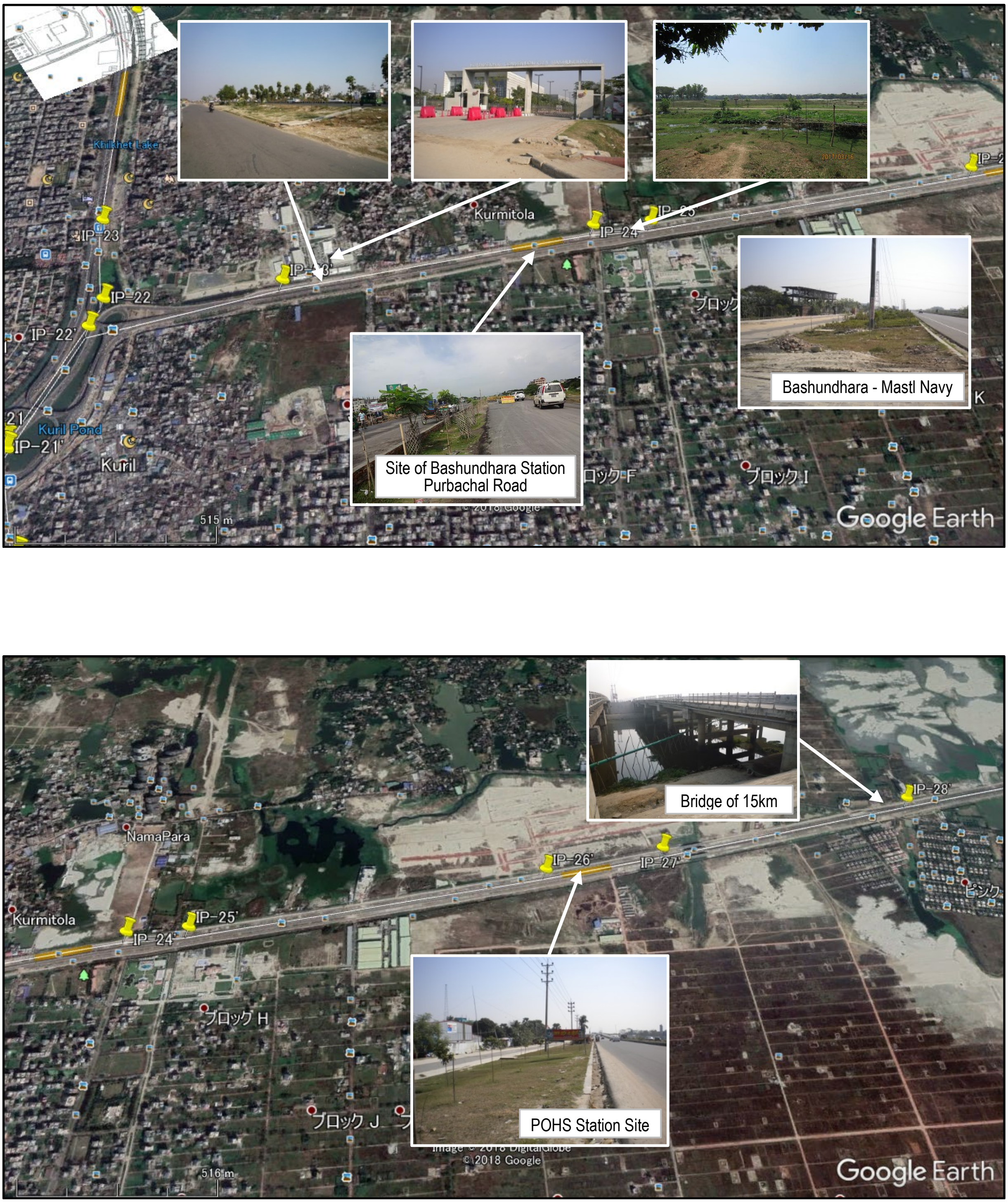
Source: JICA Study Team

Figure 3.2.3 Present Scenery of Sites for Stations (3)



Source: JICA Study Team

Figure 3.2.3   Present Scenery of Sites for Stations (4)

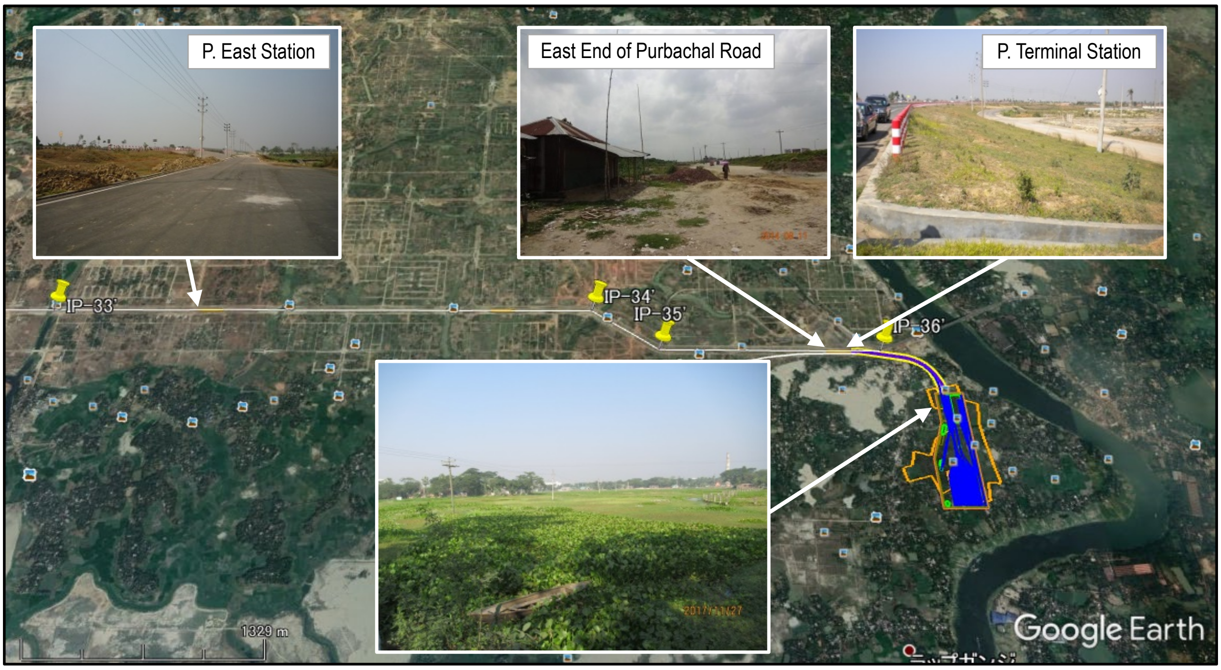


Source: JICA Study Team

Figure 3.2.3 Present Scenery of Sites for Stations (5)

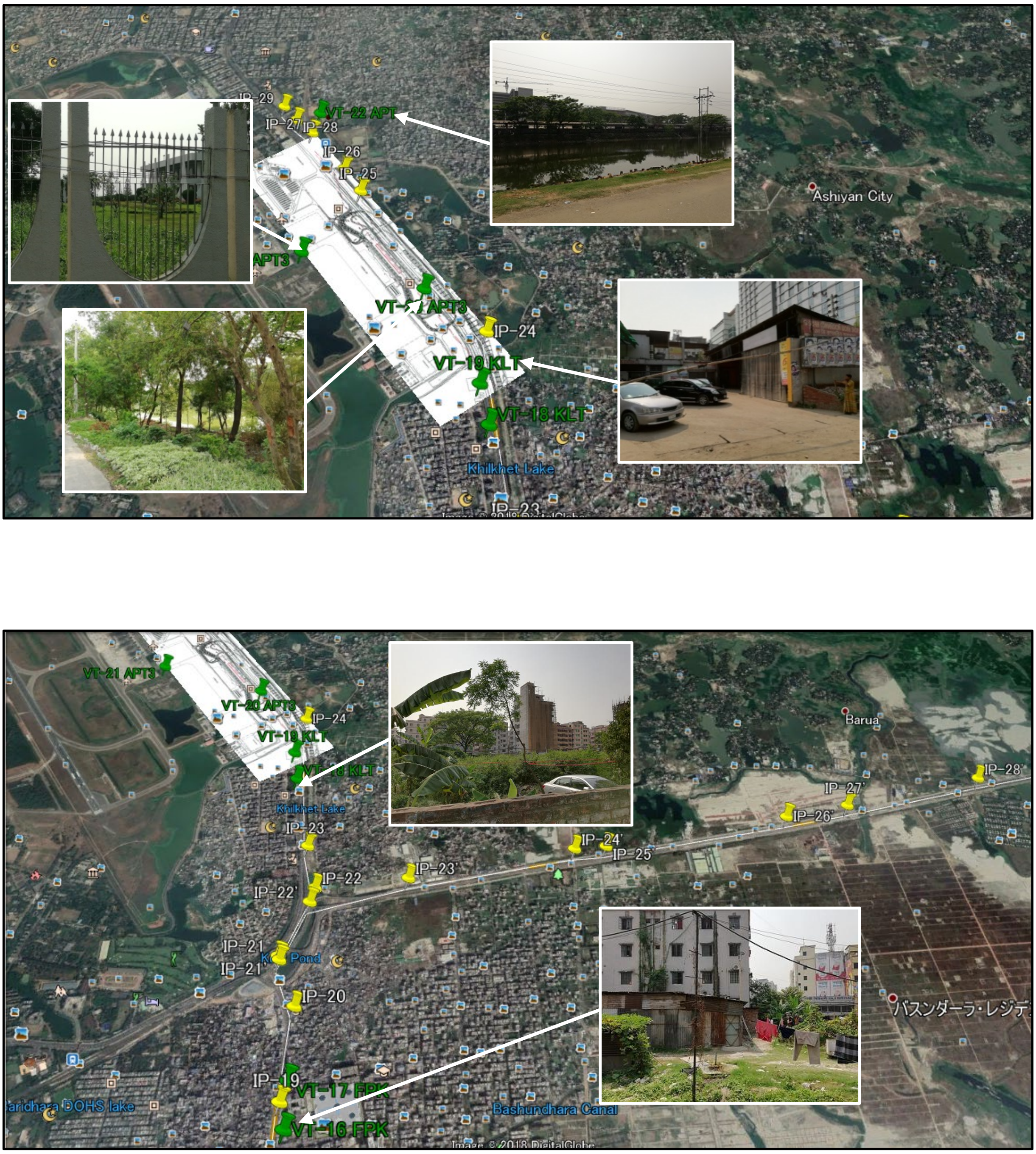
Source: JICA Study Team

Figure 3.2.3 Present Scenery of Sites for Stations (6)



Source: JICA Study Team

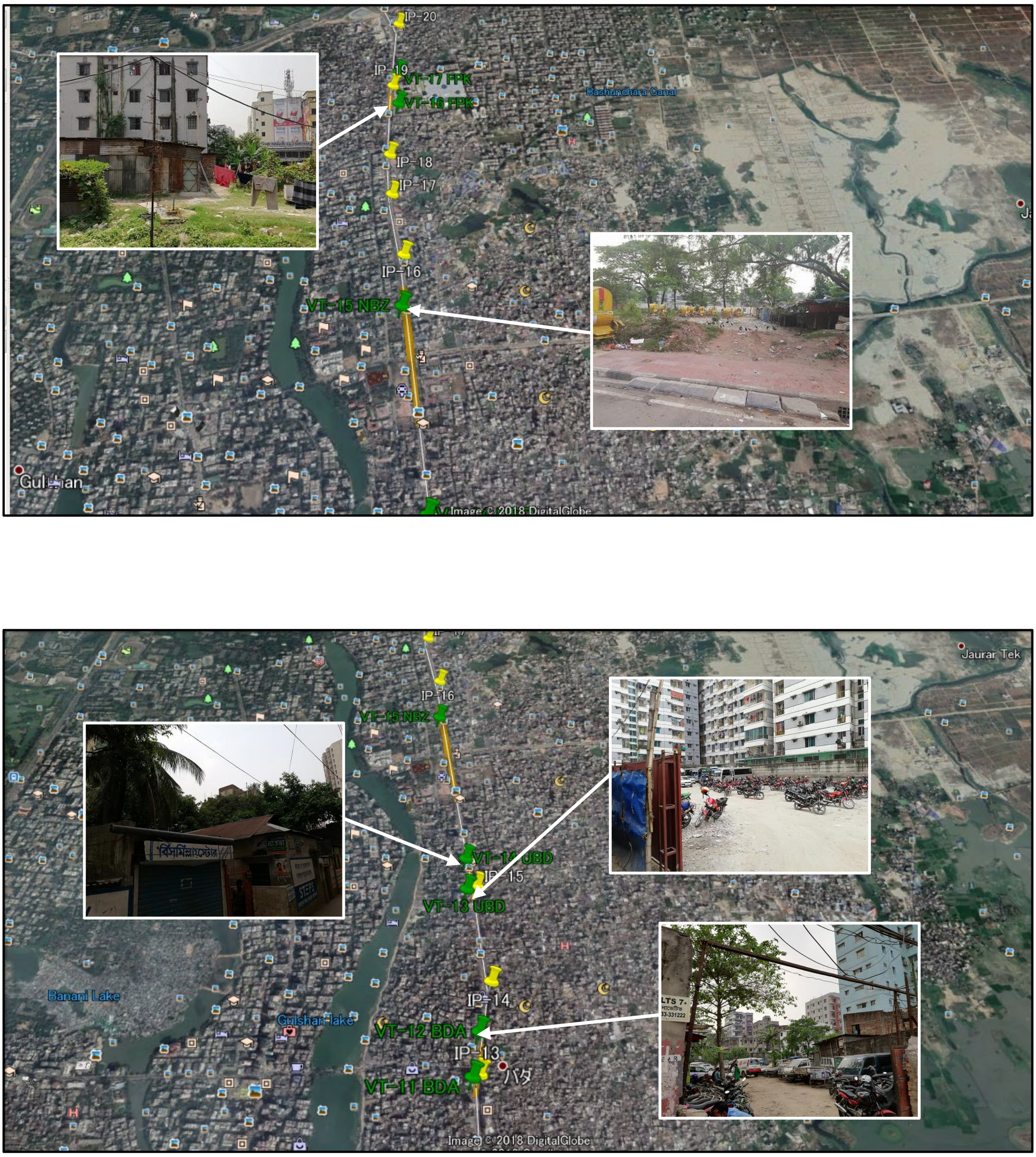
Figure 3.2.3 Present Scenery of Sites for Stations (7)



🟢 : Ventilation

Source: JICA Study Team

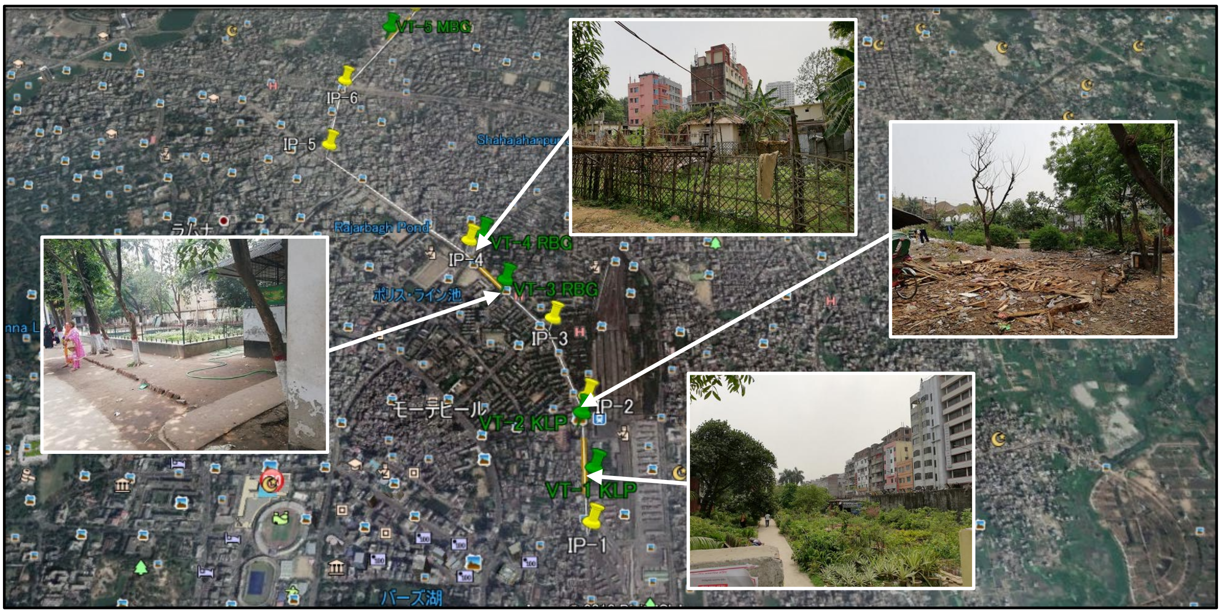
Figure 3.2.4 Proposed Location of Ventilation (1)



📌 : Ventilation

Source: JICA Study Team

Figure 3.2.4 Proposed Location of Ventilation (2)



📌 : Ventilation

Source: JICA Study Team

Figure 3.2.4 Proposed Location of Ventilation (3)

3.2.3 Infrastructure Facility Alternative Study

As for the type of structure for an urban railway, there are three kinds of structures, namely, elevated structure, underground structure and at-grade structure, but an at-grade structure is undesirable in respect of the installation of level crossings and splitting of communities. Thus, an at-grade structure is not an alternative. As for Purbachal Line, the planned road is wide enough to construct elevated structures. An underground structure, which is costly, shall not be adopted, but an elevated structure shall be adopted. As for the Airport Line, the following three alternatives were compared with the combination of underground structures and elevated structures.

Plan A: The section between Kamalapur Station and Malibagh Station, underground structure; the section between Rampura Station and Notun Bazar Station, elevated structure; the section between Future Park Station and Kuril flyover, underground structure; and the remaining section, elevated structure.

Plan B: The section between Kamalapur Station and Malibagh Station, underground structure; other sections, elevated structures.

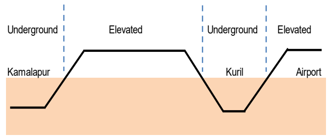
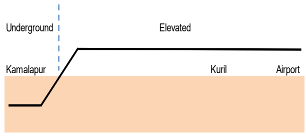
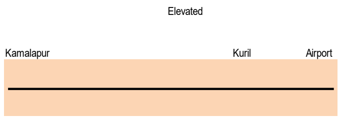
Plan C: All sections will have underground structures.

The above plans were compared in terms of the following aspects and the results are shown in Table 3.2.3:

- Social Environment: Land Acquisition, Affected Households
- Natural Environment: Protected Area, Biological Diversity (Marsh), Flood Risk, Landscape
- Pollution Prevention: Noise/Vibration, Air Pollution, Water Pollution, Ground Settlement
- Technical Aspect: Construction Cost, Road Traffic, Construction Difficulty, Convenience for Passengers

The comparison results confirmed that Plan C is inferior to other plans in respect of water pollution, ground settlement and construction cost, but Plan C is superior to the other plans in respect of other items. Therefore, Plan C shall be adopted. The main reasons why Plan C is adopted are less land acquisition, less affected households and less effect to road traffic.

Table 3.2.3 Comparison of Alternative Proposals for the Airport Line Structure

	Plan A (Starting Point and Kuril Area Underground)	**Plan B (Starting Point Underground)**	**Plan C (All Lines Underground)**
Concept			
Social Environment			
Land Acquisition	× There are three transition sections and land acquisition is required especially at the transition section between Malibagh Station and Rampura Station and the transition section between Notun Bazar Statin and Future Park Station.	△ Land acquisition is required at the transition section between Malibagh Station and Rampura Station.	○ The lowest land acquisition is required as compared with other plans because there is no transition section.
Affected Households	× 145	△ 135	○ 115
Natural Environment			
Protected Area	○ There is no protected area along the proposed route.	○ There is no protected area along the proposed route.	○ There is no protected area along the proposed route.
Biological Diversity (Marsh)	○ Since the route is proposed in the centre of Dhaka City, there is no place of biological diversity such as marshes.	○ Since the route is proposed in the centre of Dhaka City, there is no place of biological diversity such as marshes.	○ Since the route is proposed in the centre of Dhaka City, there is no place of biological diversity such as marshes.
Flood Risk	△ There is a risk of flooding around Kamlapur Station. Appropriate flood countermeasures are necessary because of the underground structure.	△ There is a risk of flooding around Kamlapur Station. Appropriate flood countermeasures are necessary because of the underground structure.	△ There is a risk of flooding around Kamlapur Station. Appropriate flood countermeasures are necessary because of the underground structure.
Landscape	× Not desirable in respect of landscape because there are a lot of elevated sections.	× Not desirable in respect of landscape because there is the longest elevated section.	○ Most desirable in respect of landscape because all sections are underground.
Pollution Prevention			
Noise/ Vibration	○ It is expected that noise and vibration are caused by the operation of construction machines during the construction of stations and viaducts. A higher effect than the plan of all sections underground. Noise is caused by train operation at elevated sections.	○ It is expected that noise and vibration are caused by the operation of construction machines during the construction of stations and viaducts, but there is less of an effect than the elevated plan at Kuril. Noise is caused by train operation at elevated sections.	◎ It is expected that noise and vibration are caused by the operation of construction machines during the construction of stations and viaducts, but causes the least effect among the three plans.
Air Pollution	○ A higher effect than the plan of all underground, but less effect than Plan B.	○ A higher effect than the plan of all underground because elevated section is longer than other plans.	◎ It is expected that air pollution is caused by the operation of construction machines at stations, but causes the least effect among the three plans.
Water Pollution	◎ Least effect among the three plans because the underground section is shortest among three plans.	○ It is expected there will be less effect than Plan C.	△ It is expected to have the most effect among the three plans because the underground section is the longest.

	Plan A (Starting Point and Kuril Area Underground)	**Plan B (Starting Point Underground)**	**Plan C (All Lines Underground)**
Ground Settlement	◎ It is expected that limited ground settlement may be caused because the underground section is shortest among three plans.	○ It is expected that ground settlement may be caused, but the effect is less than Plan C.	△ It is expected that ground settlement may be caused because all sections are underground.
Technical Aspect			
Construction Cost	△ Approximately 80% of Plan C	○ Slightly lower than Plan A	× Highest
Road Traffic	× Effect to road traffic even during construction is huge because the road alignment is changed at the section of transitions.	× Structure north of Malibagh Station is a viaduct and there is no transition between Notun Bazar Station and Future Park Station, but the effect to road traffic during construction is huge.	○ Effect to road traffic is least for both the construction period and completion.
Construction Difficulty	△ It is necessary to construct transitions in narrow roads. It is required to take into consideration road traffic and traffic accident prevention because the elevated structure is constructed at a median strip. General-purpose construction method is adopted, but a skilled engineer is required. Since it is the first time for Bangladesh to construct underground structures, training for labourers is also required. High quality materials for segments etc. are required and plans for them must be built from zero base in this country.	○ The same as Plan A	○ It is necessary to construct transitions in narrow roads. It is required to take into consideration road traffic and traffic accident prevention because elevated structure is constructed at a median strip. General-purpose construction method is adopted, but a skilled engineer is required. Since it is first time for Bangladesh to construct underground structures, training for laborers is also required. High quality materials for segments etc. are required and plants for them must be built from zero base in this country. Highly skilled operation is required to construct a tunnel through Kuril flyover and DEE.
Convenience for Passengers	○ There is no special inconvenience for passengers.	× Platform is constructed at the same level as 6th floor of the buildings around Kuril area. Therefore, it is expected that there are effects of driving rain and strong wind. Evacuation is needed in case of an emergency.	○ There is no special inconvenience for passengers.

※The transition section is switching point on the elevated bridge and underground, especially the section which cannot secure the construction gauge under the beam from the opening part in the existing road part shall indicate the section influencing the road traffic

Source: JICA Study team

3.2.4 Design Criteria for MRT Line 1

Dhaka MRT Line 1 consists of the Airport Line, which goes through highly developed commercial areas or the district where garment factories or wood processing plants exist randomly, and the Purbachal Line is expected in future development.

The Airport Line intersects twice with the original BR Line, and there are passengers transferring at the Airport and Kamalapur stations. To make the transferring smooth, it should be considered that both lines shall be as close together as possible. The Multiple Transport Hub concept has currently been promoted for the Airport Line. The MRT Line 1 stations shall consider the transfer between BR or other BRT lines or the convenience of passengers of the Airport Terminal 3.

The specifications for MRT Line 1 are basically the same as that of MRT Line 6 and this enables the trains to operate on both systems. Though mutual transferring between Line 1 and Line 6 is difficult in reality, the electric system, track, and spare parts of rolling stock shall be used together. The table below is the construction specification of Line 6, which shows that there is no difference of items between Line 1 and Line 6.

Table 3.2.4 MRT Line 6 Specifications

No.	MRT Line 6 Specifications	
1	Gauge	1435mm
2	Train Operation	
	Train Frequency at peak hour	4 min 30 sec (2020), 4 min (2025)
	Train Frequency at off peak hour	7 min
3	Congestion Rate	180%
4	Operation Hour	6:00 - 23:30, 5:30 - 0:00 (in summer season)
5	Design Life	
	Facility	Until 2051
	Civil Structure	100 years
6	Design Speed	110 km/hr (for Rolling Stock Design),
	Viaduct Design	100 km/hr
7	Standard Voltage	DC 1500V
8	Rolling Stock	
	Formation	4M2T
	Propulsion	VVVF Inverter
	Traction Motor	140-200 kw
	Braking	Mechanical & Electrical (regenerative)
	Body	Aluminium alloy or Stainless Steel
	Window	400mm opening
	Seat Arrange	Longitudinal seating with wheelchair space
	Operation Speed	Max. 100km/hr
	Acceleration	3.3 km/h/s (0,92 m/s2)
	Deceleration	Service 3.5km/h/s Emergency 4.5km/h/s
	Adhesion	Less than 20%
	Axle Load	Max 16t
	Vehicle Dimensions	Width 3000mm
		Gauge Length 20,300mm (End car)
		Gauge Length 20,000mm (Middle car)
	Floor height	1,150 mm
	Bogie Wheel Base	2,100 mm and 13,800 mm centre distance
	Wheel Diameter	860 mm
	Door	W: 1,300 mm, H: 1,850mm 4 door/car each side
	Ventilation	Forced air ventilation13m^3/h per person
	Air Conditioning	Outside: 40 C, 90% RH
		Inside: 24 C 60% RH with 200% Congestion
	Carrying Capacity	1,738 pax. At 180% Congestion
	Number of Train	24 sets in 2026
9	Power Supply	
	OHC	Simple Catenary
	Number of Receiving Substations	2 Receiving Substations (132kV/33kV) in 2051
	Number of Traction Substations	7 Traction Substations (33kV/1,500 VDC)
	SCADA	Equipped
	Voltage of Distribution Line	33 kV
10	Number of distribution line circuits	Ring main

No.	MRT Line 6 Specifications	
11	Escalator & Lift	Install (Number to fix)
12	Signal	
	Block system	CBTC Moving Block
	Signal appearance	Cab Signal
	ATP	CBTC, ATP, Speed Restriction Control, Possession Control, ATO
13	Running	Left side
14	Interlocking	CIL to CBTC & CTC
15	Train operation Control	CTC from OCC
16	Depot Control	Shunting Signal (Test track CBTC)
17	Telecommunications	
	BTN	MPLS
	Master Clock	GPS base
	Communication for Safety	
	Radio communication	LTE (instead TETRA)
	Telephone	DLT and PABX
	PA and PIS	Peak SPL 70dB(A) - 96dB(A), Display LCD
18	CCTV	PTZ Camera
19	AFC	
	Ticket	Contactless IC ticket
	Data Transmission	ISO/IEC 18092 (Type C) or ISO/IEC 14443
	Security Level	EAL 4 of ISO/IEC 15408
	IC Ticket Media	Single Journey, Day Ticket, Stored Value, Commuter
	Capacity	60 persons/min
	TVM	Provided
	Ticket Office machine	Provided
	Fare Adjustment	Provided
	Type of AG	Horizontally swing flap door
20	Civil Structure	
	Viaduct Superstructure	30 m Segment Box Type
	Sub-structure	Independent Pier and Portal Frame
	Foundation	Cast-in pile, steel pipes, mono pile or group pile
	Bridge	Cast-in balanced cantilever right type PC Bridge
	Station	Track and Station are independent
21	Track	Main Line: Non-Ballasted track Plinth Type, Depot: Ballasted Track
22	Distance between two tracks	Rolling Stock Gauge + 800mm = 3.8m
23	Clearance for outer structure	2.5 m
24	Platform	
	Length	170m
	Width	Lateral: 7m, Island 10 m
	Height	1100mm above rail top
	Edge Clearance	70mm
25	PSD	Half Height
26	Horizontal Curve	
	Between Stations	Min. 180 m
	Station	Min. 400 m (Main), 120 m (Depot)
	Vertical Curve	3000 m (2000 m in absolute min.)
		4000 m (3000 m in absolute min.) less 600m curve
27	Maintenance Facility	
	Car Shed for	39 eight-car trains
		5 inspection lines, 5 heavy lifting line
	Stabling	36 eight-car trains
28	Facility SCADA	Equipped

No.	MRT Line 6 Specifications	
29	OCC	OCC in Depot
30	Emergency Crossover	Install
31	Evacuation Method	Evacuate from both ends. In case of fire, train runs until nearest station
32	Rescue Operation	Emergency Crossover
33	Noise & Vibration	To Be study
34	One-man Operation	With ATO

Source: MRT Line 6 Design Report

Since it is the first time to construct a metro in Bangladesh, it is necessary to establish a construction standard for underground structures or systems. In particular, a structure plan of the underground stations shall be assumed considering disaster prevention or emergency situations. The Technical Standards for the Metrorail in Bangladesh (December 2014) was established with financial and technical assistance from JICA. Chapter 13 presents qualitative performance specification of underground structures while detailed design requires the tailor made quantitate specification, design criteria or manuals which reflect character of Dhaka such as climate, culture, religion, national geopolitics etc.

Furthermore, the regulations on development activities regarding working over the top of underground structures will be amended in the future, so that legislation must consider the compensation standard in these cases. Special attention shall be paid to land development such as construction of high stories buildings over the tunnels. In the Hanoi Line 2 development, the Ministry of Transportation made the Circulation which prohibits any action within the Protection Zone and requests permission from the Authorities regarding development activity within the Restriction Zone. The Government of Dhaka also shall create such Circulation.

It is essential to carry out topography surveys to implement the main construction design since the current design was done based only on the existing data because of a shortage of resources to do the site survey and measurements. At this time, the elevation is measured by Google Earth, and this causes several tens of centimetres of differences between the real and measured values.

During the documentation of this draft final report 2, no boring survey on the Airport line will be carried out. The construction method for the tunnels and structure size of underground stations need to be inspected during the engineering section.

3.2.5 Connecting with Other MRT Lines

1) Connection with MRT Line 6

MRT Line 6, which is currently ongoing, runs north to south in Dhaka, some 5km west from MRT Line 1. At Uttara 3, rolling stock maintenance depot is provided. Line 6 originates at UTTRA 3 development area and runs in the southern direction to Mirpur via Pallabi. From Mirpur the line runs along Begun Rokeya Road, west of Tejigaon Airport, comes to Farm Gate then enters Airport Road. At Shahbag, it turns east then forward to Bangladesh Bank, the terminal of Line 6. It is important to connect Lines 1 and 6 to increase passengers for both MRT Systems. JST studied several ways to connect them, but the following barriers were found:

1. MRT Line 6 is an elevated system, while MRT Line 1 is built underground.
2. Connection between Line 6 and Line 1 by elevated structure is difficult due to space availability.
3. There is a high building - Bangladesh Bank.

Then JST proposed an underground box culvert which connects between Line 6 Motijiheel and Line 1 Kamalapur under Kamalapur Road (refer to section 4.5.2 which discusses how to make a box culvert).

A detailed study regarding fares for the customers who use two lines shall be done at the Design Stage.

2) Connection with Line 5

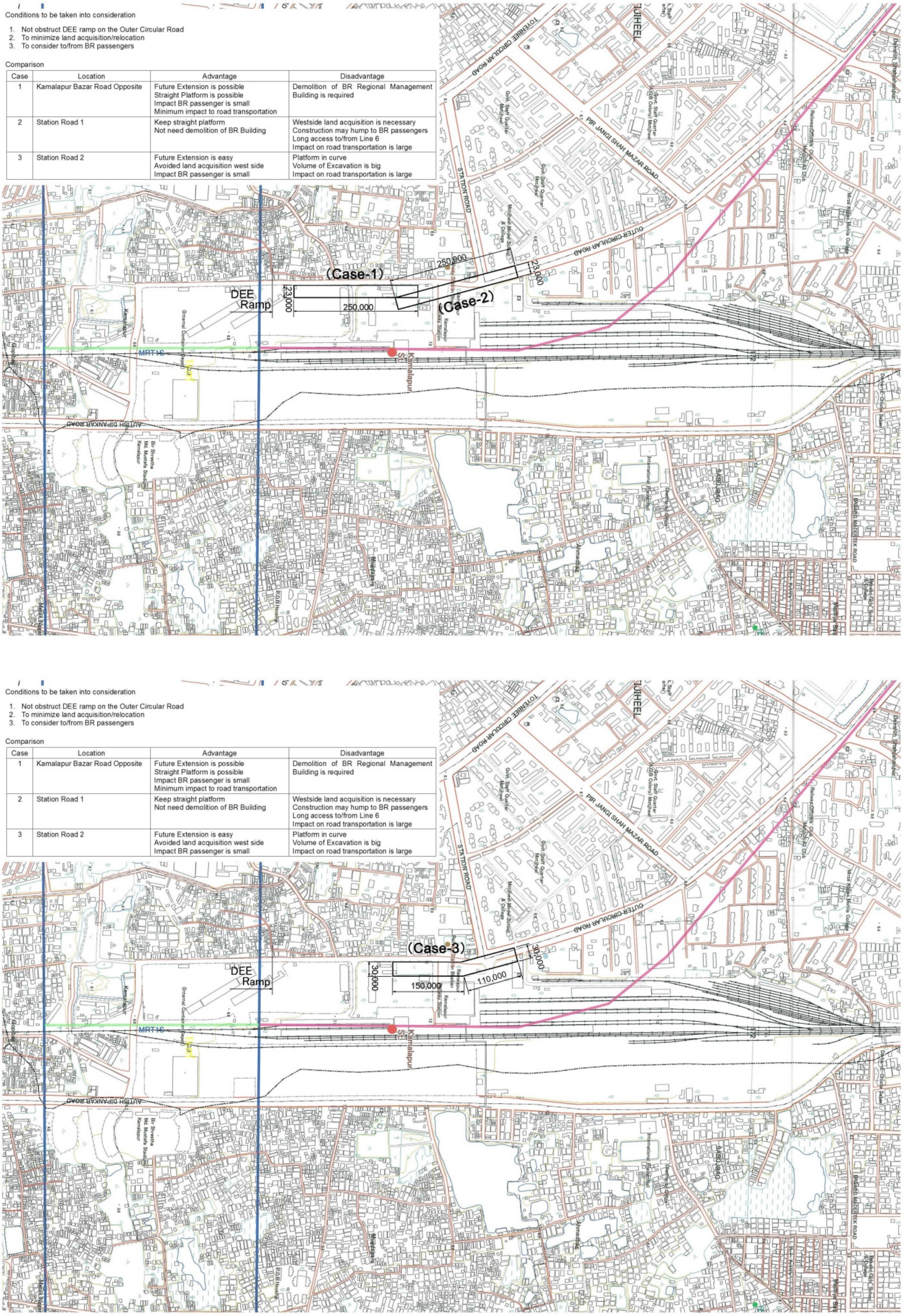
It is expected that traffic conditions in Dhaka City will drastically improve by the establishment of the MRT Line 6 and Line 1, especially incoming traffic to the city from north to south, and create the backbone of city transportation. In order to increase passengers for those lines, the line which runs west to east plays an important role. MRT Line 5 originates west of Dhaka, Gabtori, then runs to Mirpur where the line crosses with MRT Line 6. As the line goes further east, it crosses with Line 1 at Natun Bazar. A passageway by which passengers of Line 1/5 can transfer to Line 5/1 will be provided underground (for details, please refer to section 4.5.2, Underground Structure, (9) Connection with MRT Line 5).

3) Connection with Bangladesh Railways (BR)

(1) Kamalapur Station

As discussed in 3.1, the Kamalapur Station is the project stating point of Phase 1. In the Feasibility Study, the Study Team tried to arrange the entrance of MRT Line 1 to be close to the BR entrance in order to effectively use the BR networks. At present, BR has a very wide land in front of Regional Management Building. JST proposes DTCA/DMTCL at the seminar held on 17 September, 2017 at JICA Training Center that utilize this area for Temporary Working Depot for the Contractor, and after completion of Underground Station Construction, this area will be the Transfer Park where passengers can be picked up by a taxi, CNG or bus.

With regard to the location of the MRT Kamalapur Station, JST studied three alternatives and proposed Case 1. The following figures show advantage and disadvantage of three alternatives.



Conditions to be taken into consideration

1. Not obstruct DEE ramp on the Outer Circular Road
2. To minimize land acquisition/relocation
3. To consider to/from BR passengers

Comparison

Case	Location	Advantage	Disadvantage
1	Kamalapur Bazar Road Opposite	Future Extension is possible Straight Platform is possible Impact BR passenger is small Minimum impact to road transportation	Demolition of BR Regional Management Building is required
2	Station Road 1	Keep straight platform Not need demolition of BR Building	Westside land acquisition is necessary Construction may hump to BR passengers Long access to/from Line 6 Impact on road transportation is large
3	Station Road 2	Future Extension is easy Avoided land acquisition west side Impact BR passenger is small	Platform in curve Volume of Excavation is big Impact on road transportation is large

Conditions to be taken into consideration

1. Not obstruct DEE ramp on the Outer Circular Road
2. To minimize land acquisition/relocation
3. To consider to/from BR passengers

Comparison

Case	Location	Advantage	Disadvantage
1	Kamalapur Bazar Road Opposite	Future Extension is possible Straight Platform is possible Impact BR passenger is small Minimum impact to road transportation	Demolition of BR Regional Management Building is required
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3	Station Road 2	Future Extension is easy Avoided land acquisition west side Impact BR passenger is small	Platform in curve Volume of Excavation is big Impact on road transportation is large

Source: JICA Study Team

Figure 3.2.5 Kamalapur Station-Case 1, 2, 3

(2) Connection with BR Airport Station

Refer to Figure 3.1.9. The Line 1 Airport Station will be built between DEE and BR. Line Considering the entrance of MRT Line 1 will be built in front of the BR Airport Station to make smooth passenger transfer between MRT and BR Line. But now Bangladesh Railway has a plan to develop the Airport Station. In Detailed Design, both organizations shall discuss the situation in detail.

(3) Connection with BRT Line 3

As discussed in section 3.1, the stations of three transport modes, i.e., BR Airport Station and BRT Line 3 Airport Station together with MRT Line 1, are in front of the Hazrat Shajal International Airport. An image of arrangement of these three modes is shown in Figure 3.1.9.

At present, with financial assistant from ADB, the Bus Rapid Transit (BRT) System Line 3 Project is ongoing. This project connects Northern Suburban with CBD. But as Phase 1, BRT Line 3 north part until the International Airport will be built.

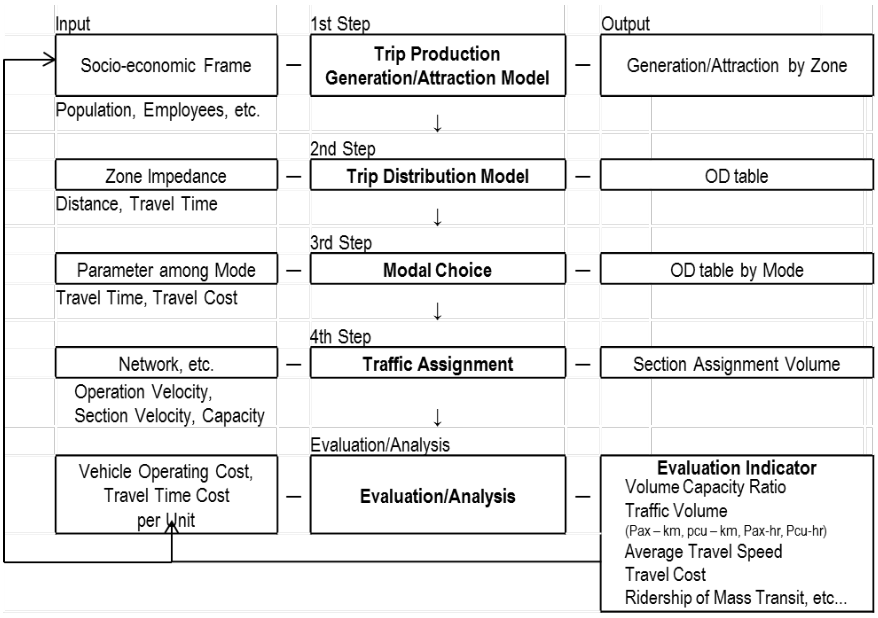
(4) Airport Terminal 3

The BRT Line 3, as the first phase, terminates at International Airport. Passengers coming from UTTRA end can transfer to MRT Line 1 and go to the CBD, while air passengers and airport workers have no transport mode except automobiles. At present, the Bangladesh Government is implementing the Airport Terminal 3 Building Construction project. The JST studied how to connect MRT Line 1 to Terminal 3 and concluded to provide the Airport Terminal 3 Underground Station. And the Terminal 3 Building Construction Project shall build an underground passageway 9m wide and 6m high within Navigation Authority’s right of way (ROW) while the MRT Line 1 Project will build the same road ROW.

3.3 Passenger Demand Forecast for MRT Line 5

3.3.1 Framework of Demand Forecast

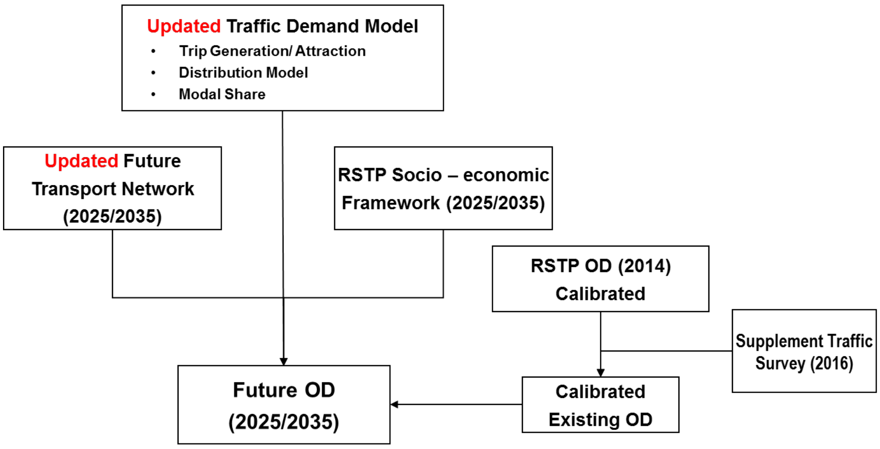
Demand forecast was carried out by 4 step models as shown in Figure 3.3.1. Database used in the study was based on RSTP which is the basis of target MRT routes of the Study.



Source: JICA Study Team

Figure 3.3.1 Flowchart of 4 Step Traffic Demand Forecast Model

Updating OD tables was carried out by the method as shown in Figure 3.3.2. The OD table developed in RSTP was updated through supplemental traffic survey along MRT corridors. The outline of the supplemental traffic survey is described in following section.



Source: JICA Study Team

Figure 3.3.2 Flowchart of Updating OD Table

3.3.2 Update of RSTP Traffic Demand

1) Supplemental Traffic Survey

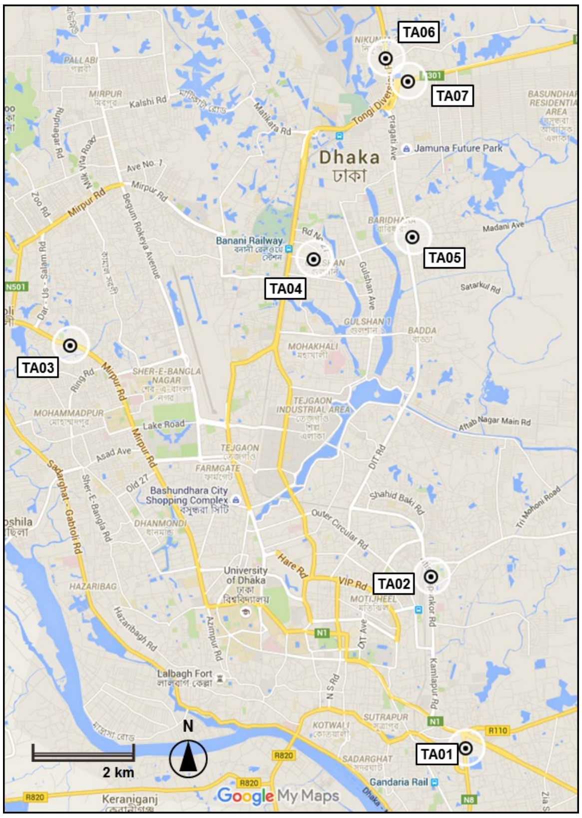
Supplemental Traffic Survey is to provide vehicular traffic and passenger information to update the current distributed traffic volume along the planned UMRT corridors. The survey location is shown in Table 3.3.1 and Figure 3.3.3.

Table 3.3.1 Traffic Count Survey Stations

Code	Survey Station	Survey Period (no. of hours) 1)		Survey Date
		Vehicle Count	Vehicle Occupancy	
TA 01	Dhaka–Mawa Highway	24	16	11 May 2016 (Wed)
TA 02	Kamlapur Road	16	16	16 May 2016 (Mon)
TA 03	Mirpur Road	16	16	17 May 2016 (Tue)
TA 04	Kemal Ataturk Avenue	16	16	18 May 2016 (Wed)
TA 05	Madani Avenue	24	16	10 May 2016 (Tue)
TA 06	Dhaka–Mymensingh Highway	24	16	23 May 2016 (Mon)
TA 07	Purbachal Express Highway	16	16	04 May 2016 (Wed)

1) 24: conducted for 24 hours from 6 a.m. to 6 a.m of the following day.
16: conducted for 16 hours from 6 a.m. to 10.p.m. of the same day.

Source: JICA Study Team



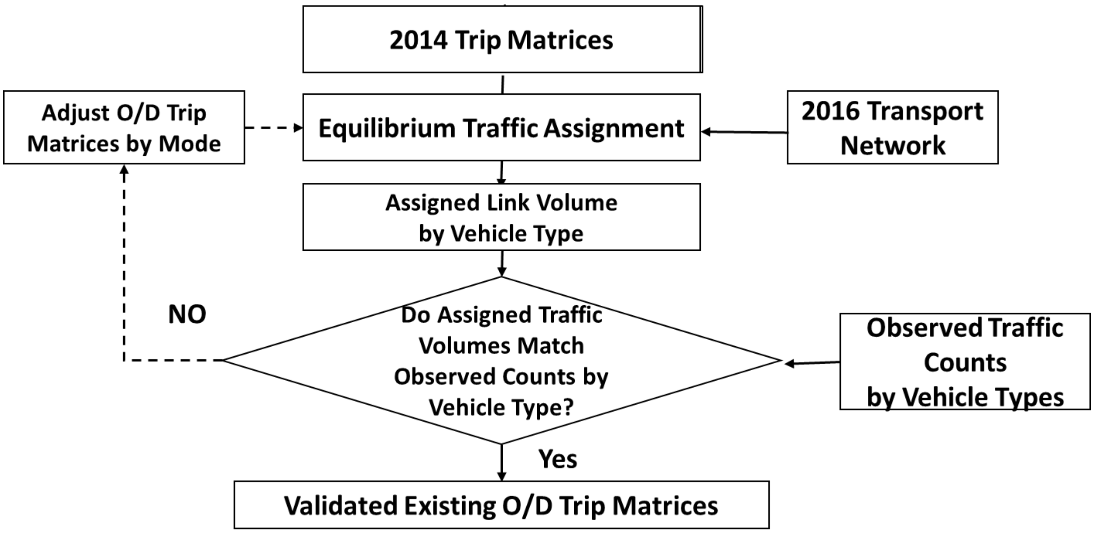
Source: Worked out by JICA Study Team, based on Google

Figure 3.3.3 Location of Supplemental Traffic Survey

2) Carburation of O-D Table

The base year model validation was carried out by comparing the assigned traffic volume against the result of supplemental traffic survey. The initial OD trip tables for each mode were assigned to the updated network using the traffic assignment model. The modelled results, i.e., the assigned traffic volumes were compared with the observed traffic counts across the survey location.

The OD table adjustment and traffic assignment were repeated until the assigned traffic volumes were within +/- 10% of the observed counts, at which stage the model was then considered valid. The final iteration of the OD trip matrices was deemed as the validated 2016 travel demand. This process is illustrated in Figure 3.3.4.



Source: Worked out by JICA Study Team, based on Google

Figure 3.3.4 Update of Current O/D Table

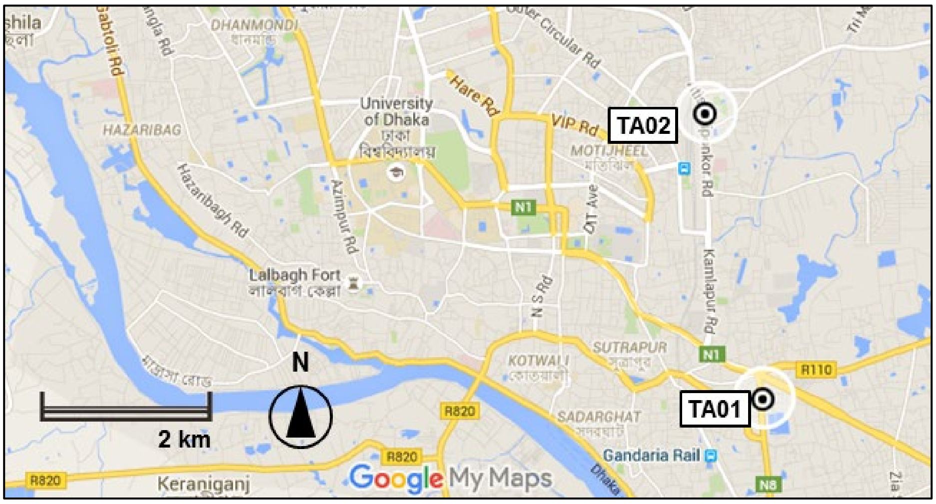
Based on the validated current O/D table, the future O/D table also will be updated. The socio-economic indicators such as population, employment and student by traffic analysis zone is of RSTP study. MRT Line 5 is planned to open in 2028 and OD table in 2028 has not been created, therefore the OD table in 2028 is estimated by interpolating between 2025 and 2035 and assigned on 2025 transport network. Passenger demand in 2055/ 2058 is also necessary because the economic project life of MRT Line 1 and Line 5 is 30 years. Therefore, it is assumed that annual growth rate is 1 % from 2035 to 2058.

3) Hourly Passenger Demand Forecast

(1) Policy of Data Utilization

Hourly demand forecast is required to formulate the train operation during peak time and off-peak time. There is no current MRT in operation. In addition, BR is functioned as an intercity railway, so it is not suitable to refer the BR operation statistics for MRT hourly demand forecast. Thus, hourly trip ratio of current bus operation is applied for MRT hourly demand forecast because bus passengers' behaviour is similar to MRT passenger even though bus is the road transport.

The latest traffic count survey was conducted by RSTP supplement study in May 2016 at 7 sites. There are four count sites along the MRT Line 1, and 2 of the survey stations are in existing city centre as shown in Figure 3.3.5 and cross section traffic of north-south direction was observed at the sites.



Source : Edited by JICA Study Team based on RSTP Supplement Study

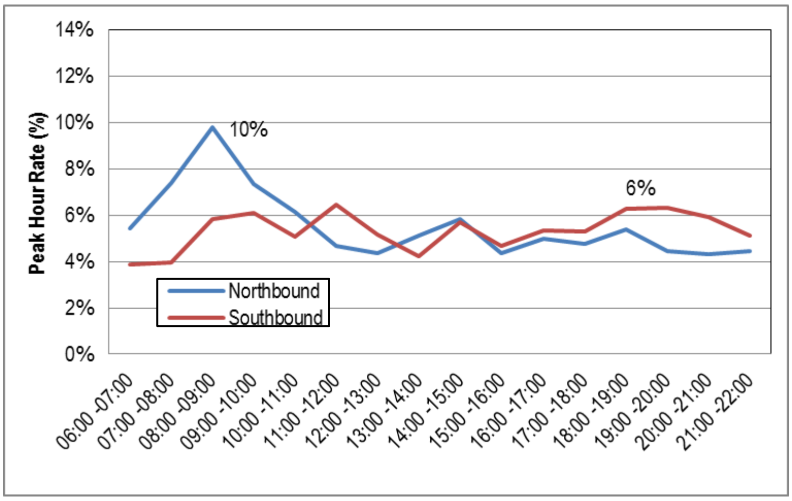
Figure 3.3.5 Location Map of Traffic Count Survey by RSTP Supplement Study

(2) Calculation Method and Its Result

Calculation method is as follows;

- Target transport modes are “Micro Bus/ Mini Bus”, “Standard Bus” and “Large Bus”.
- The hourly number of person trips for each direction.

Hourly trip ratio is shown in Figure 3.3.6 as calculated by above procedure. Peak ratio is 10 % at 8:00-9:00 for eastbound. After this peak time, there is no clear peak or off-peak and it looks similar pattern between eastbound and westbound. Peak time for westbound is 6 % at 18:00 – 19:00.



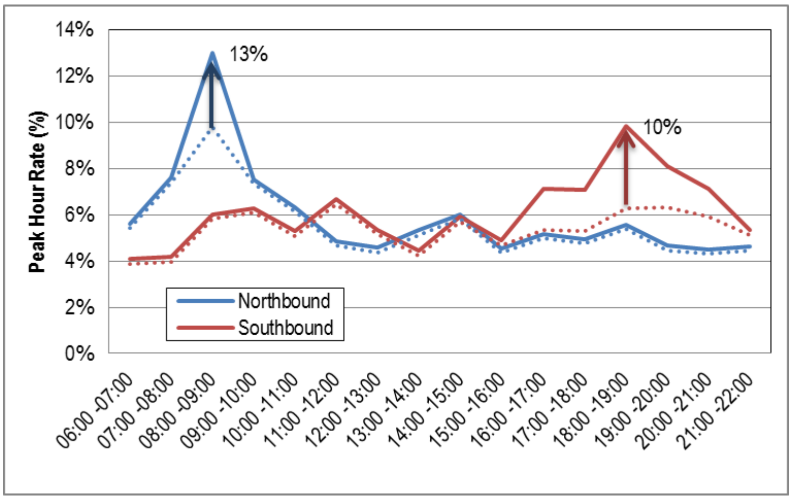
Source: JICA Study Team

Figure 3.3.6 Hourly Trip Ratio (Present)

(3) Hourly Trip Ratio for Train Operation Plan

Current trip ratio as shown in Figure 3.3.6 is applied because MRT will start to operate from 2028. After 2035, several MRTs will be operated. In general, peak ratio increases with the development of urban railway. The peak ratio of MRT Line 6 is set as 13%, therefore the future peak ratio of MRT Line 1 in 2025 and 2035 is assumed as 13% coordinated with MRT Line 6.

Other time of passenger ratio is distributed by increased equally. Regarding southbound, although clear peak time and off-peak time are not shown, symmetry pattern will be seen between northbound and southbound normally. Peak time is 6.3% between 18:00 and 19:00 at present, so this time, it is assumed to be 10%. Figure 3.3.7 shows the adjusted hourly trip ratio.



Source : JICA Study Team

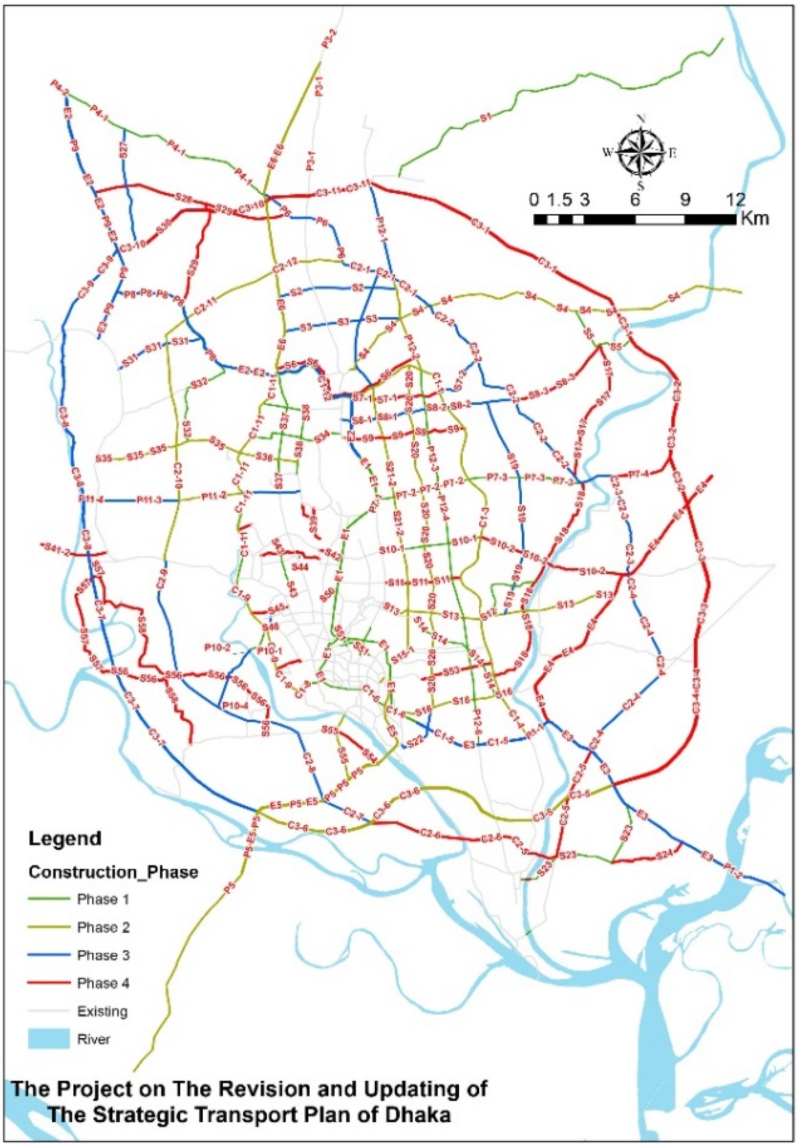
Figure 3.3.7 Hourly Trip Ratio (After 2035)

3.3.3 Network Settings

1) Updating Transport Network

(1) Road Network

In demand forecast, the road network is based on the road development plan proposed in RSTP study. The proposed road network by phase is shown in Figure 3.3.8.



1) Phase 1:2016 – 2020, Phase 2: 2021-2025, Phase 3: 2026-2030, Phase 4: 2031-2035

Source: RSTP Study (2016)

Figure 3.3.8 Road Development by Phase Proposed in RSTP

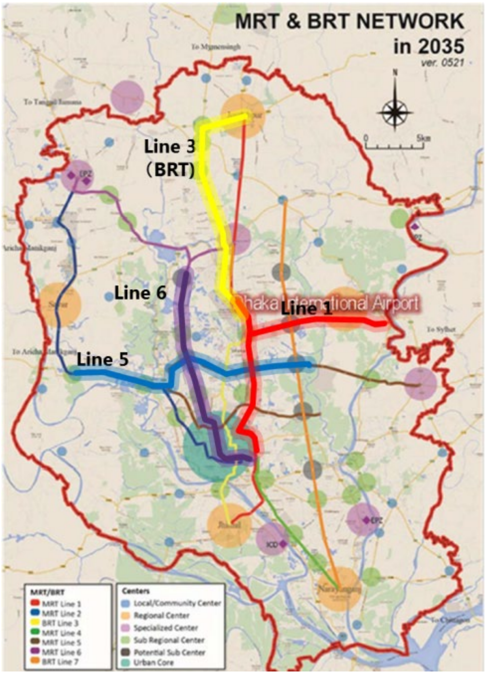
(2) MRT/BRT Network

Although the mass transit network assumed in the study is consistent with RSTP study, the development roadmap was updated from RSTP. The parts of Route 2 and Route 5 are proposed to be integrated into route 5 and proactively developed as east – west urban transit backbone. The mass transit network proposed in the study is shown in Table 3.3.2 and Figure 3.3.9.

Table 3.3.2 List of Prioritized Route / Section

Route	Section	Length (km)
MRT Line 1	Kamalapur – Bashundhara (Main Line) Future Park - Purbachal Terminal (Purbachal Line)	28.2
MRT Line 5	Hemayetpur- Vatara	22.4
MRT Line 6	Kamalapur – Uttara	20.4
BRT Line 3	Airport - Joyedpur	20.4

Source : JICA Study Team



Source: JICA Study Team

Figure 3.3.9 Prioritized Route / Section

2) LOS and Fare Setting of Mass Transit

LOS and fare setting assumed in this demand forecast model is shown in Table 3.3.3.

Table 3.3.3 List and Fare Setting of Mass Transit

Mode		2025/2028	2035
MRT	Headway (min)	3.5	
	Capacity (000 pax/day/ direction)	200	
	Speed (km/h)	35	
	Fare (Tk)	22.6+2.8 /km	30.6+3.8 /km
BRT	Headway (min)	3.0	
	Capacity (000 pax/day/ direction)	64	
	Speed (km/h)	23	
	Fare (Tk)	9.9+4.5/km	13.4+6.1 /km
BR	Headway (min)	60	
	Capacity (000 pax/day/ direction)	64	
	Speed (km/h)	15	
	Fare (Tk)	0.7 / km	1.0 / km

Source: JICA Study Team

3.3.4 Daily Passenger Demand Result

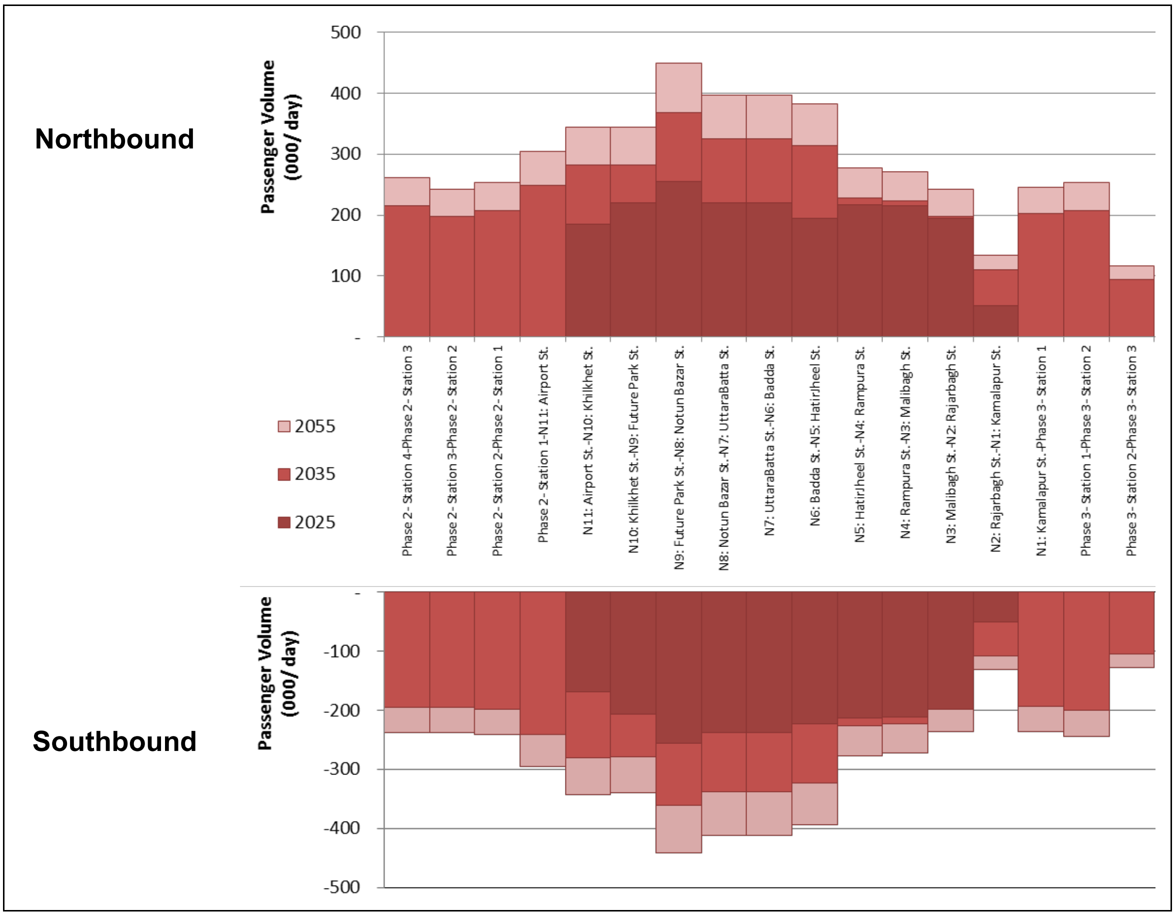
Table 3.3.4 shows the estimated railway performance indicators of MRT Line 1. PPHPD (Passenger Per Hour Per Direction) will be 26,500 pax in 2025, 48,000 in 2035 and 58,500 in 2055. This demand can only be handled by Mass Transit.

Table 3.3.4 Estimated Performance Indicators of MRT Line 1

	Route Length (km)	Ridership (000)	PPHPD 1)	Pax-Kms (000)	Pax/km (000)	Pax-kms /km (000)
2025	28.2	1,105	26,500	9,975	39,379	354
2035	52.7	1,812	47,970	21,117	34,377	400
2055	52.7	2,541	58,500	25,786	48,179	489

1) Peak Hour Rate is assumed to be 10 % in 2025 and 13 % in 2035 & 2055.
Source: JICA Study Team

Traffic demand by section of the main line is indicated in Figure 3.3.10 and Table 3.3.5. The most congested section is Notun Bazar to Future Park, which will carry 500,000 pax /day in 2025. For phase 2 sections, the northern part shows high demand and suggests the possibility of further extension.



Source: JICA Study Team

Figure 3.3.10 Line Volume by Section of MRT Line 1 (Main Line)

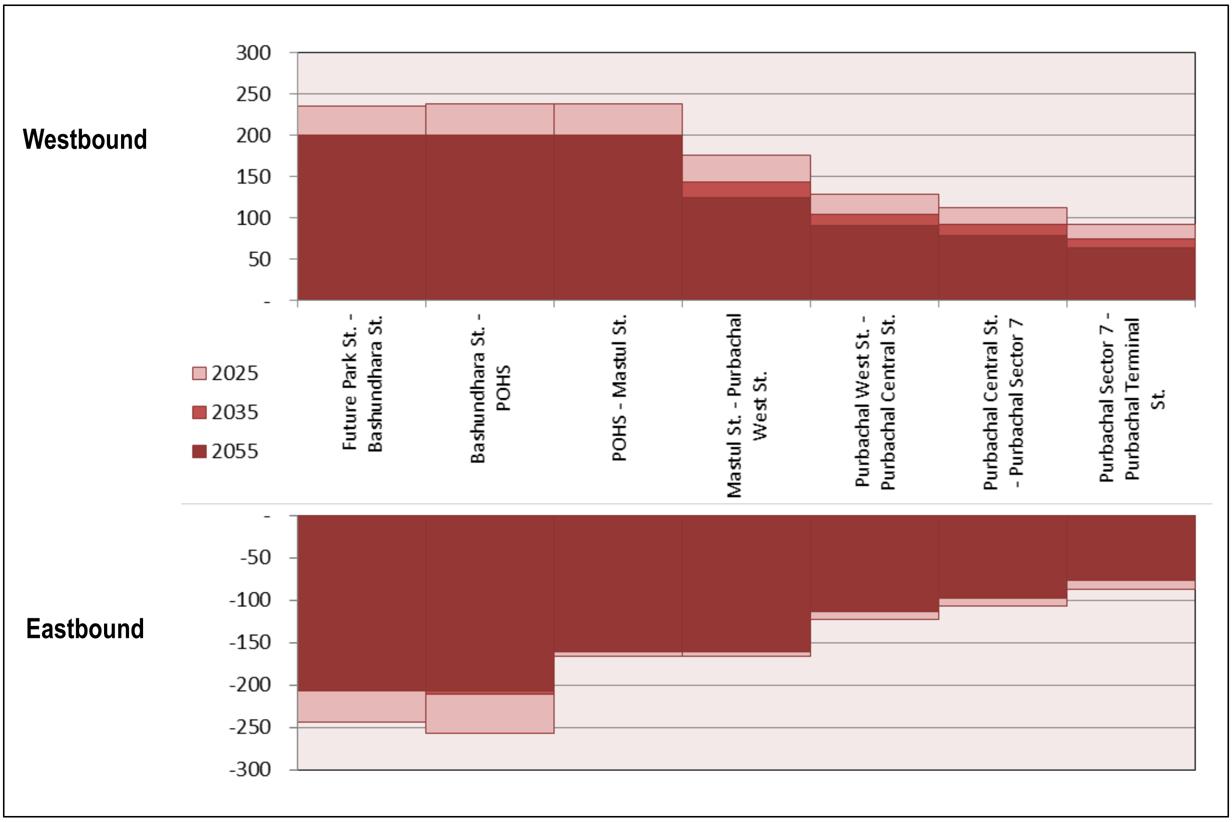
Table 3.3.5 Line Volume by Section of MRT Line 1 (Main Line) : 000/day

Station	2025		2035		2055	
	Line Volume		Line Volume		Line Volume	
	Northbound	Southbound	Northbound	Southbound	Northbound	Southbound
Phase 2- Station 4			215	195	262	238
Phase 2- Station 3			198	195	242	238
Phase 2- Station 2			207	198	253	242
Phase 2- Station 1			249	242	304	295
Airport St.	184	203	282	281	344	343
Khilkhet St.	211	231	282	279	344	340
Future Park St.	204	208	369	362	450	442
Notun Bazar St.	265	206	325	338	397	412
UttaraBatta St.	265	206	325	338	397	412
Badda St.	261	204	314	323	383	394
HatirJheel St.	236	237	228	227	278	277
Rampura St.	232	235	223	223	272	272
Malibagh St.	198	198	198	194	242	237
Rajarbagh St.	61	49	111	108	135	132
Kamalapur St.			202	194	246	237
Phase 3- Station 1			207	200	253	244
Phase 3- Station 2			95	105	116	128
Phase 3- Station 3						

Source: JICA Study Team

Traffic demand by section of Purbachal line is indicated in Source: JICA Study Team

Figure 3.3.11 and Table 3.3.6. The line volume is comparable with main line and the most congested section is Bashundhara to Mastul which will carry more than 400,000 pax /day in 2025. On the other hand, the demand in eastern part is less than 200,000 pax/day in 2035. On the east of Purbachal, there is no specific development is proposed, and the passenger demand can't be expected.



Source: JICA Study Team

Figure 3.3.11 Line Volume by Section of MRT Line 1 (Purbachal Line)

Table 3.3.6 Line Volume by Section of MRT Line 1 (Purbachal Line): 000/day

Station	2025		2035		2055	
	Line Volume		Line Volume		Line Volume	
	North bound	South bound	North bound	South bound	North bound	South bound
Future Park St.						
	200	207	193	200	235	244
Bashundhara St.						
	200	207	195	210	238	256
POHS						
	200	160	195	136	238	166
Mastul St.						
	125	160	144	136	176	166
Purbachal West St.						
	91	113	105	100	129	122
Purbachal Central St.						
	79	97	92	87	113	107
Purbachal Sector 7						
	64	76	75	71	92	87
Purbachal Terminal St.						

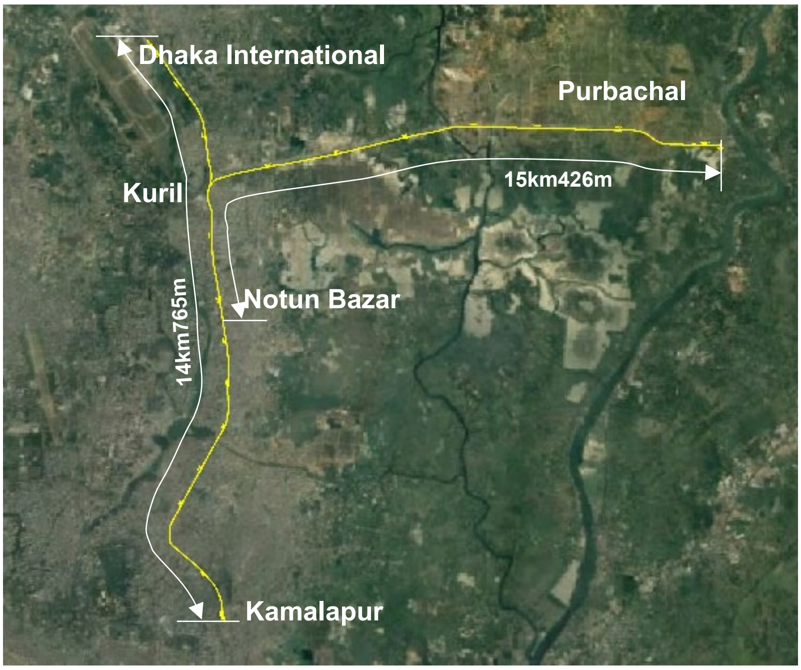
Source: JICA Study Team

4 Project Implementation Plan for Line 1

4.1 Alignment Planning

MRT Line 1 consists of two lines: one route connects Kamalapur in central Dhaka with the Dhaka International Airport (hereafter the "Airport Line"), and the other route branches off from the Airport Line at Notun Bazar Station to the Purbachal area (hereafter the "Purbachal Line") where large-scale urban development is currently under way. The Line 1 route is shown in Figure 4.1.1. Future extension concepts include a northbound line from the airport to Gazipur, and a southbound line from Kamalapur to the Jhimil residential area in Keraniganj.

The Airport Line will run entirely through an underground tunnel, and the Purbachal Line will run through an underground tunnel from Notun Bazar to Kuril, after which it will emerge above ground to become an elevated structure to its destination at Purbachal.



Source: JICA Study Team

Figure 4.1.1 Route of Line 1

4.1.1 Basic Policies of the Alignment Planning

The specifications required for alignment planning are shown in Table 4.1.1 below.

Table 4.1.1 Specifications Required for Alignment Planning

Item		Description
Track gauge		1435mm
Maximum design speed		110km/h
Maximum operating speed		100km/h
Minimum radius	Main line	400m
	If absolutely necessary	160m
	Platform sections	400m or greater
Maximum gradient		25/1000 (recommended), 35/1000 (upper limit)
	Station	0 (recommended), 5/1000 (upper limit)
	Stabling track	0
Minimum gradient	Underground sections	2/1000
Vertical curve radius		3000m
		4000m (where R=600 or smaller)
Car length		20m
Track centre intervals	Tangent sections	4.0m
Platform length	8-car trains in the future	170m
Platform width	Island type	11m
	Separate type	3m

Source: JICA Study Team

4.2 Design Standards and Basic Policies of the Alignment Planning

4.2.1 Design standards

Design standards conform to the "Bangladesh MRT Engineering Standards" (2014.12 DTCA, JICA) , appending some sentences as may be necessary.

4.2.2 Basic Policies of the Alignment Planning

1) Route Overview

Airport Line

The Airport Line, which runs through an underground tunnel, starts at the Kamalapur Station of Bangladesh National Rail (BR), travels westward under the Outer Circular Road, northward under the Rampura DIT Road and Pragati Sharani Road, crosses the Kuril flyover, and proceeds under the New Airport Road to its destination at Dhaka International Airport.

The underground tunnel will consist of shielded tunnels for single tracks. Typically, tunnels running directly underneath roads will be arranged horizontally in two rows side by side. However, if there are any underground obstacles, the tunnels will be built in a two-tier configuration, or by separating the two lines for trains to overtake and pass. In this project, a typical arrangement will need to be made at the fly-over between Rajarbagh and Malibagh, the Rampura Bridge, and the Kuril fly-over.

Purbachal Line

The Airport Line will branch off to the Purbachal Line at Notun Bazar instead of Future Park according to site availability. The station box which contains two platforms and four tracks, requires of area about 36m in width and 250m in length for station box. As shown in Figure 4.5.20, the same width of land will be required for an extent of 200m north of the station.

However, it is difficult to construct a structure with this width in the road in front of Future Park station. Therefore, the JICA Study Team (JST) selected Notun Bazar station as the junction for the Airport Line and Purubachal Line. As shown in Figure 3.2.2, Prangati Sharani Road, where Notun Bazar station is planned to be constructed, has a width of 39.15m. The four tunnels laid out horizontally leading up to Future Park will be of an upper and lower tier configuration, the upper for the Purbachal Line and the lower for the Airport Line. Both of these lines will circumvent the pile foundations at the Kuril fly-over and the Dhaka Elevated Expressway (DEE) that is currently under construction, and run to the north and east, respectively.

The elevated section of the Purbachal Line begins at the above ground exit/entrance built on the east side of the Kuril fly-over, and will proceed eastward directly above the median strip of the Purbachal Highway to the Purbachal Terminal station. However, on curved sections of the road, the line will run over service roads. The highway crosses six river bridges 70-80m long, and the line will run directly over these bridges.

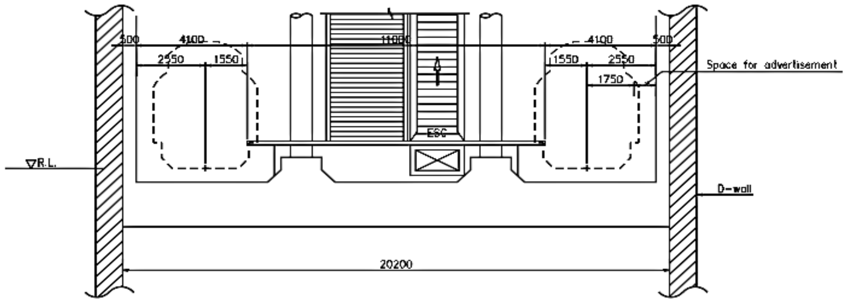
2) Station Location

Taking into account the railway station catchment area, stations will be generally located roughly 1km apart, and 1.5km apart in the suburbs. Their locations will be determined by considering the locations of major facilities, connections to other traffic lines, and the locations of fly-overs.

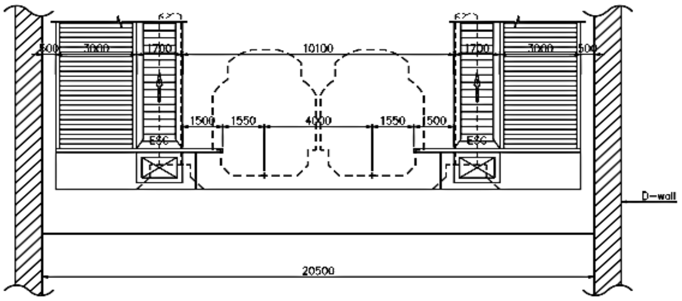
3) Island Platform and Lateral Platform

Two types of platform are shown below.

Island Platform



Separate Platform



Source: JICA Study Team

Figure 4.2.1 Island Platform and Separate Platform

For elevated stations, side (lateral) type platforms will be provided while underground stations contain an island platform.

Side platforms have some advantages for elevated stations, while having disadvantages in the underground stations as shown below.

(Advantage of Side Platform)

Provided track alignment is straight tangent or large radius.

Station area land acquisition is limited

(Disadvantage of Side Platform)

1. Number of station facilities such as escalators and elevators are twice that for Island platforms; and
2. Number of station staff is also twice that for island platforms.
   ① Station Box of lateral type of platform requires wider space than island type.
3. In front of station box, a sharp S-curve is inevitable, because the distance between two tracks is 14m in the TBM section while it is 4m in a station box.

4) Track Layout Planning

The alignment planning will be considered based on the track layout planning below.

(a) Track Layout in Station Yards

As a general rule, underground stations will have one island type platform for two tracks. Exceptions are the Malibagh Station with two layers each with one platform for one track, the Notun Bazar Station with two platforms for four tracks, and the Future Park station with two layers each with one platform for two tracks.

Elevated stations will generally have two separate platforms (Lateral Platform) for two tracks, except the Purbachal Terminal station, which will have two platforms for three tracks.

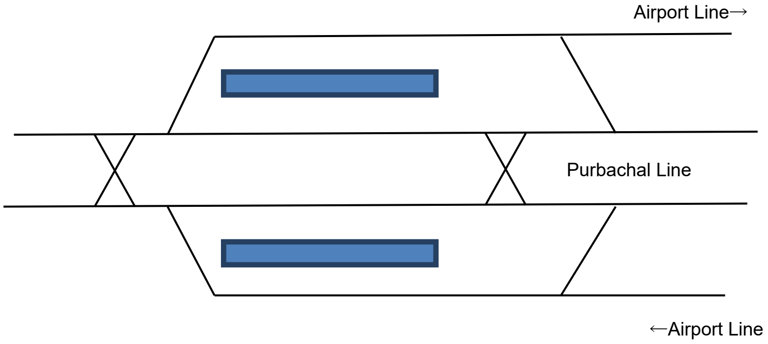
(b) Branch Layout at the Notun Bazar Station

The Airport Line, which enters the Notun Bazar station from the Kamalapur direction, will branch off from the two tracks to four before it reaches the platform. The four tracks leaving the station will run on two tiers to the Future Park station, the upper tier being the Purbachal Line, and the lower being the Airport Line.

Furthermore, at initial stage of MRT Line 1 commercial operation, since development of Purbachal Project may be still on the way, among 13 trains per hour from Purbachal 10 trains shall be returned at Notun Bazal station, remaining 3 trains shall go ahead to Komulapur Terminal. As a result Purbachal Line shall use inner two tracks of Notun Bazar Station while the Airport Line shall use outer two tracks.

(c) Notun Bazar Track Layout

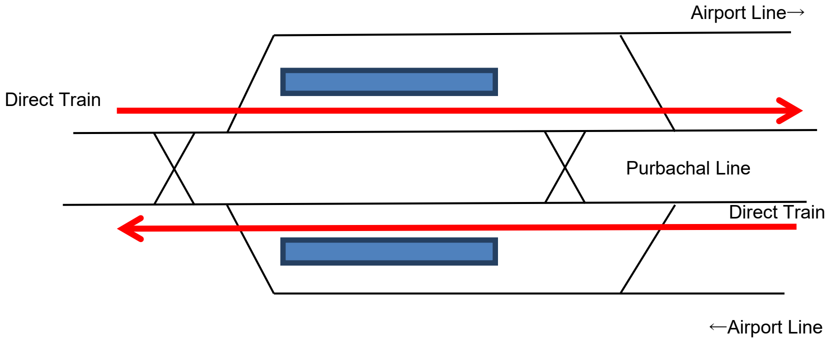
① Track Layout of Notun Bazar Station



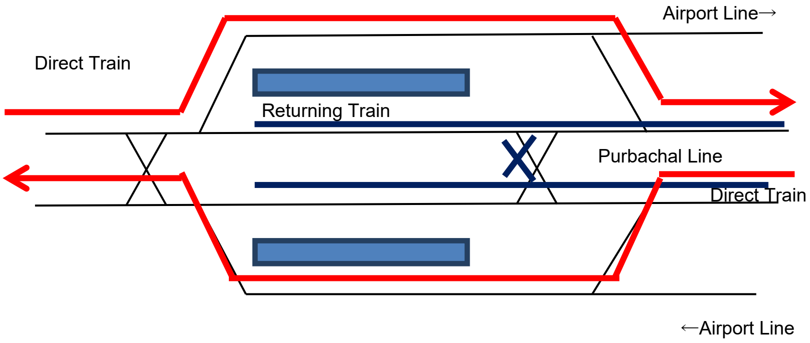
② Track Layout Plan

To turn back a part of the train to the Purbachal Line at Notun Bazar Station, the track for the Airport Line shall run outside and the Purbachal Line inside at the station. Also, to prevent obstruction at the platform section due to conflict with the following direct train for Kamalapur Station (or the direct train from Kamalapur Station to the Purbachal Line) when the shuttle train is present at the platform section, a cross between the Purbachal Line and the Airport Line was established on the Future Parks Station side of the Notun Bazar Station.

○ In case there are no trains at the platform section

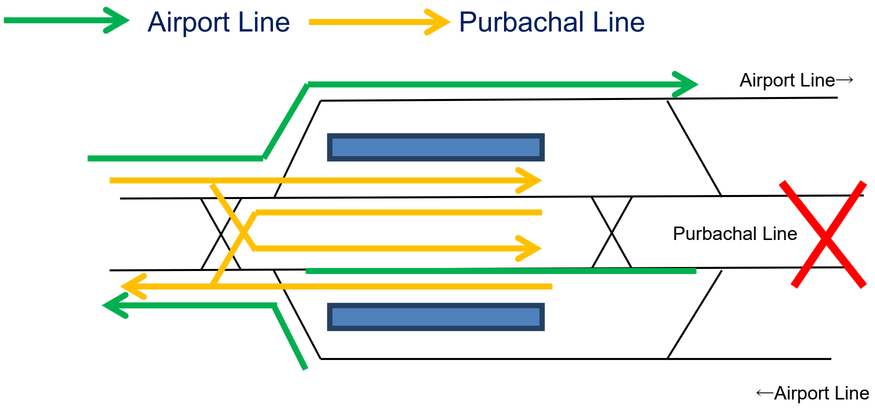


○ In case there is a train turning back



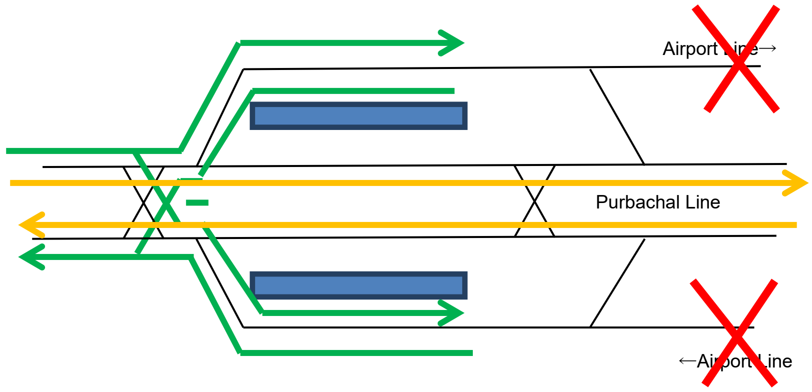
③ In case of emergent shuttle operation

- Purbachal In case train service is cancelled at Purbachal Terminal side



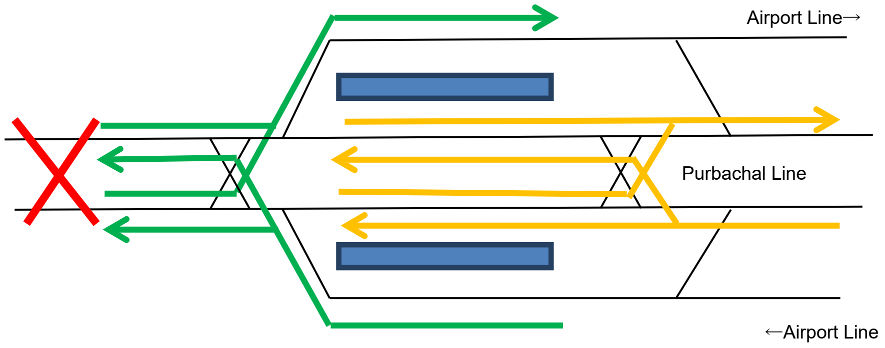
In case a failure occurs at the Future Park side of Notun Bazar, the train coming from the Kamulapur side will turn back. The Airport Line will be able to continue operation.

- In case train service is cancelled at the Airport Line side



In case troubles occur at the Airport Line, the Purbachal Line will continue to operate normally.

- Airport Line In case train service if cancelled at the Kamalapur side



All trains with troubles at the Kamalapur will turn back at Notun Bazar.

(d) Terminal Station Turn Back Track

Train turn backs at the Kamalapur, Airport, and Purbachal Terminal stations will be achieved by placing a double cross-over at the front of the platform to reduce turn back times.

(e) Stabling Tracks at Station Yards

At the Airport station, two stabling tracks of one train length will be placed at the rear of the platform. At Kamalapur Station, the platform track will be used as the stabling track.

(f) Branch Point Track Layout to the Depot

The approach track to the Depot was studied based on Option 4 regarding the depot site, and the details will be discussed clause 10.2 of this Chapter 4. The proposed depot site is located on the eastern side of the Purbachal Terminal Station. The Station Master of Purbachal Terminal Station shall control leaving/approaching trains from/to the station. The track layout of this station was designed taking into 1) train turn back, 2) approach to depot and 3) future extension of Line 1. The Purbachal Terminal Station contains two scissors-crossings for easy handling in the future. At present, the approach line consists of double tracks near to the station, while near the depot a single track is provided. The proposed depot plan was created based on Google Earth Map, while a topographic survey is inevitable for detailed design, especially crossing between MRT and Road.

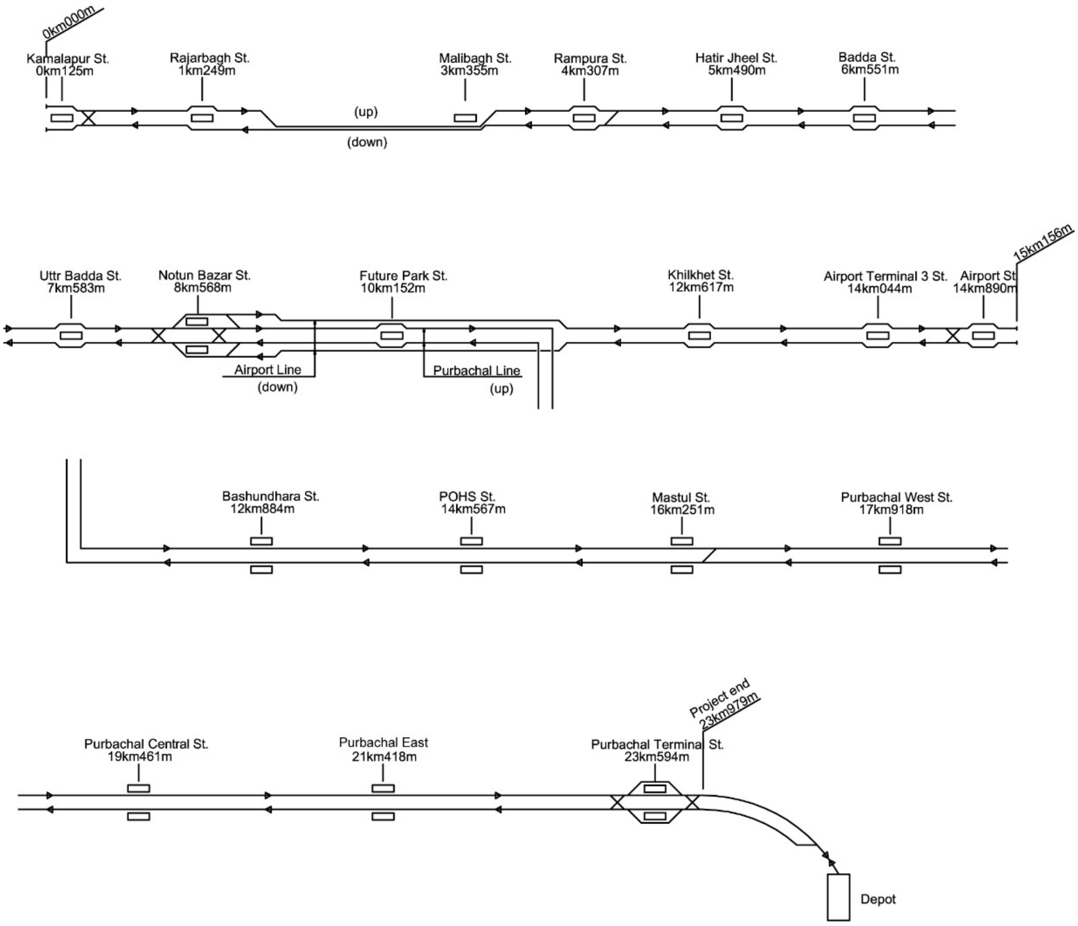
JST planned the approach viaduct with a track considering cost saving. In generally, it is commonly early morning to put trains from depot to commercial tracks and returning to depot of the trains are expected after 10 O'clock AM or after service hour. Since train operation on the approach line is so simple that it is possible control depot work with single track. Further Depot approach track shall be provided at the Purbachal Terminal Station which contains two platforms and four tracks. The single depot approach track starts from the eastside of the Purbachal Terminal therefore in/out service trains don't obstruct main line commercial operation. Generally, the train operation plan will have more allowance if the Depot Access Line is a double track. Especially when depots will be established in-between stations, precise operation is necessary between the depot and main track in order to prevent obstructions to the operation of the commercial line. Therefore, the approach line may be double tracks as well.

(g) Emergency Crossovers

Emergency crossovers will be placed at the Rampura, Notun Bazar and Mastul stations to allow for turn back operations in the event of accidents or failures.

(h) Track Layout Diagram

Figure 4.2.2 shows a diagram summarizing the station locations and track layout planning described above.



Source: JICA Study Team

Figure 4.2.2 Track Layout Diagram

5) Defining Rail Levels and Required Clearances

With regard to the overburden thickness of a single track shielded tunnel, the tunnel will have a diameter of at least 7m, and the rail level of underground stations will be at -16.0m from the existing ground surface, or deeper. The rail level at the Notun Bazar station will be restricted to 16m taking into account its intersection with Line 5. At the Malibagh and Future Park stations, both of which will have two-tiered platforms, the rail clearances on the top and bottom tiers will be 7.65m and 8.05m, respectively. Vertical Alignment is presented as Appendix Track Plan and Profile.

The standard clearance between shielded tunnels and that between a shielded tunnel and nearby structures will be equal to or greater than the tunnel diameter. If the clearance must be smaller than this, measures such as reinforcement construction must be considered.

The standard rail level in elevated sections will be +13.0m from the existing ground surface. If it must be lower than this, the rail level must be defined to ensure proper clearance for the roadway below the elevated structure.

4.2.3 Control Points

1) Fly-Over between the Rajarbagh and Malibagh Stations, and nearby Buildings

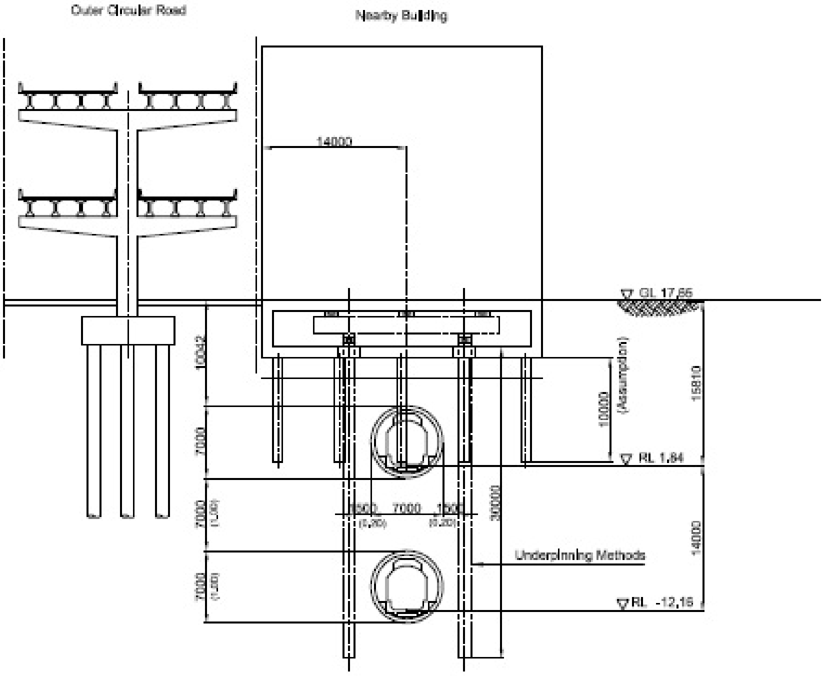
The widths of the Outer Circular Road and Rampura DIT Road between the Rajarbagh and Malibagh stations vary between 30-35m. Construction of a fly-over in these sections is currently under way, and there are buildings, including commercial facilities, along the road near the fly-over. As the clearance between the pile foundations of the fly-over and nearby buildings is expected to be around 14m, an in-depth study of the foundations must be carried out.

Another fly-over from the south will merge at a perpendicular angle with the fly-over above the Outer Circular Road. Since the fly-overs at the merge point will be near each other in a complex fashion, there is believed to be no clearance for the passage of underground tunnels. Therefore, the path of the underground tunnel will be restricted to the south side of the fly-over, and the shielded tunnels will have to have a two-tier configuration.

At the intersection of the Outer Circular Road and Rampura DIT Road, and at the curved road section near the BR railroad crossing, there will be a sharp curve section in the underground tunnel and the tunnel will pass directly under nearby buildings. While the impact on buildings can be minimized by employing a curve radius of 200m, which is close to the minimum radius, the foundations of the underground tunnel and several buildings will interfere with each other. Methods such as underpinning construction are potential options for replacing the loads of these buildings. In light of this, in-depth investigations of the foundations should be conducted as soon as possible. Attached photos show fly-overs at the crossing DIT road and New Circular road, at this point a whole a day heavy congestion is observed.

Figure 4.2.3 shows the JST arrangement of the Existing Fly-over, Existing Building and MRT 1. The Existing Building at the point where the New Circular Road and DIT Road cross shall be supported during TBM construction. JST proposes that the building be supported by additional piles which will be constructed from the basement of the building.

Corner of Outer Circular and Rampura-DIT Road



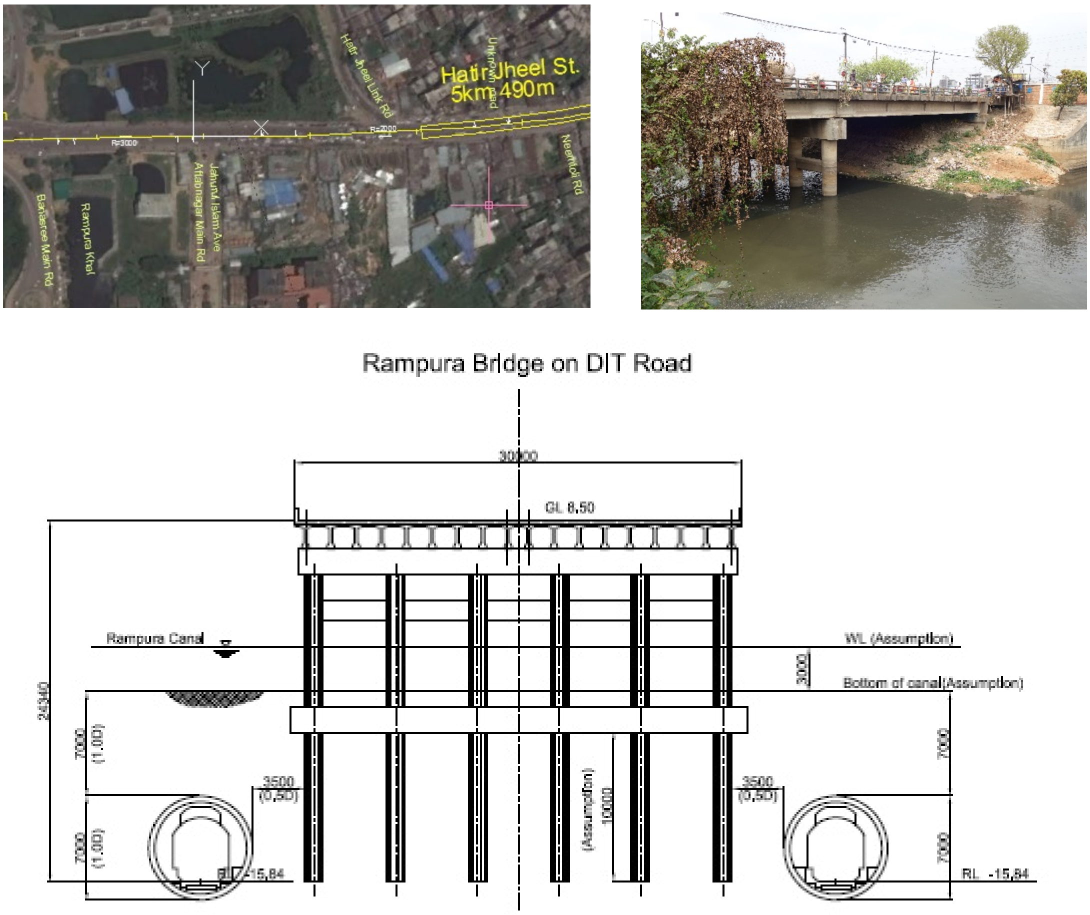
Source: JICA Study Team

Figure 4.2.3 Sharp Curve Section at Malibagh

2) Rampura Bridge

While the plan calls for the rail level at the Hatir Jheel Station to be at the standard level, because the Rampura Bridge that is built on a pile foundation is situated nearby, the underground tunnel must be shifted towards the regulating reservoir and canal. And because the tunnel will be passing directly under the bottom of the water, the rail level must be lowered considerably. In this case, because the gradient between the bridge and station will exceed the maximum gradient, the rail level at the station must be lowered to lessen the gradient. Therefore, in the design stage, a river survey must be performed to determine the water depth.

Prior to establishment of final alignment, detailed data of piles such as length, venue, and type of pile are needed. Figure 4.2.4 shows proposed position of TBM.



Source: JICA Study Team

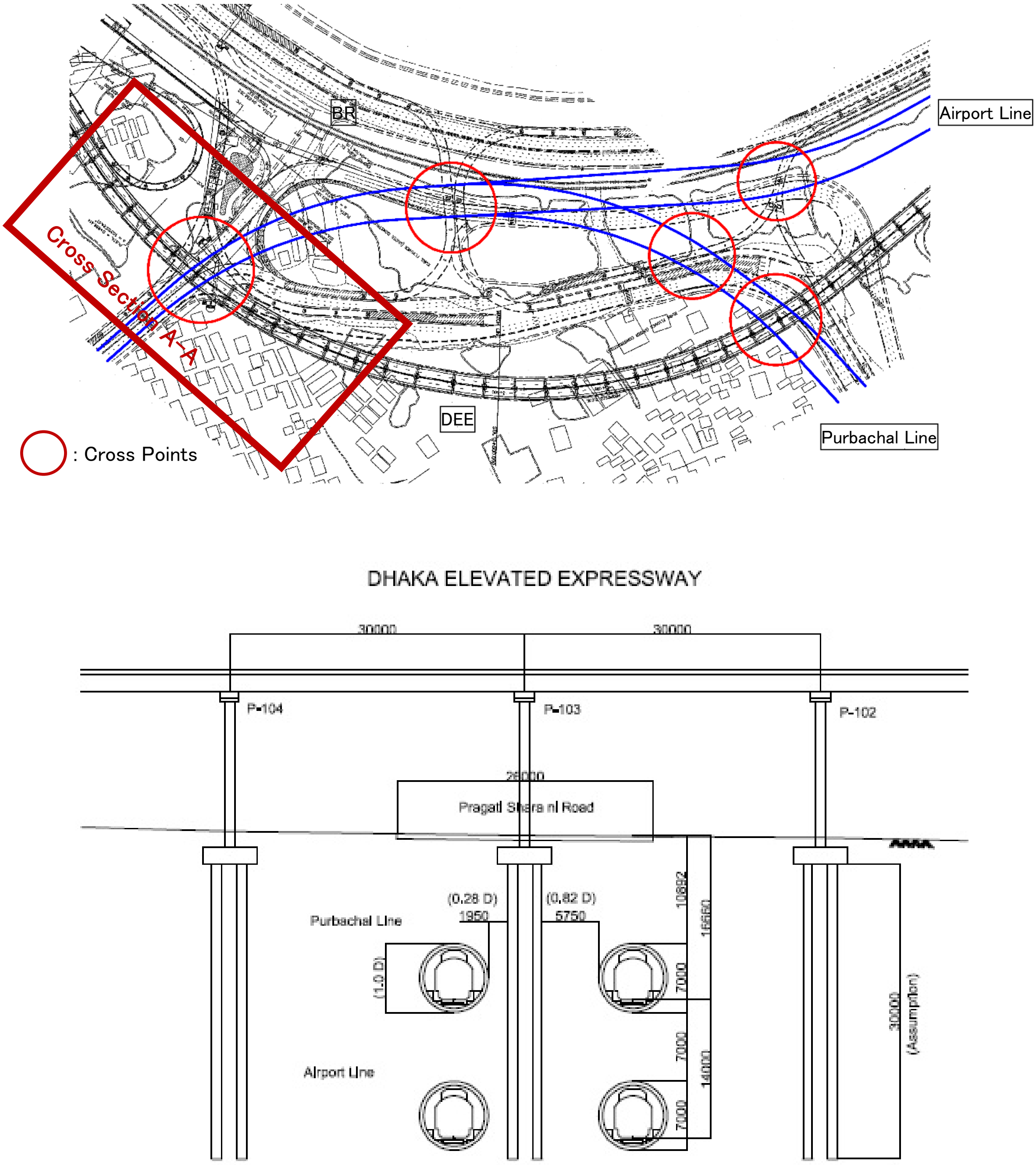
Figure 4.2.4 The Area near the Rampura Bridge

The above photo shows that the Rampura Bridge has piers in the canal and the bridge contains pile foundations. Since the distance between the Hatir Jheel Station and Rampura Bridge is relatively small, a sharp gradient may be applied.

3) Kuril Fly-over

The Kuril fly-over is shaped in a rotary configuration, and therefore, the Airport Line and Purbachal Line will intersect with the fly-over at five points. Additionally, the DEE currently under construction will intersect at one or two points. Since the length of one span in the fly-overs is approximately 30m, the single track shielded tunnel can pass through the centre of the span. The use of underpinning construction will be considered as needed.

Figure 4.2.5 shows the proposed route of passage.



Source: JICA Study Team

Figure 4.2.5 Proposed Kuril Fly-Over Route of Passage

4) Above Ground Exit and Entrance at Kuril

The exit and entrance from the underground Purbachal Line to above ground is planned to be located at the 10m wide green median between the main line of the Purbachal Highway and its service road near the convention centre. The rail gradient will be 30 /1000, and the distance from the exit/entrance to the elevated section will be approximately 550m.

Source: JICA Study Team

Figure 4.2.6 Location of the Exit and Entrance

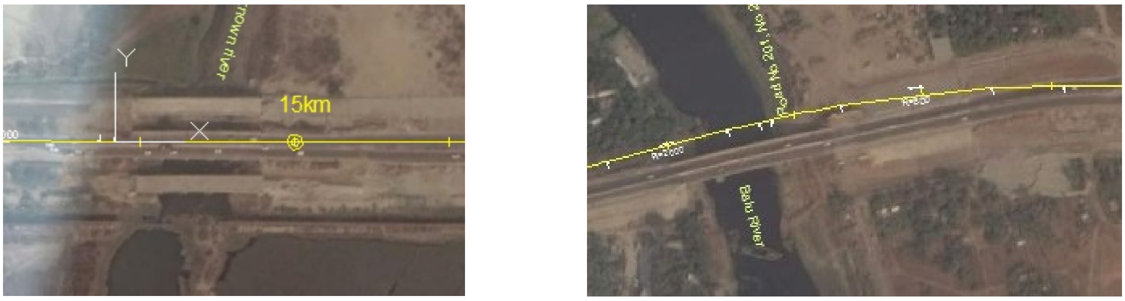
5) Purbachal Highway River Bridges

The Purbachal Highway has six river bridges that come in two different types as shown in Figure 4.2.7. Both of these are PC-bridges with girder lengths of 18m (left) and 45m (right). The bridges are all 70-80m long.

Source: JICA Study Team

Figure 4.2.7 River Bridges

Since the Purbachal Line runs over the centre of the highway, it will pass directly above the river bridges. The exception is at the Balu River bridge shown in the right photo. This section includes a curved section so the line will shift to above the highway service road.



Source: JICA Study Team

Figure 4.2.8 Alignment at River Bridges

6) Plan and Profile Drawings

The plan alignment and profile alignment of the Airport Line and Purbachal Line will be designed based on the basic policies of the track layout planning and the points that need to be kept in mind regarding the control points. The plan and profile alignments are attached at the end of this document.

4.3 Underground Utilities and Soil Conditions

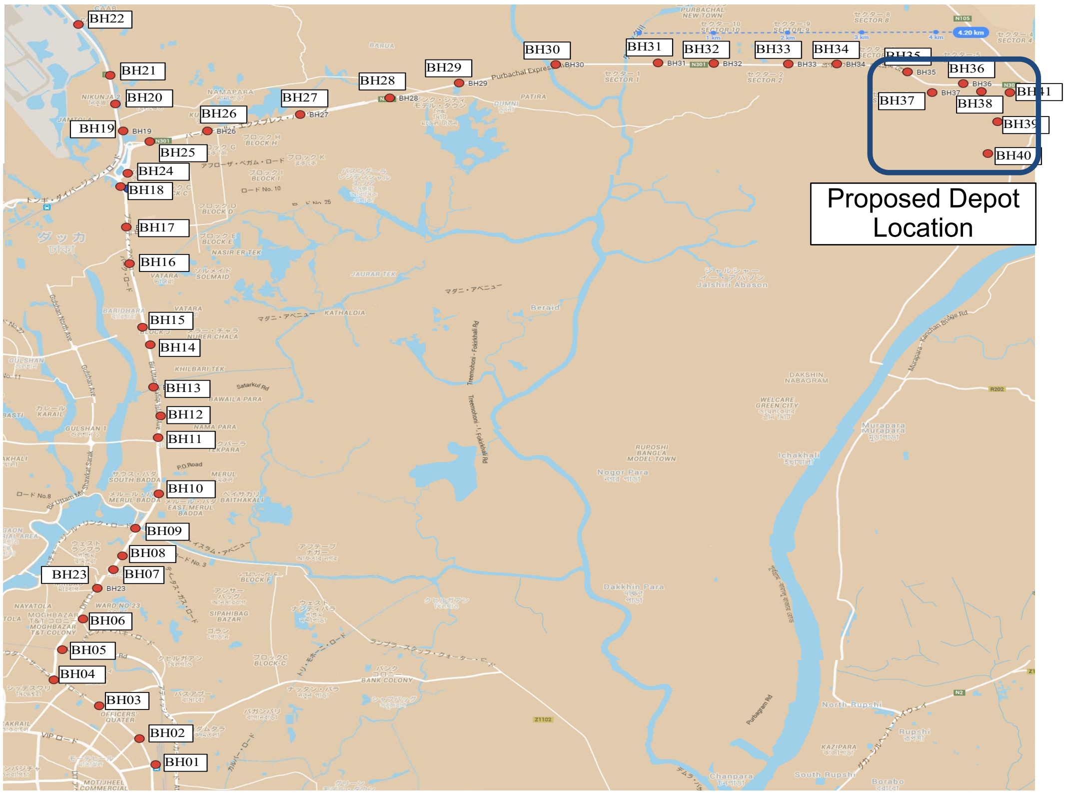
As for utilities along proposed alignment of Airport Line (Kamalapur Station to Airport Station), there are gas line, sewerage line and WASA (Water Supply & Sewerage Authority) line under the ground and electric line and BTCL (Bangladesh Telecommunications Company Limited) line over head at almost all the sections. The other hand there is no utilities along proposed alignment of Purbachal Line (Bashundhara Station to Purbachal Terminal Station.

A geotechnical investigation for the elevated section of Purbachal Line was smoothly conducted without problem, but it took time to get permission to conduct investigation for the underground section. The permission was finally obtained and 1 borings were conducted in total.

4.3.1 The Result of Geotechnical Survey

1) Location of Geotechnical Investigation

Seventeen (17) borings (BH25 to BH41), as shown in Figure 4.3.1, out of 41 borings have been done. Borings for BH01 to BH24 are being conducted.



Source: JICA Study Team

Figure 4.3.1 Boring Location

2) Characteristics of Geological Layers

Several layers as shown in Table 4.3.1 are identified in the section where 17 borings were conducted.

Holocene sediments, “Ac” and “Ap” are observed only between BH26 and BH29. Pleistocene sediments, “Dc” and “Ds”, appear in all the boreholes as the same Pliocene sediments, “Pc” and “Ps”.

“Dc” layer is called “Madhpur clay” in Bangladesh.

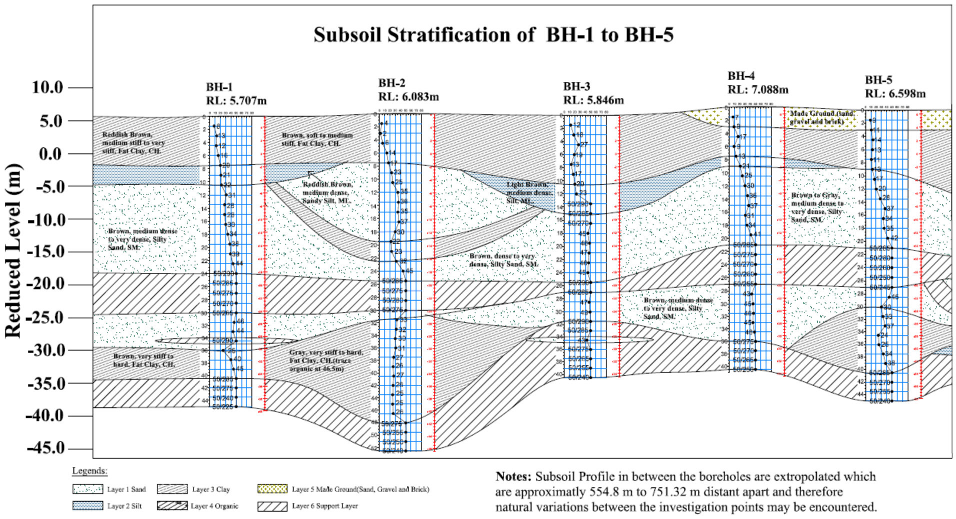
Table 4.3.1 Summary of Soil Layers

Layer	Average N-Value	Thickness (m)	Description
B	7	6～9m	Road embankment, consisting of loose, poorly graded sand mainly. Appeared from BH25 to BH29. Gray
Ap	4	3～4.5m	Organic clay, soft to medium stiff. Appeared between BH26 and BH27 only. Dark Gray or Dark Brown.
Ac	2	6～13.5m	Soft Clay or silt. Appeared between BH28 and BH29 only. Gray or light Gray.
Dc	17	6～33m	Medium to stiff Clay or Silt. Appeared at all Boreholes except BH29. Observed at surface in the eastern side of BH30.
Ds	22	4.5m～18m	Medium dense to Dense sandy soil. Appeared as lens form in Dc layer. Brown or reddish.
Pc	39	1.5m～7.5m	Very stiff clay or silt with sand. Observed N=50 over at some Boreholes. Appeared as the lens form in Ps. Gray.
Ps	48	5m～	Very stiff sandy soil. Possible bearing layer for large structures. Mostly indicating N=50 and over.

Source: JICA Study Team

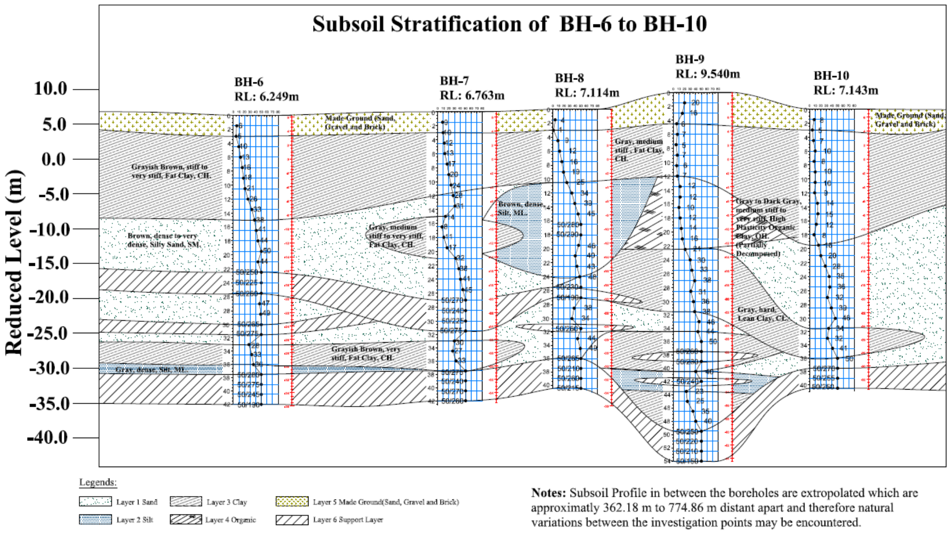
3) Geological Cross Section

Geological cross section which is made from the result of conducted borings is shown in Figure 4.3.2.



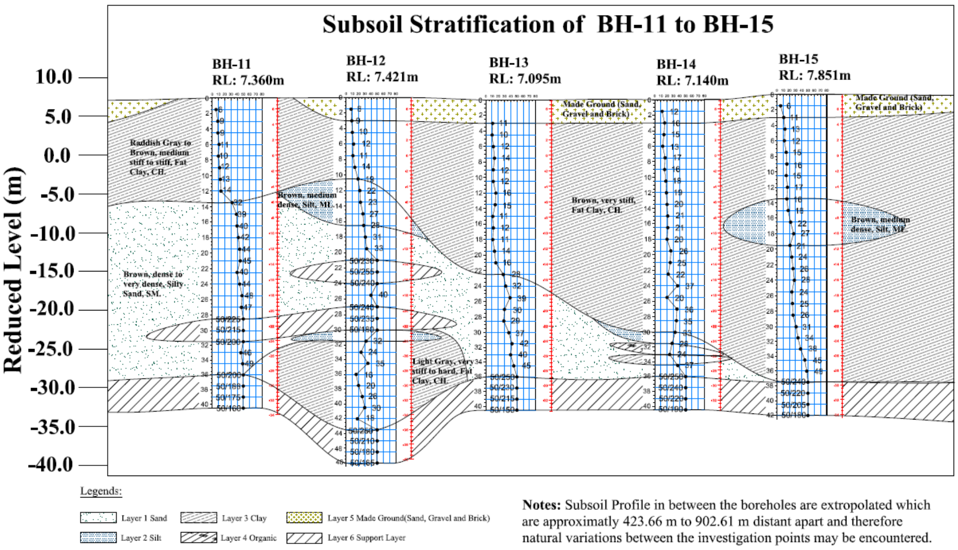
Subsoil Stratification of BH-1 to BH-5

Notes: Subsoil Profile in between the boreholes are extropolated which are approximatly 554.8 m to 751.32 m distant apart and therefore natural variations between the investigation points may be encountered.



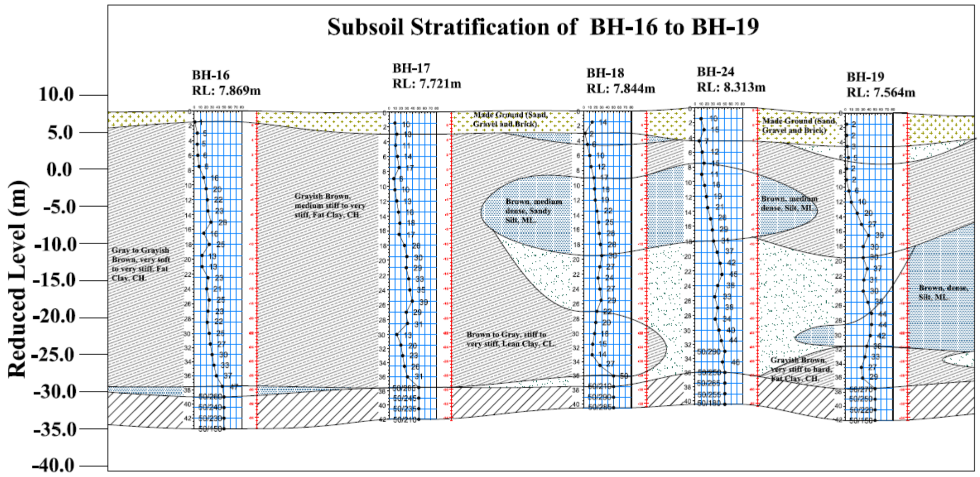
Subsoil Stratification of BH-6 to BH-10

Notes: Subsoil Profile in between the boreholes are extropolated which are approximatly 362.18 m to 774.86 m distant apart and therefore natural variations between the investigation points may be encountered.

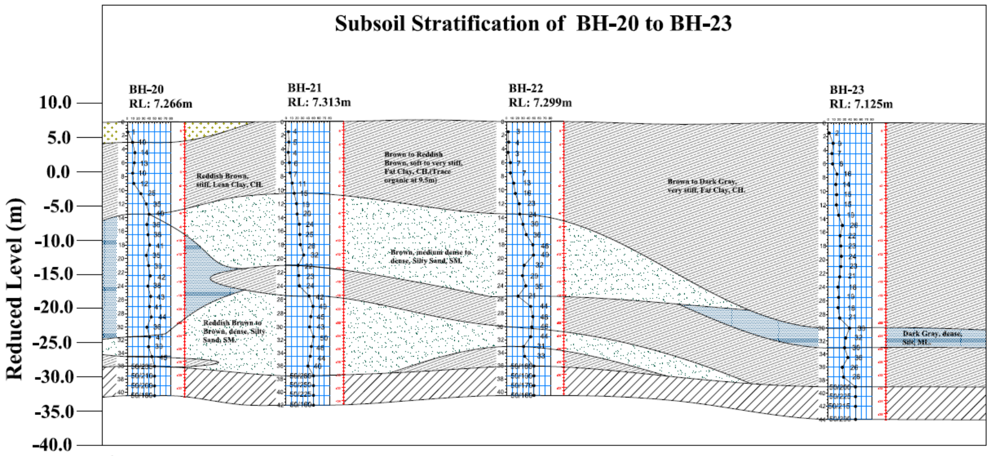


Subsoil Stratification of BH-11 to BH-15

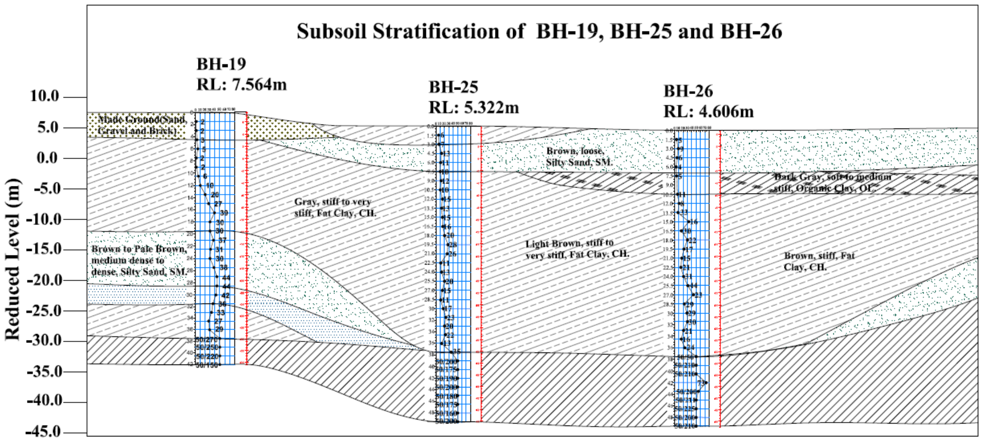
Notes: Subsoil Profile in between the boreholes are extropolated which are approximatly 423.66 m to 902.61 m distant apart and therefore natural variations between the investigation points may be encountered.



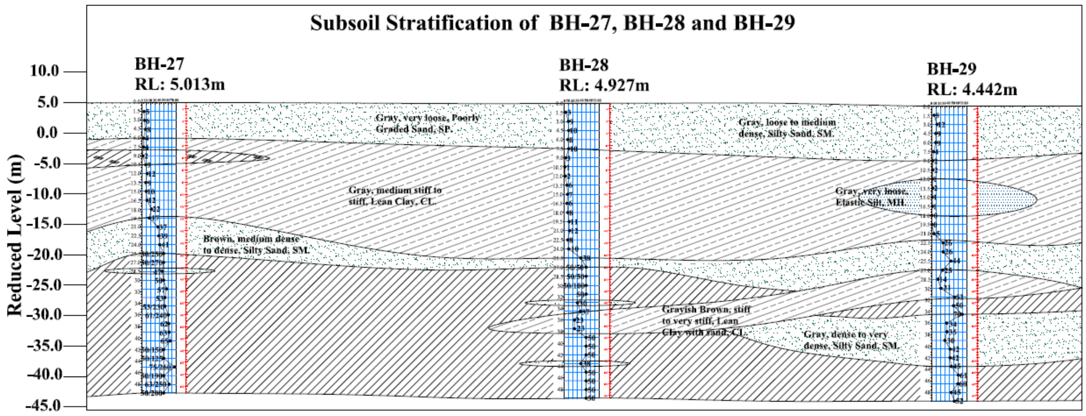
Notes: Subsoil Profile in between the boreholes are extrapolated which are approximately 120.91 m to 953.30 m distant apart and therefore natural variations between the investigation points may be encountered.



Notes: Subsoil Profile in between the boreholes are extrapolated which are approximately 637.71 m to 1253.30 m distant apart and therefore natural variations between the investigation points may be encountered.



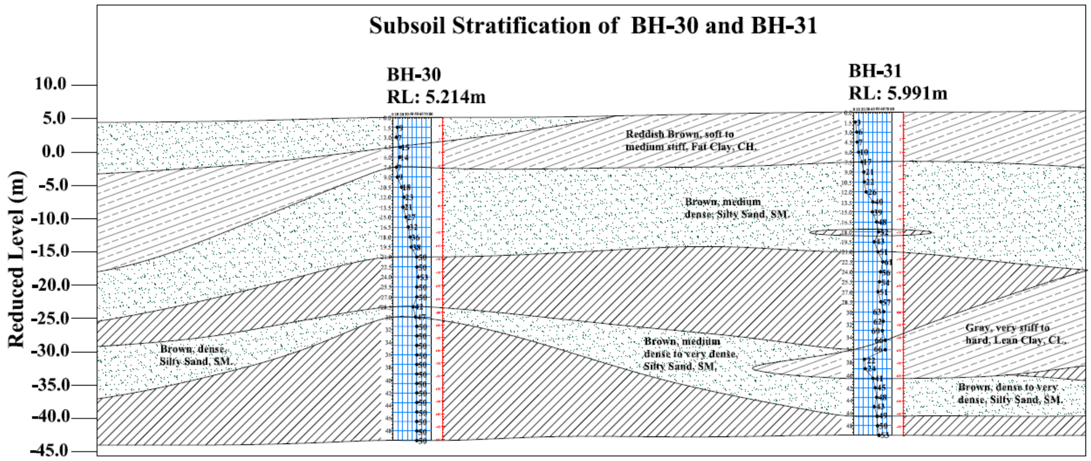
Notes: Subsoil Profile in between the boreholes are extrapolated which are approximately 367.0m to 772.0m distant apart and therefore natural variations between the investigation points may be encountered.



Legends:

▨ Layer 1 Sand ▨ Layer 3 Clay ▨ Layer 5 Organic
▨ Layer 2 Silt ▨ Layer 4 Support Leyer

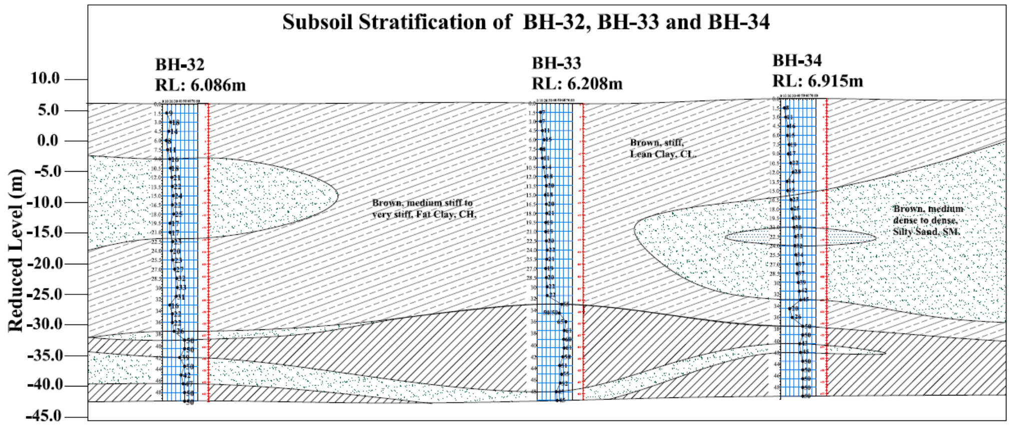
Notes: Subsoil Profile in between the boreholes are extropolated which are approximatly 970.0m to 1235.0m distant apart and therefore natural variations between the investigation points may be encountered.



Legends:

▨ Layer 1 Sand ▨ Layer 3 Clay
▨ Layer 2 Silt ▨ Layer 4 Support Leyer

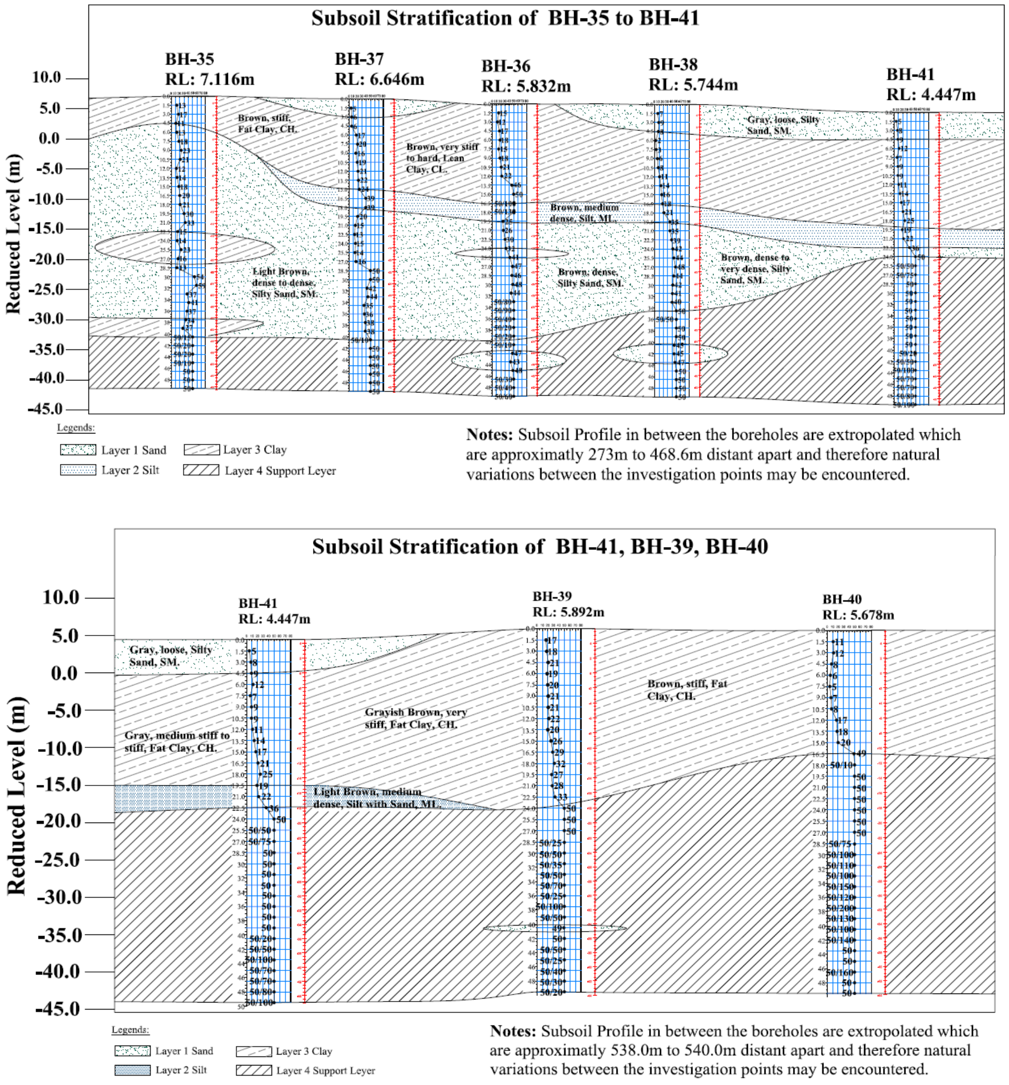
Notes: Subsoil Profile in between the boreholes are extropolated which are approximatly 1377.45m distant apart and therefore natural variations between the investigation points may be encountered.



Legends:

▨ Layer 1 Sand ▨ Layer 3 Clay
▨ Layer 2 Silt ▨ Layer 4 Support Leyer

Notes: Subsoil Profile in between the boreholes are extropolated which are approximatly 660.85m to 1014.0m distant apart and therefore natural variations between the investigation points may be encountered.



Notes: Subsoil Profile in between the boreholes are extropolated which are approximatly 273m to 468.6m distant apart and therefore natural variations between the investigation points may be encountered.

Notes: Subsoil Profile in between the boreholes are extropolated which are approximatly 538.0m to 540.0m distant apart and therefore natural variations between the investigation points may be encountered.

Source: JICA Study Team

Figure 4.3.2 Geological Cross Section

4) Soil Parameters

Soil parameters are shown in Table 4.3.2.

Table 4.3.2 Soil Parameters

Layer	Average N-Value	Unit Weight γt (kN/m^3)	Cohesion c (kN/m^2)	Angle of Internal Friction Fai (°)	Modulus of Deformation E (kN/m^2)
B	7	18	0	25	4,900
Ap	4	20	24	0	2,800
Ac	2	18	30	0	1,400
Dc	17	19	62	0	11,900
Ds	22	19	0	33	15,400
Pc	39	20	230	0	27,300
Ps	48	20	0	42	33,600

Source: JICA Study Team

5) Discussion

As the SPT-N values of the “Ps” layer are mostly over 50, that layer is the first option as a “Bearing Layer for the Viaduct” in the project. On the other hand, the depth of the bearing layer must be determined at each borehole based on the SPT-N because the SP-N value of some parts of the Ps layer is less than 50. If the SPT-N value of “Pc” and “Dc” layers is over 50, the layer is the first option as the bearing layer on the condition that the thickness of the layer is adequate to serve as the bearing layer (more than 5m).

As “Ac” and “Ap” layers are identified as “Unconsolidated Layer” based on the calculations conducted in the section, negative friction must be taken into account while designing the pile foundations for the section between BH26 and BH29.

As for ground settlement in the proposed depot area, the final settlements are 22.2cm and 36.0cm for BH38 and BH41, where the embankment is 5m in height. Therefore, some soil improvement is required for the proposed depot area.

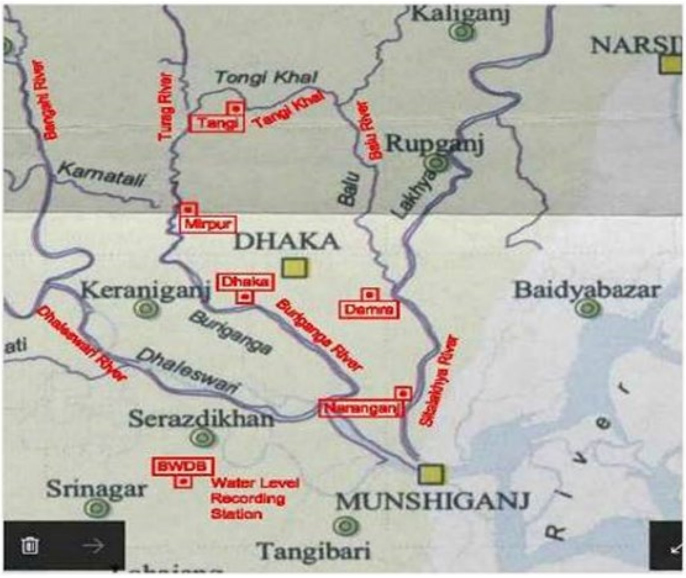
Although no literatures showing the existence of active faults in Dhaka are found, seismic design should be carried out on basic and detailed designs, after acquiring detailed data on earthquakes and active faults from universities such as BUET.

4.4 Hydrological Survey

The flood survey results by the Bangladesh Water Development Board (BWDB) in Bangladesh are summarized in the "Flood Study in and around Dhaka City", April 2017.

According to the survey results, flooding in Bangladesh is categorized into flood of rivers during monsoon, flash flood, rain flood, storm surge and so on. Among those items, the most important point in the project area is the effect of flooding caused by monsoon rains. A total of 75% of annual rainfall occurs from June to September. Dhaka is prone to flooding, and since 1982 Dhaka has had floods several times. Especially large flood damage occurred in 1988 and 1998, and the city was flooded to a depth of 0.3m to 4.5m.

Five Water Level Recording stations are set up around Dhaka City. Based on the records at each point, the elevation of the highest water level so far is 8.35m above MSL.



Source: BWDB HP

Figure 4.4.1 BWDB Water Level Recording Stations around Dhaka City

The name of the river, danger level and respective highest flood level are shown in the table below.

Table 4.4.1 Danger Levels and Respective Highest Flood Level around Dhaka City Area

Station	River	Danger level (m PWD)	HWL (m PWD)	Year corresponding to HWL
Demra	Balu	5.75	7.11	1988
Dhaka	Buriganga	6.00	7.58	1988
Tongi	Tongikhal	6.08	7.84	1988
Mirpur	Turag	5.94	8.35	1988
Narayangonj	ShitaLakhya	5.50	7.00	1988

Source: JICA Study Team

According to the measurement data, it is necessary to assume that the elevation of the highest water level in Dhaka City is 8.35m or more when designing all structures since the elevation of the highest water level in the rainy season is 8.35m.

Countermeasures against rainfall caused floods have been taken such as levee construction, water level adjustment reservoirs, pipe culverts and so on. Looking toward the future, flood countermeasures, drainage planning, flood embankments, reinforced concrete walls, water quantity adjustment structure equipment, etc. are being studied.

Currently, the surveying of the planned site has not yet been carried out, and accurate ground height has not been measured. Since the elevation of the highest water level in the rainy season is 8.35m, the design high water elevation level is set to 8.5 m.

In this connection, the underground station entrances and ventilation towers, etc., shall be planned to be 8.5m above MSL in this plan. The design high water level of 8.5m is used as a virtual design in the Feasibility Study, and when proceeding with the basic design and detailed design, the design high water level should be decided in agreement with the client. After considering the survey results to be implemented in the future, the scale of detailed flood response should be decided.

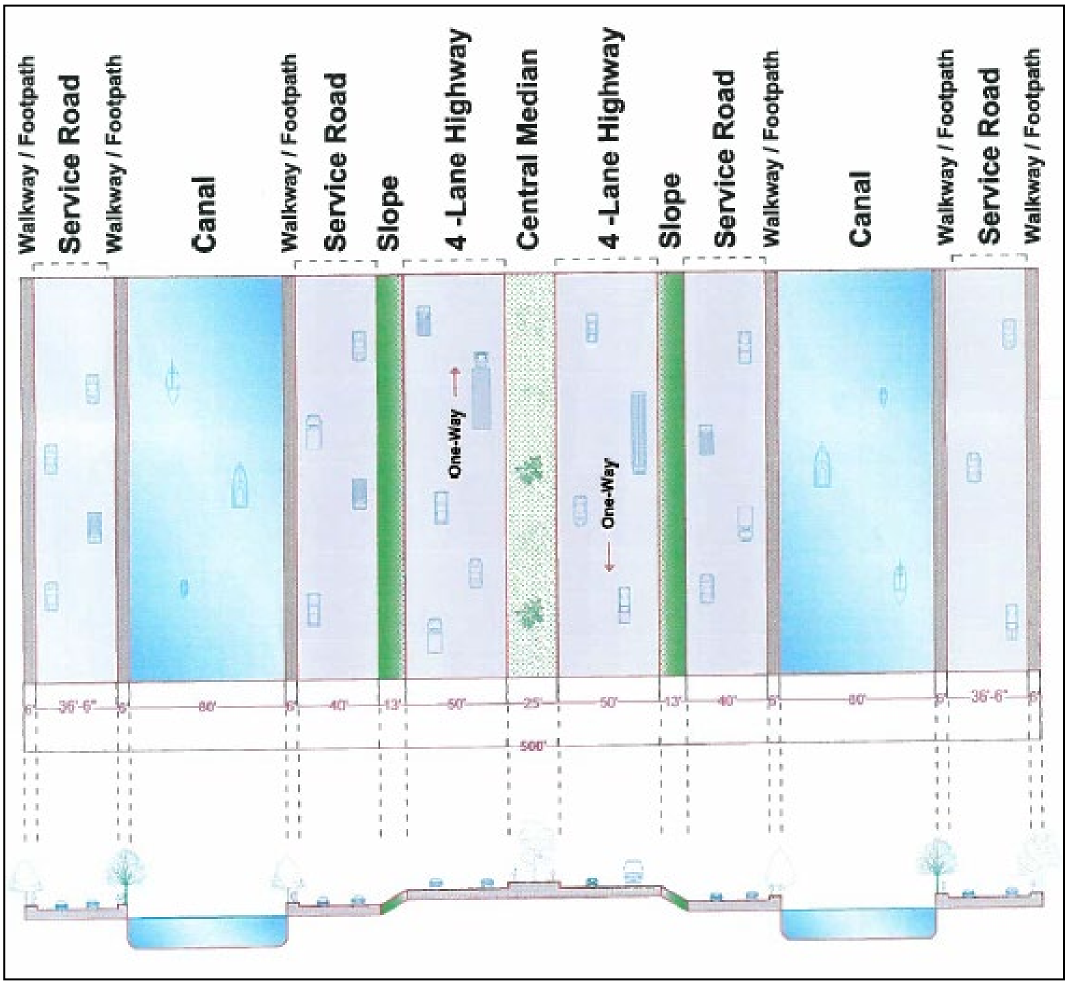
4.5 Civil and Utilities Plan

4.5.1 Elevated Structure

1) Purbachal Road Plan

The Purbachal Road Plan, shown in Figure 4.5.1, is to construct a road whose width in total is 500m and which includes two (2) canals. Currently, although these canals have not been constructed yet, the highway at the centre of the road and the service roads on both sides are under construction. Then, this line will contain six (6) river bridges. There is a big bridge over Balu River, which is a large river of about 100m wide, and the others are relatively small bridges.

Basically, Line 1 will be on the median strip and the stations will also be constructed at the centre of the road. However, Bashundhara Station will not be constructed at the centre but at the north part of the slope because the transition part from the underground to the elevated part will be constructed at the slope on the green. Balu River is planned to be constructed at the northern part of the existing bridge since it is unrealistic to construct a bridge for the metro at the centre of the existing bridge.



Source: DTCA

Figure 4.5.1 Road Plan along the Purbachal Line

The following photos show existing features of Purbachal Road.

General	Bridge
	

Source: JICA Study Team

Figure 4.5.2 Existing Features of Purbachal

2) Selection of Structure for Elevated Track

Table 4.5.1 shows the comparison of structure type for the selection of an adequate structure for Purbachal Road.

Table 4.5.1 Comparison of Structure Types

Item	Elevated Structure	Underground Structure	Banking
Outlook			
Social Environment			
Land Acquisition	If the road shape is smaller than the curve radius, land acquisition for MRT is necessary.	Excluding incidental facilities of station building, ventilation tower, etc. No land acquisition required.	On current routes, the impact of embankment is enormous.
Number of affected households	A lot	Least	Quite a lot
Width of Land	Width of the site at completion is around 2.5mm between stations.	Basically it is unnecessary in the inter-station area.	Width of the site at completion is about 16m between stations.
Natural Environment			
Protected Area	There are no protected areas along the railroad tracks. There is a river (Balu River) designated as ECA, and it is necessary to prevent further deterioration of the environment.	There are no protected areas along the railroad tracks. Although there is a river (Balu River) designated as ECA, there is no influence due to the underground structure.	There are no protected areas along the railroad tracks. There is a river (Balu River) designated as ECA, and it is necessary to prevent further deterioration of the environment.
Biodiversity	Nature such as vegetation remains in the Purbachal District, but it is presumed that there is no big influence.	Nature such as vegetation remains in the Purbachal District, but due to the underground structure, the influence is estimated to be very small.	Nature such as vegetation remains in the Purbachal District, but it is presumed that there is no big influence. Because of the embankment structure, there is a possibility that the movement of animals may be obstructed.
Risk of flood	No special measures are necessary.	• An emergency drainage system (pump) is placed. • Flood gates required.	• There is a possibility that the embankment will stop the drainage. Additional drains are needed to minimize floods.
Pollution Control			
Noise（Vehicles outside）	Noises are generated along the railroad tracks. However, it can be mitigated by installing soundproof walls.	There is no noise along the railway.	Noises are generated along the railroad tracks. However, it can be mitigated by installing soundproof walls.
Noise（Vehicles inside）	Small	Very big	Small
Air Pollution	There is concern about the impact of exhaust and dust of construction machinery during construction.	The impact of exhaust and dust of the construction machinery at construction is the smallest.	The impact of exhaust gas and dust of the construction machinery during construction gives much cause for concern.
Water pollution	There is a river (Balu River) designated as ECA, and it is necessary to prevent further deterioration of the environment.	There is a possibility that groundwater will be affected during construction. Although there is a river (Balu River) designated as ECA, there is no impact due to the underground structure.	There is a river (Balu River) designated as ECA, and it is necessary to prevent further deterioration of the environment. It is necessary to pay attention to the generation of turbid water from the embankment.

Item	Elevated Structure	Underground Structure	Banking
Ground subsidence	No ground subsidence occurs.	There is a possibility of ground level subsidence during tunnel excavation.	There is a possibility of ground subsidence in soft ground.
Construction Period	Shorter than underground structure	The longest	Can be shortened if ground improvement is not required.
Technical aspect			
Construction Cost	Inexpensive compared to the underground structure	Extremely expensive	Cheaper than the elevated structure
Operation/Maintenance	Easy access and easy maintenance	• High maintenance cost. • Periodic inspections should be conducted, in particular, leakage investigations that cause electrocution.	Easy access
Disaster Prevention	• Relatively safe • Easier countermeasures than underground structure	Fire in the tunnel will be a major disaster.	• Relatively safe • Easier countermeasures than underground structure
Earthquake Resistance	The structure is designed in consideration of the seismic load.	Subsurface structures are difficult to be affected by earthquakes, but underground structures are designed in consideration of the seismic load.	The embankment structure is designed in consideration of the seismic load.
Scenery from the window	Good	Not Good	Good
Landscape	The shape of the structure must be designed in consideration of the landscape	There is no influence on the landscape.	The shape of the structure must be designed in consideration of the landscape
Physical Condition	It is necessary to build structure to avoid bridges over the Balu River.	It is necessary to make it linear so as to avoid the piles of the six existing bridges.	Even if it is reinforced embankment, the impact on the road is serious. In addition, underpass is necessary in order not to provide a railroad crossing.
Overall Assessment	Evaluated comprehensively, it is the most suitable structure.	There is no merit corresponding to cost.	The impact on the road is serious, and merit is little compared with the elevated structure.

Source: JICA Study Team

As a result of comparison study, JST recommends an Elevated Track on the Viaducts.

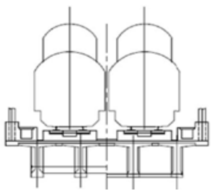
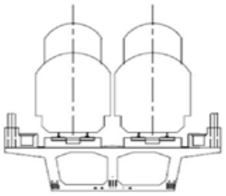
3) Selection of superstructure

According to the recommendation mentioned in the previous section, a detailed structural study of superstructures was done as follows.

(1) Standard Girder

The Dhaka MRT Line 6 adopted the PC box girder as the standard superstructure instead of PC-I section girder in consideration of its workability in an urban area, short construction period and high rigidity. Table 4.5.2 shows the comparison between PC-T girder and PC box girder. The PC one shell type box girder was adopted in MRT Line 6 because of lighter weight and easy maintenance. Further, optimum length of Girder was 30m as a result of comparison study among several lengths and their construction costs. In consideration of the effect on road traffic, JST adopted the same type of Girder on the Purbachal Line.

Table 4.5.2 Comparison between PCT Girder and PC Box Girder

	Type A : PC-T Girder	**Type B : PC-Box Girder**
Section		
Construction Cost	Type A is more costly than Type B	
Construction Method	• Pre-fabricate in the Production Yard • Pre-stress in the Production Yard • No need to support Girder • Ordinary truck-crane may be available • At site cast concrete to lateral girder	• Pre-fabricate in the Production Yard • Pre-stress at site to erect • Temporary support may be required • Easy erection • Minimum site concrete casting work is required • Combination Girders by using Epoxy
Time to Erect	• There is no difference because the pre-casting /segment girder is produced in another production yard. • Type A. There is some concrete casting work at the site. • Type B. Pre-stressing work at site is required.	
Structure Analysis	• Weakness against torsion, curved girder cannot be recommended. • In order to spread load, lateral girder shall be provided. • A base plate is simply supported and live load is not completely continuity. • Each beam needs bearings.	• Enough strength against torsion, curved Girder possible. • No lateral girder is required • Since live load can cause twist, the load should be dispersed. • Though the dead load is light, the bending moment can be disposed by pre-stressing.
Maintenance	• Both type Girders require similar input • Type A Girder requires more “shoes”, therefore, maintenance of shoes increases.	
Appearance	Possibility of spoiling scenic beauty	Less impact on scenic beauty
Evaluation	There are many curved sections in the alignment, Type B may be recommended.	

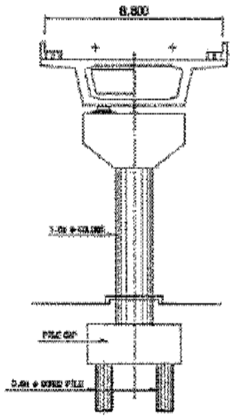
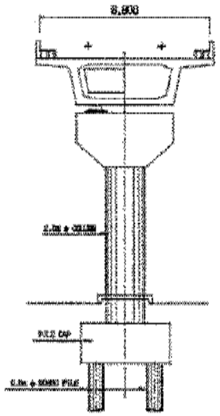
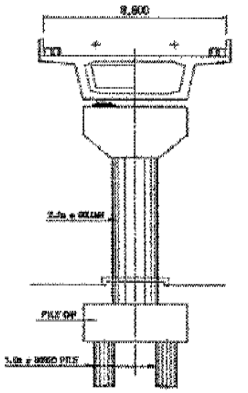
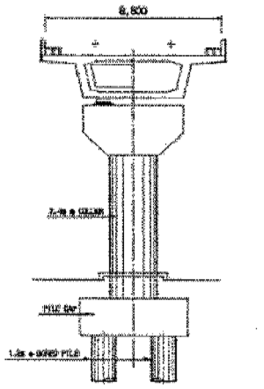
Source: NKDM

4) Selection of Sub-structure

As discussed above, although viaducts shall be constructed on the Purbachal Road as much as possible, there are some sections where viaducts cannot be placed in the road centre dividers. In that case, the piers will be provided in the green area located between the centre divider and the slope as shown Figure 4.5.3.

Table 4.5.3 shows comparison of girders, brought from the Design Report for Dhaka MRT Line 6 and recommends 30m span length substructure arrangement. Detailed study shall be made in the Engineering Study after detailed topo survey. In principal 30m or 25m span length girders are recommended as standard span length.

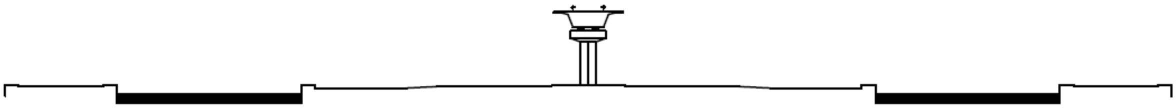
Table 4.5.3 Comparison Among Girders

		25m	30m	35m	40m
Cross Section					
Pile Cap (Φ)		Φ=1.8(m)	Φ=2.0(m)	Φ=2.2(m)	Φ=2.4(m)
Pile(Φ) Required Nos.(n)		Φ=800(mm), n=4	Φ=800(mm), n=4	Φ=1000(mm), n=4	Φ=1200(mm), n=4
Result of Analysis (R/Ra))		R/Ra=75%	R/Ra=86%	R/Ra=83%	R/Ra=70%
Cost	Item	Ratio			
	Super Structure	0.66	0.70	0.76	0.78
	Sub-Structure	0.35	0.30	0.35	0.42
	Total	1.01	1.00	1.11	1.20
Evaluation		As a result of Analysis a 30m Span length shall be recommended.			
Conclusion			◎		

Note) As a noise protection wall, a 1.5m wall is planned to be installed for Line 5 during implementation and it is also planned for Line 5. However, a 1.5m wall is unnecessary for Line 1 since RAJUK Road is 500 feet wide and far from residences. A detail study is needed at the design stage.

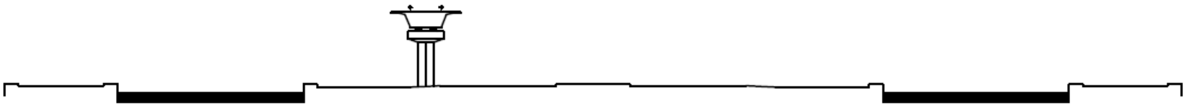
Source: NKDM

As pile foundation, it is reasonable to consider the supporting layer of 15m～30m under ground level. At the time of construction, cast-in pile is recommended taking into consideration noise and vibration from equipment.



Source: JICA Study Team

Figure 4.5.3 Between Stations Standard Cross Section (Centre Divider)



Source: JICA Study Team

Figure 4.5.4 Typical Viaduct Provided in the Green Space

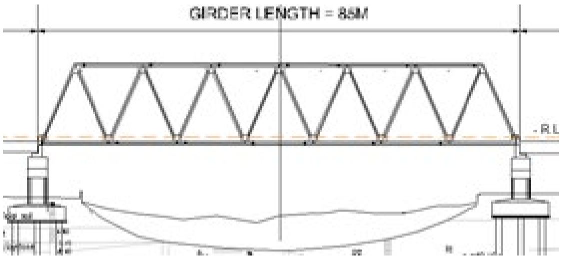
(1) Balu River Bridge

There is an existing Road Bridge over Balu River as shown Figure 4.5.5. It consists of simple girders with three (3) spans of 40m long each. Ships are confirmed to sail past this point. Ships usually pass in the centre where some 40m clearance above high water is available. Also, the western side has enough space to pass. The Study Team recommended an 80m span at the centre and a truss girder (see Figure 4.5.6).

Northern Side	Southern side
	

Source: JICA Study Team

Figure 4.5.5 Balu River Highway Bridge



Source: JICA Study Team

Figure 4.5.6 MRT Line 1 Balu River Bridge

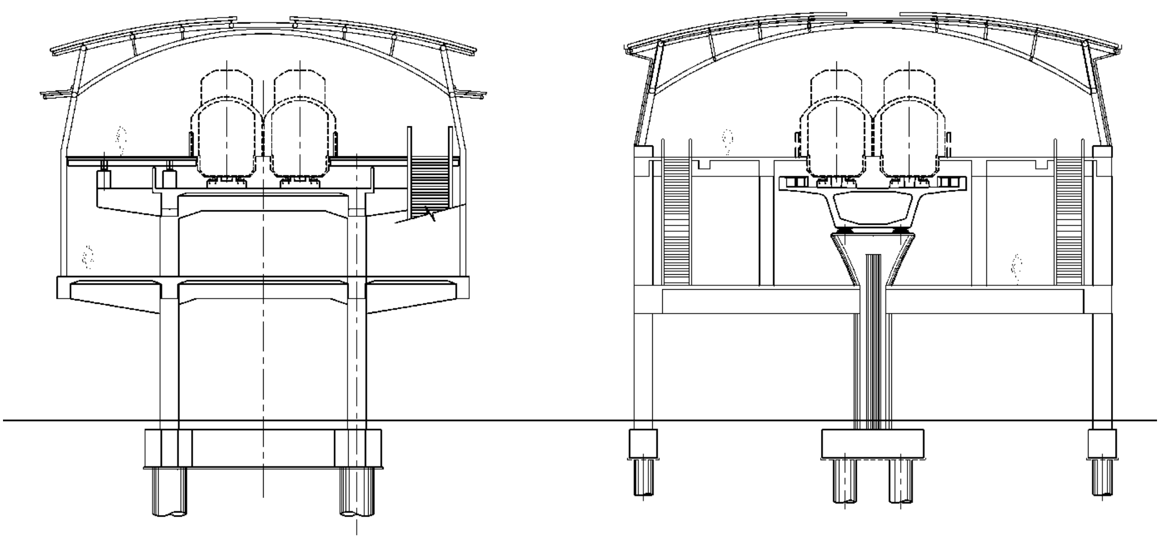
(2) Other Bridges

At present, six (6) bridges are needed for MRT Line 1 on the Purbachal Line including Balu River Bridge. Except for the Balu River Bridge others are relatively shorter, so it is possible to adopt a standard type PC Girder.

5) Structure for Elevated Station

In general, the station structures are of two types: a Rigid Frame Structure and a Pier + Girder Structure. JST selected the latter because of workability, economic reason, and impact to existing road traffic.

With regard to platform type (discussed in Chapter 3), JST adopts side platforms for whole elevated section.



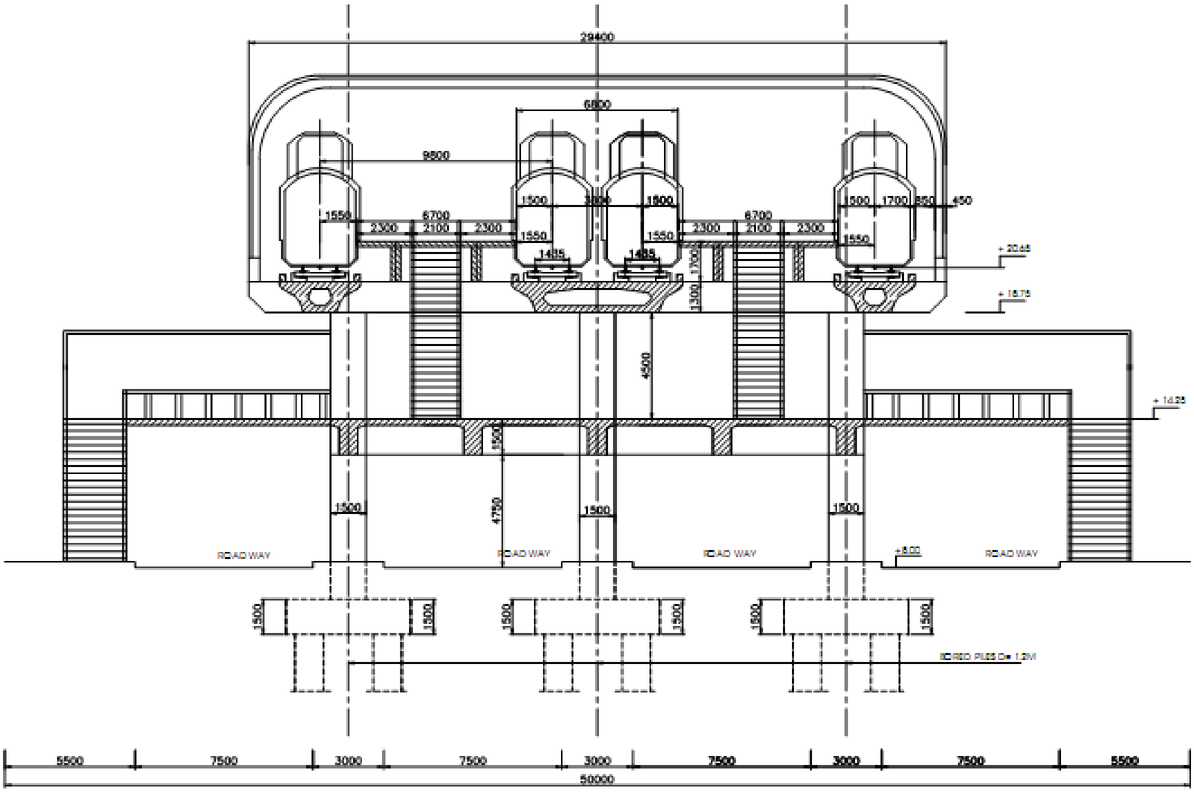
Rigid Frame Structure

Pier + Girder Structure

Source: JICA Study Team

Figure 4.5.7 Structural Cross Sections of Station

With regard structure of Purbachal Terminal Station, which contains two platforms and four tracks, is shown by Figure 4.5.8 Imaged Structure Cross Section of Purbachal Terminal Station.



Source: OCG Archives Hanoi Line 2 Basic Design Report

Figure 4.5.8 Purbachal Terminal Station

4.5.2 Underground Structure

1) Tunneling Plan

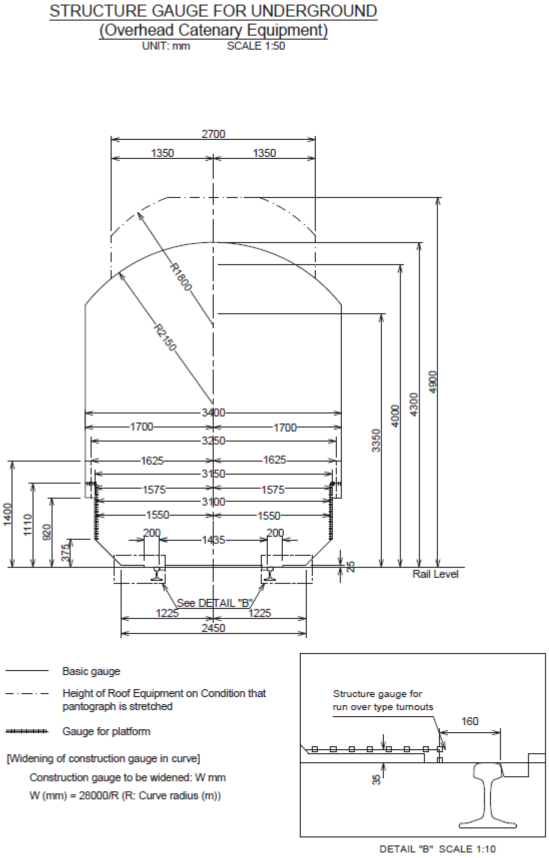
(1) Tunnelling Method

In general, tunnel construction is implemented on a major road on which a certain amount of vehicles run. Not only JST but also many civil experts thought the tunnel boring machine (TBM) method is the most adequate tunneling method to keep resettlement to a minimum. Tunneling by NATM method is one of the possible methods, but the soil condition of the route does not allow use of this method.

Between stations, there are two types of tunneling: one is two tunnels with two single tracks and another is one tunnel containing double tracks. In comparing these two types, the face of tunnel of single track-double tunnel is 77m^2 while the latter is 79 m^2. As a result, JST recommends two tunnels with two single tracks type.

(2) Construction Gauge of Underground section

The following figure is adopted by MRT Line 6 as recommended by STRASYA (Standard Urban Railway System for Asia) and applied for the Jakarta MRT, Ho Chi Minh Line 1, and Hanoi Line 2. The Dhaka MRT Line 1 shall use the same.



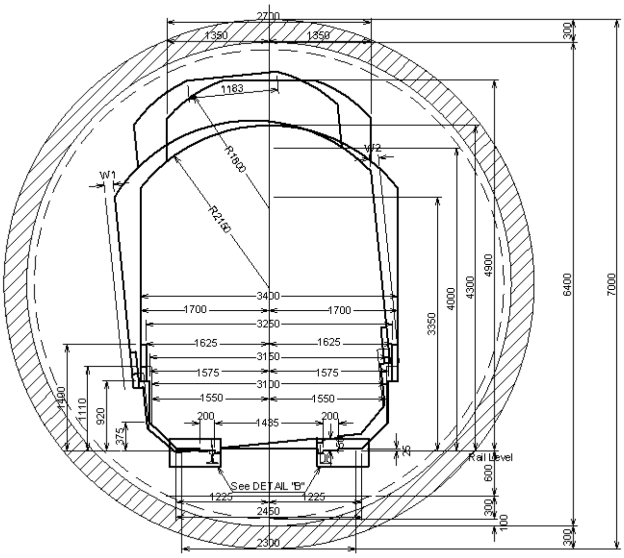
Source: STRASYA

Figure 4.5.9 Construction Gauge Recommended by STRASYA

(3) Cross Section of Tunnel

a. Cross Section of Tunnel

The tunnel cross section design shall be made based on the Rolling Stock Envelopment, Track Structure, Drainage System, Management & Maintenance Staff Passageway and space for Facilities. In addition to this, construction allowance shall be taken into account. The distance from Rail Level (RL) to the Formation Level (FL: Level at surface of the Invert Concrete) is 600mm. The distance from FL to face of Shield Segment is 300mm. Furthermore, the gap between the Construction Gauge and Rolling Stock Gauge is 100mm. As a result, the radius of tunnel becomes 6,400mm. In this FS, facilities put into tunnel are still rough estimates; therefore, JST added some allowance and the tunnel radius becomes 7,000mm. The following Figure 4.5.10 shows the cross section.



W1 ; Deviation towards the inside of curve
W2 ; Deviation towards the outside of curve

Source: JICA Study Team

Figure 4.5.10 Cross Section of Tunnel

b. Segment

There are several types of segments, such as RC segment, composition segment, ductile segment, and steel segment. According to the site condition, the designer makes the decision which segment type shall be adopted. As a normal practice, considering the economical advantage, RC segment is widely used. But under special conditions like under buildings, which is a unique condition, sometimes the ductile segment is utilized. In MRT Line 1, at Malibagh, tunnel boring through the station and later segments shall be discontinued to connect the Station Box and tunnel. JST considered the segment made of ductile iron or steel as suitable for this works.

In general, the depth of RC segment shall be 4% of tunnel radius, outside of segment. According to this practice,

$$t \geqq (6400+2t) \times 0.04 \quad \rightarrow t \geqq 280\text{mm}$$

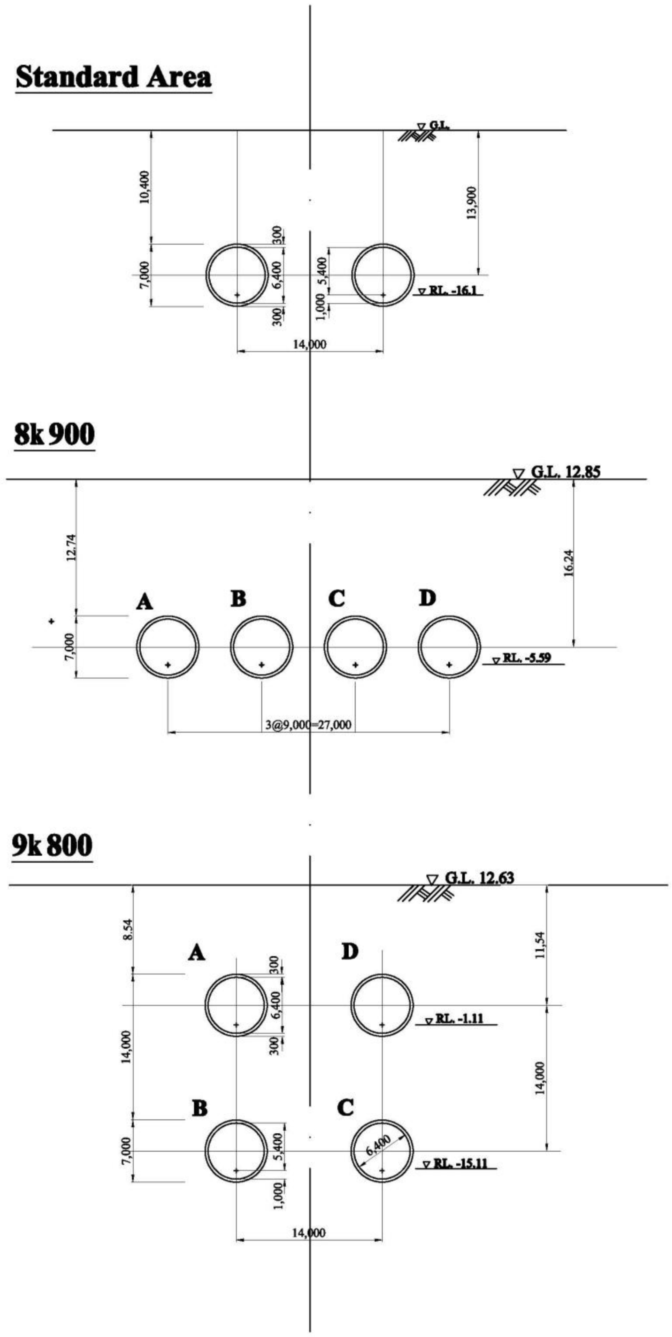
Further allowance was added and t=300mm was found.

Based on this idea, segment external radius is D= 7.0m.

With regard the length of segment ring, according to normal practice in Japan, L=1.2m is adopted.

c. Distance between TBMs

Distance between TBMs shall be kept at 1D (7m) as normal practice.



Source: JICA Study Team

Figure 4.5.11 TBM Arrangement

2) Underground Station Structure Plan

The cut and cover method is commonly used for underground station construction because of economic and physical reasons. In the construction of MRT Line 1, the underground station shall be designed by the cut and cover method.

(1) Depth of soil cover

There are normal lifeline utilities such as water, sewage, gas, electrical facilities, and phone cables laid under the road. In order to keep such spaces, a station box will be constructed 3m deep from ground level. When MRT Underground construction takes place, all such utilities shall be relocated safely and properly. The who, when, how, financial responsibility, permission from related authorities, etc. of utility diversion in Detail Engineering Design Stage shall be discussed with utility owners.

(2) Underground Structure Plan

a. Typical Station Structure

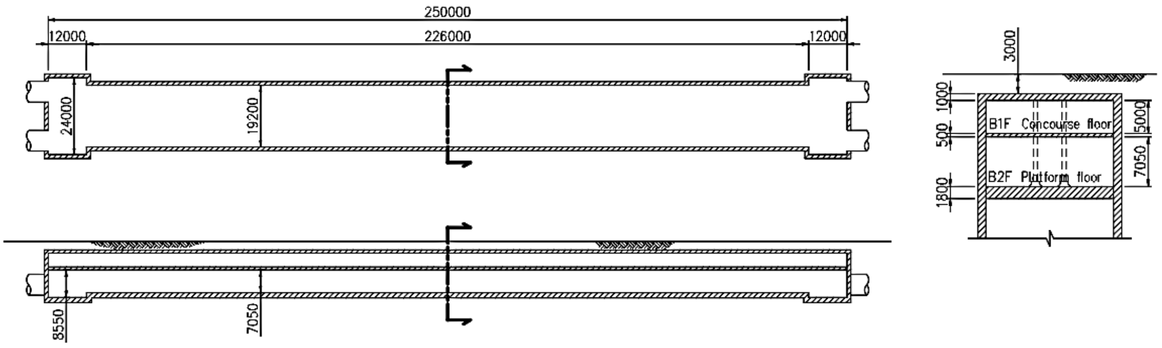
As far as underground stations are concerned, the storage of train operation facilities such as signal & telecommunication equipment, air-conditioning equipment, cooling facility, electrical distribution facility, fans, and station operation equipment, a 2-layer station is economical and reasonable for future operation. From previous experience in Japan and other Asian countries, a 19m wide and 250m long station box is enough for storage of such equipment.

B2 floor level shall be used as platform level. As discussed in Chapter 3, an island type platform shall be provided with standard width of 11m. Outside of the construction gauge, a width of 850mm is kept for advertisement boards, several stations and train operation service. A width of 19.2m is the station standard. With regard to station length, 10m is added to 160m train length.

Taking seismic design into consideration, a 2-column cross section type station is recommended, and at the end of station, shield machine launching shaft will be provided.

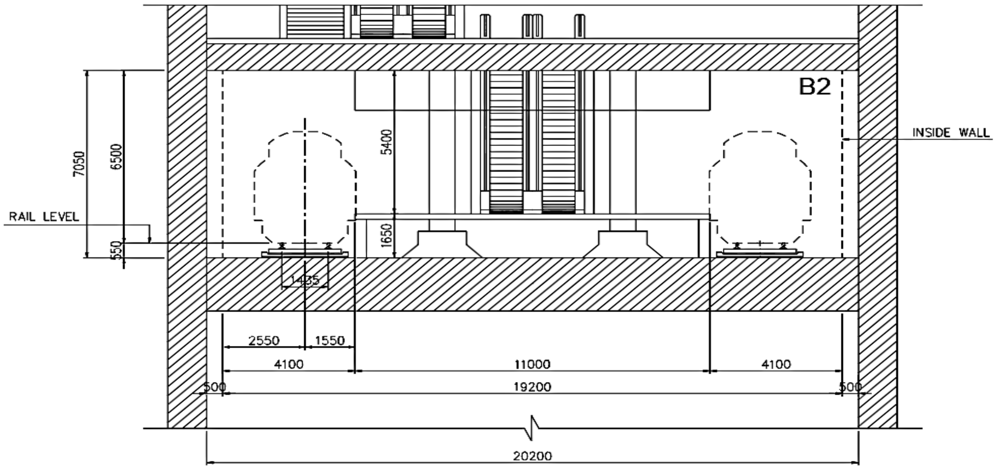
All stations contain an access/exit, ventilation shaft, and a pumping system. In order to facilitate equipment use, the effective ceiling height of 5m is provided for B1 Concourse level. Number of access/exit staircases is 4.

Figure 4.5.12 shows a standard underground plan and cross section and Figure 4.5.13 shows a standard station platform with 2 columns.



Source： JICA Study Team

Figure 4.5.12 Standard Underground Plan and Cross Section



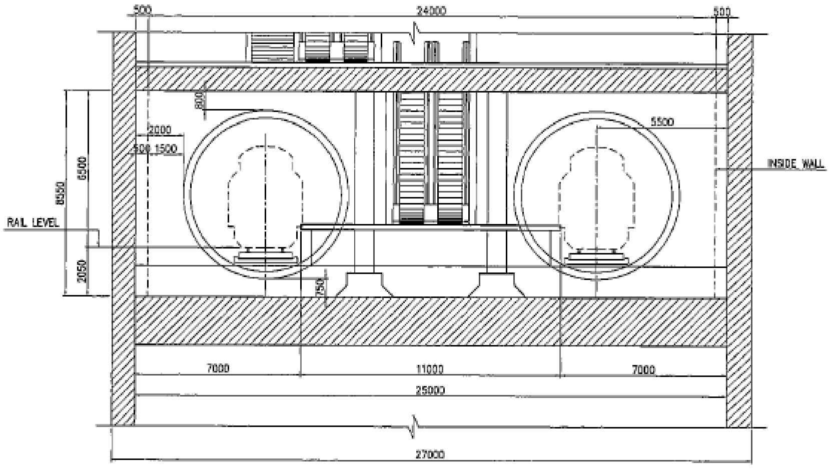
Source: JICA Study Team

Figure 4.5.13 Standard Station Platform with 2 Columns

b. Form at the End of Station (Used as TBM Launching Shaft)

The station box will be widened at the end for the TBM launching shaft. At the time TBM launches or arrives, the inner wall is not constructed yet. The distance between diaphragm wall and TBM shall be 2,000mm as shown Figure 4.5.14. Furthermore, as shown in Figure 4.5.15, for dispatch of equipment, 750mm shall be taken into account. At present, the tentative distance between outside of TBM and centre of TBM is assumed at 7m, but skin plate thickness, gap between segment and skin plate are omitted. In the detailed study, such factors shall be considered. It may be possible to reduce the thickness of segment based on the actual geotechnical condition.

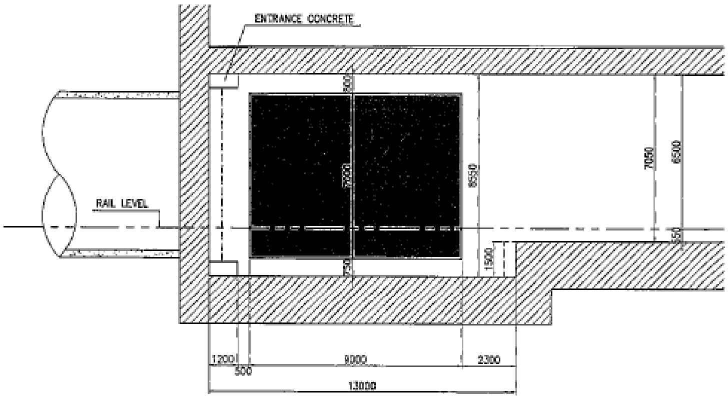
Regarding longitudinal direction, the length of launching shaft is assumed at 13m taking into account TBM L=9000mm, temporary facilities of 2300mm and allowance of 500mm. After launching or arrival of TBMs, the shaft shall be set up and the wall then becomes L=12m.



Source: JICA Study Team

Figure 4.5.14 Station end Cross Section

The following figure shows longitudinal cross section.



Source: JICA Study Team

Figure 4.5.15 Station End Longitudinal Cross Section

(3) Special Type of Underground Station

Due to narrow space at Malibagh, the standard type of underground structure is not feasible. In addition, in front of Future Park Amusement, the station shall have two platforms for the train operation. But the narrow space makes it difficult to construct two platforms and four tracks in the same layer, unless land is added to widen the space. JST makes plans for 3-layer station boxes.

The standard station length is L=250m (outside of walls), but Rampura Station has a crossing for emergencies where the TBM method shall be terminated in front of station boxes with some distance that are built by cut and cover method. In comparison with the space required for a station box, such space for track crossing is small, and the JST is concerned about D-Wall's cost performance. In the Detailed Design stage, Soil Mixed Wall (SMW) or Sheet Piling shall be studied.

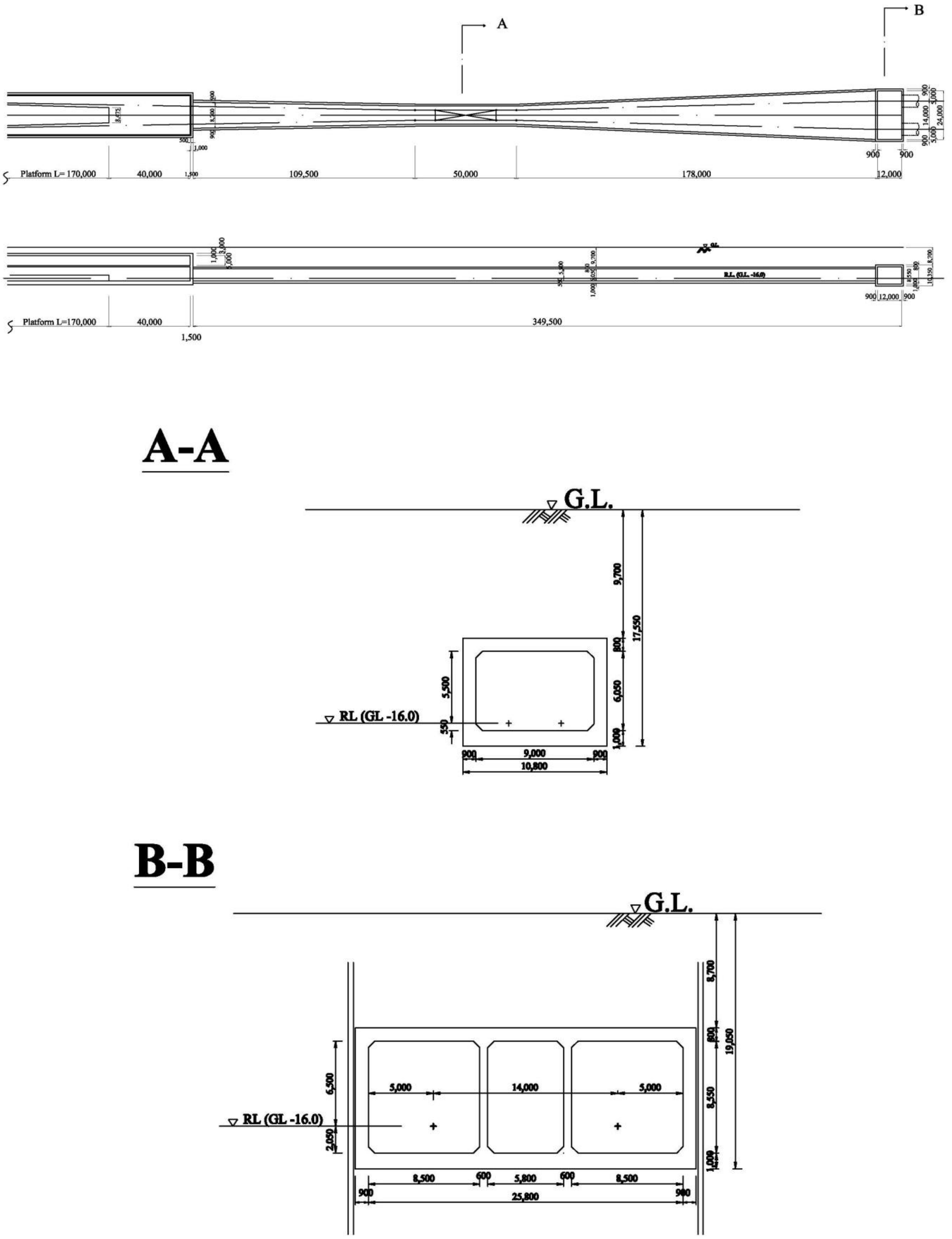
(4) Structure Plan for Each Underground Station

a. Kamalapur Station (Standard + Open cut extended)

This Station shall be the project starting point, connecting with BR and even MRT Line 6. In the future, MRT Line 1 will be extended toward Jhilmil.

In general, it is preferred to provide two platforms and four tracks at the terminal station for easy train operation; however, a station with one platform and two tracks is unavoidable due to land issues. Thus, room for expansion is to be taken into consideration when deciding on a connection through underground pass to BR and future commercial development.

In FS, JST tentatively planned a standard underground station measuring 20m wide and 250m long. As at the Airport end, a scissors crossing will be provided. About 85m from outside of 250m station box will be constructed for TBM launching shaft. The extended box culvert contains intermediate columns. The cut and cover method will be used to construct a 250m Station Box with diaphragm wall, while the extended box culvert and TBM launching shafts shall be built by cut and cover method with SMW or sheet piling.

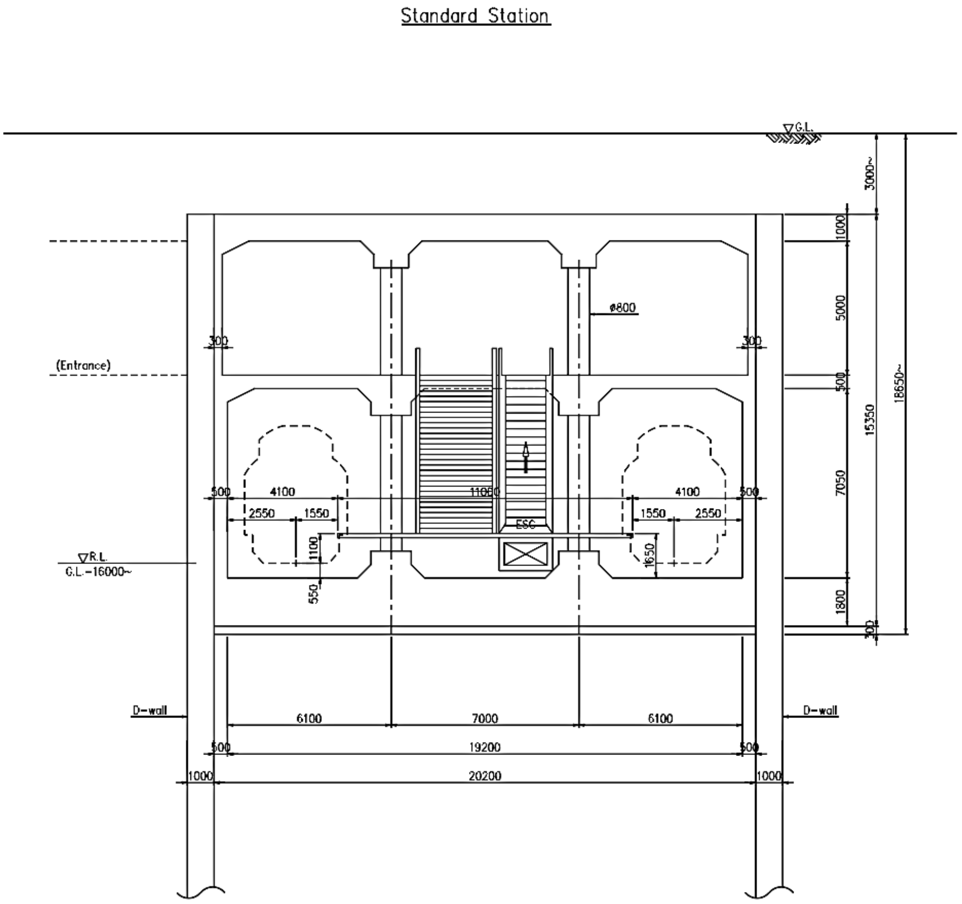


Source: JICA Study Team

Figure 4.5.16 Kamalapur Station

b. Rajarbagh Station (Standard-type Underground Station)

Since there are big spaces owned by the Police Authority, a station will be provided in the Outer Circle Road, on the south side of the Police line.

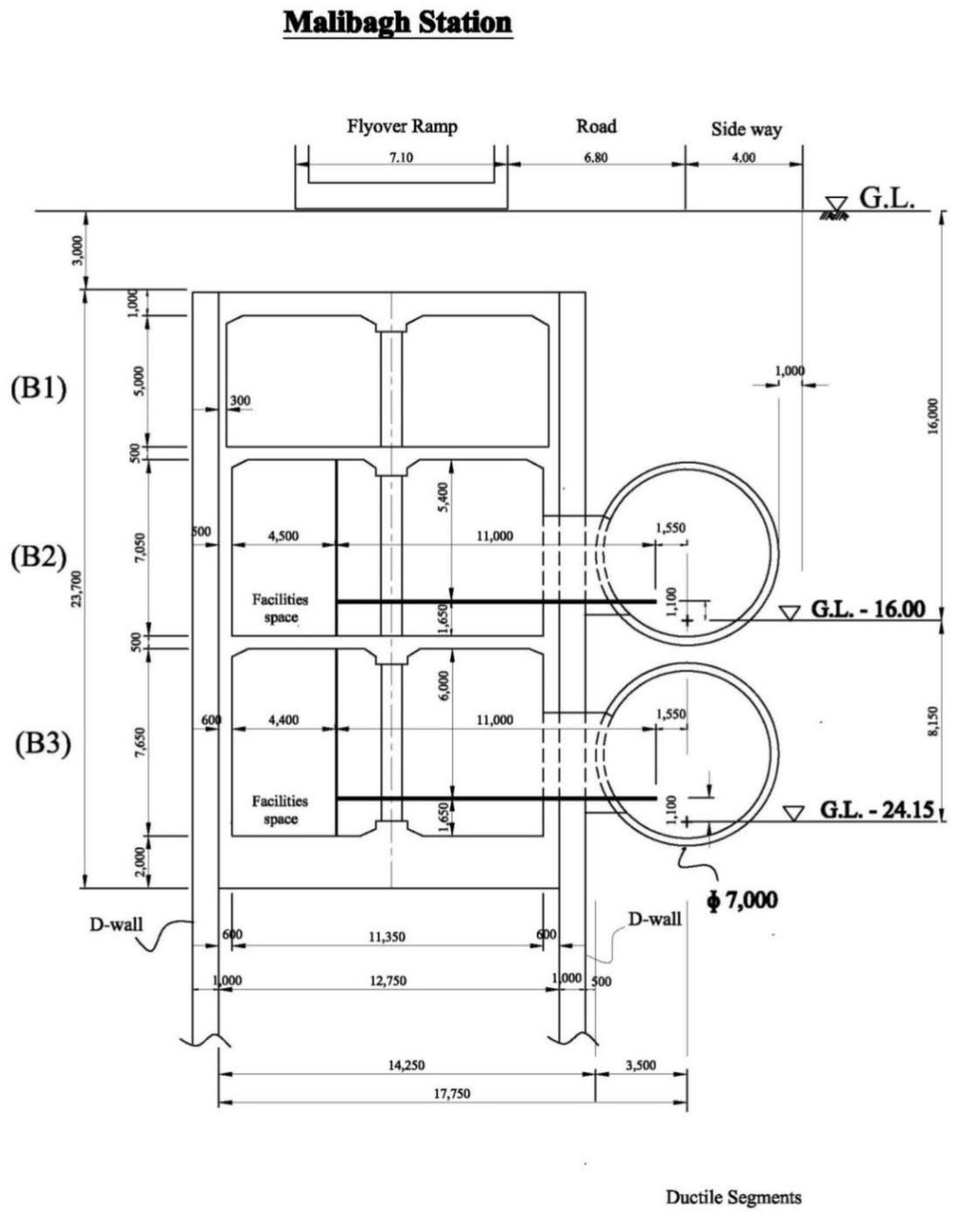


Source: JICA Study Team

Figure 4.5.17 Standard Underground Station

c. Malibagh Station (Special Station)

Ramps for the elevated road are located south of this station. The station will be constructed northward 50m from the end of the ramps. Since land for exits or ventilation towers cannot be found there, purchasing some buildings and land will be necessary. As enough land for the shielded tunnel cannot be prepared, the tunnels will be constructed with two levels on the east side of the shaft, and a station structure is constructed by connecting with the narrow width station and the tunnel of two levels in the underground. The length of the station will be longer than that of the platform to create a space for station facilities. Some parts of the segments will be removed to connect with the station in the underground. In that range, ductile cast iron segments will be used (see figure below).



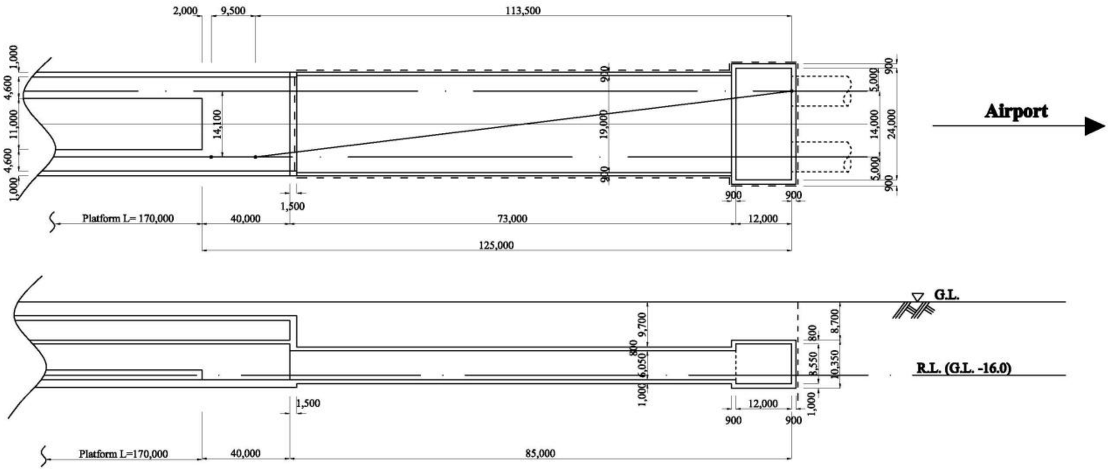
Source: JICA Study Team

Figure 4.5.18 Cross Section of Malibagh Station

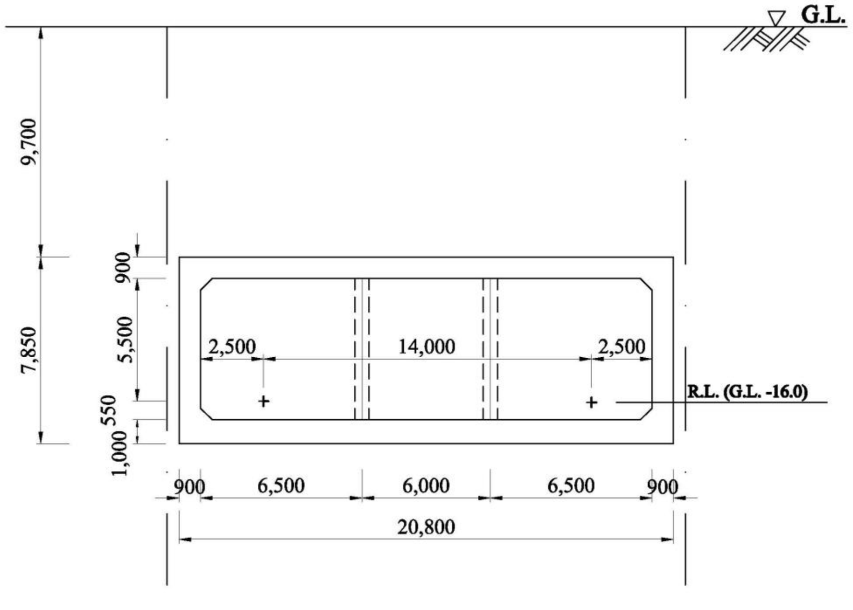
d. Rampura Station (Standard＋Extended Open Cut)

In consideration of the location of Malibagh Station, an interval of about 1km shall be prepared. Since a crossover at the airport side is planned, the station shaft will be extended about 85m. The extension section consists of a box culvert with pillars.

At the site, land for exits cannot be found, so the exits can be set at the buildings. North west of the station, there is about 20m×17m of land available and the ventilation tower will be set there.



A-A Section



Source: JICA Study Team

Figure 4.5.19 Cross Section of Rampura Station

e. HatirJheel Station (Standard-type Underground Station)

There is available land for the ventilation tower southwest of the station. Piles can be driven in the storage reservoir and the land can be used for material storage or an office by installing cover piles.

At the north of the Rampura Bridge a standard type of underground shall be provided as Hatir Jheel Station. An entrance shall be provided on the east side of station box. At the eastern side of this station there is DCC which has wide land, which at present is used as a material stock yard for the construction of a U-turn bridge. Now the U-turn bridge construction is close to completion. DTCA proposed to JST using the land for a Ventilation Tower, Cooling Tower and sub-station, and JST confirmed that there is enough space for the above structures and temporary construction material stock yard.

f. Badda Station (Standard-type Underground Station)

This station will have a standard-type underground Station. Land on the east and west side of the station can be prepared for the ventilation tower.

g. Uttar Badda Station (Standard-type Underground Station)

This station will also have a standard-type underground station. Land at the west of the station can be acquired for the ventilation tower, but it is necessary to study land for entrance/exits.

h. Notun Bazar Station (Special Underground Station)

The planned station has a very unique structure in that four TBMs are dispatched from there.

There are two platforms and four lines. The two lines on the inside reach the third floor of the Future Park station and go to the Airport Station. Next, two lines outside reach at the third floor of the Future Park Station, pass by the shaft, turn to the east, and go up on ground level in front of the Bashundhara Station. Then, by way of the elevated lines, these lines will be connected to Purbachal Terminal Station.

Since scissors crossovers are located at the front and end of the station, the shaft length of the station is 775m, which is longer than that of the general station (see Figure 4.5.22). The 775m station box may be built with SMW method to reduce the duration of construction.

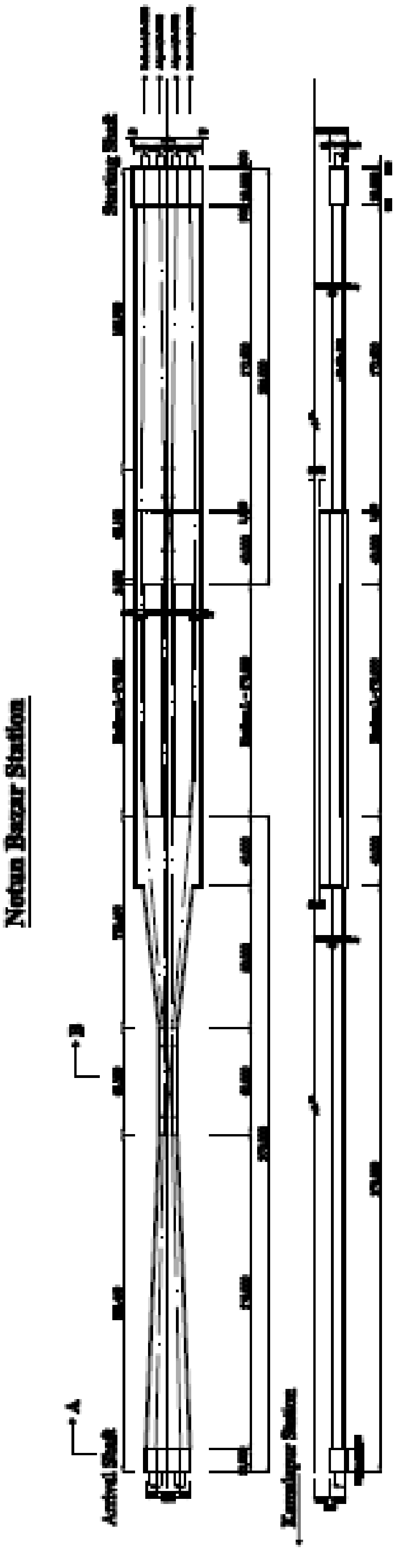
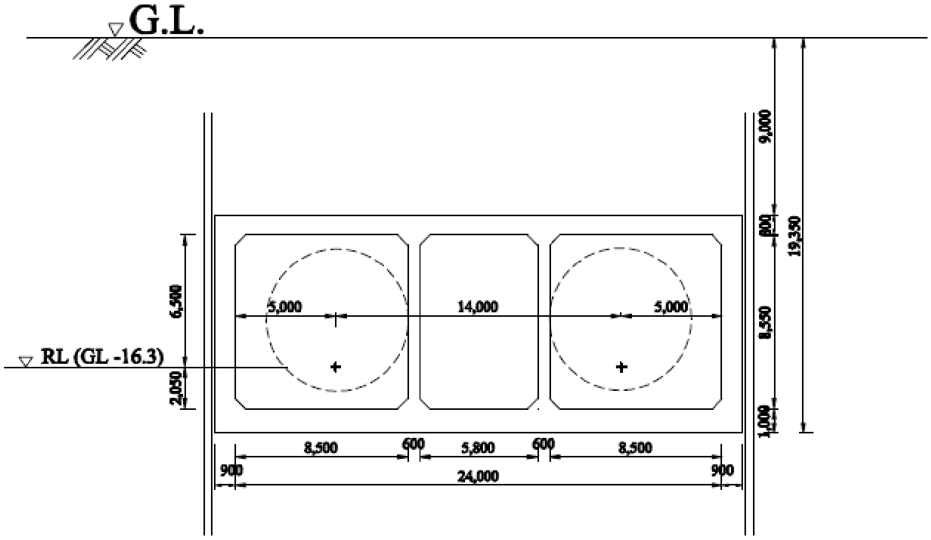


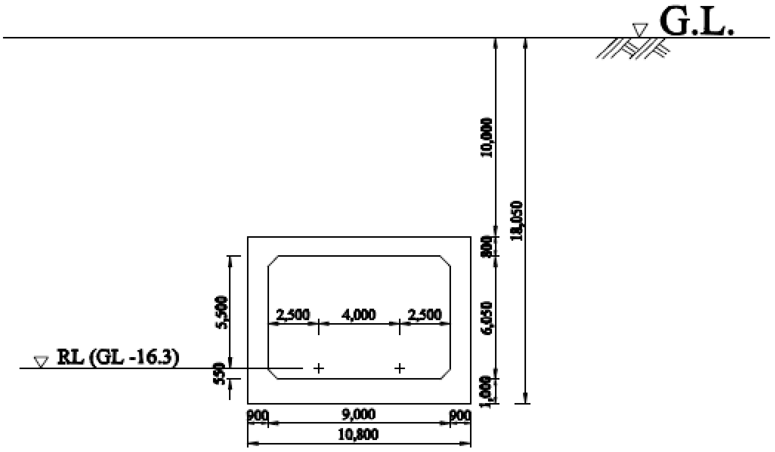
Figure 4.5.20 Notun Bazar Station Plan and Cross Sections

Source: JICA Study Team

A-A Section



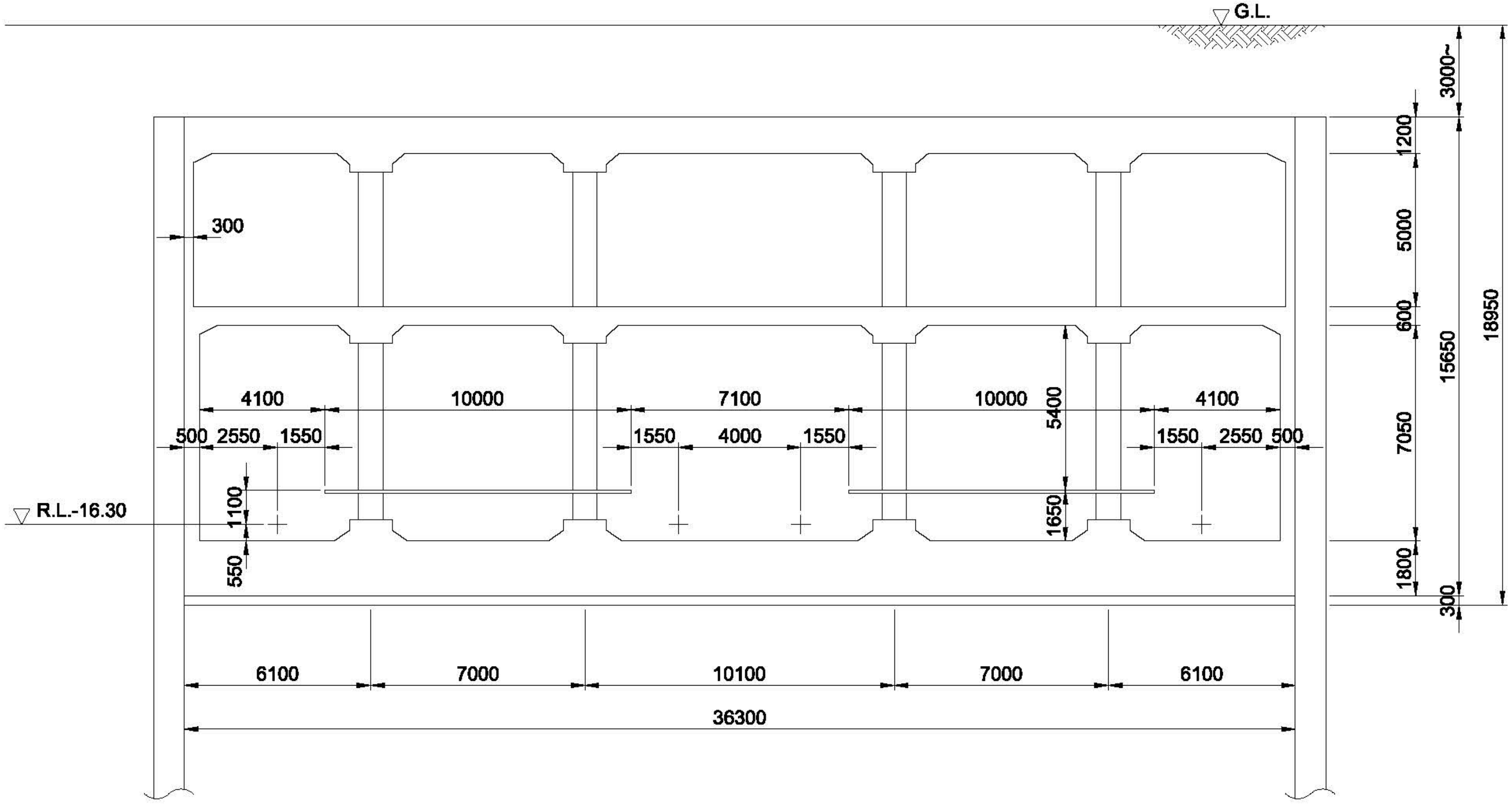
B-B Section



Source: JICA Study Team

Figure 4.5.21 Notun Bazar Station Plan and Cross Sections (A-A Section, B-B Section)

C-C Section

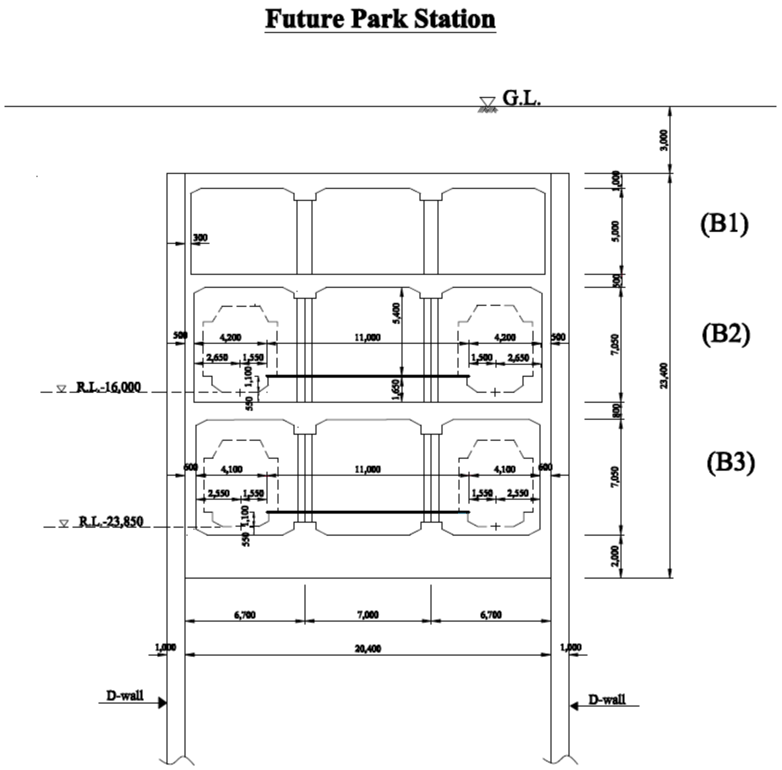


Source: JICA Study Team

Figure 4.5.22 Notun Bazar Station Plan and Cross Sections (C-C Section)

i. Future Park Station（Special Type Underground）

Future Park station can accommodate two floors and two lines operating in four shielded tunnels from Notun Bazar Station; the upper two lines (B2F) will be Purbachal Lines and the lower two lines (B3F) will be Airport Lines (see Figure 4.5.23).



Source: JICA Study Team

Figure 4.5.23 Cross Section of Future Park Station

j. Khilkhet Station (Standard-type Underground Station)

The shielded tunnel from Future Park Station goes through an area where elevated roads of DEE are randomly located. The station will be constructed at the east side of the main roads and at the west side of the Bangladesh Railway, so high level techniques of control and management of TBMs are required.

k. Airport Terminal 3 Station (Standard -type Underground Station)

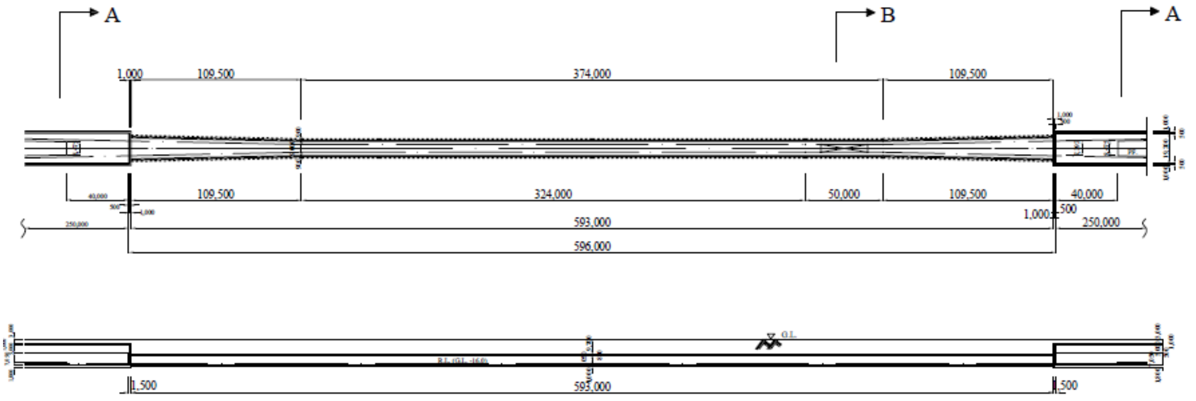
The station will be constructed on the east side of the main roads and an underpass shall be constructed to the west side of them. Although there is another plan for BRT (bus routes), it does not have to be considered now since the project is still under review including its necessity.

At present, the design of a new airport and Airport Building Terminal 3 are planned. If underground stations will be set under the new airport on the west side of the main road, this will make it convenient for passengers heading to the airport. However as a result of several discussions, it was decided to locate the MRT Line 1 Airport Terminal 3 station at the eastern side of the New Airport Road. The connection between MRT Station with the Airport Terminal 3 shall be facilitated by such equipment as people mover. With regard to the southern part of BRT Line 3, the World Bank (WB) is still to clarify the project validity.

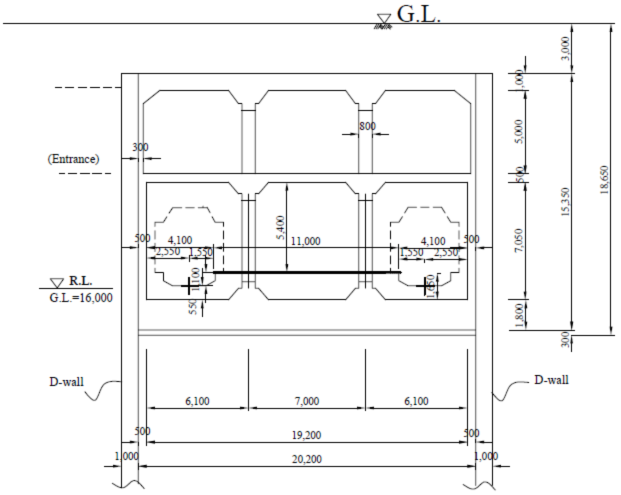
I. Airport Station (Standard-type Underground Station with draw-op track)

Since the range for the station shaft becomes larger due to the scissors crossover at the south side of the station, the area for open cut will be connected between the stations because the open cut interval is 260m and results in small distance between stations. The extension range will be constructed by the open cut method with steel sheet piles, and the structure will be constructed as a box culvert. In addition, the northern part of the station will be extended and constructed by the open cut method with box culverts.

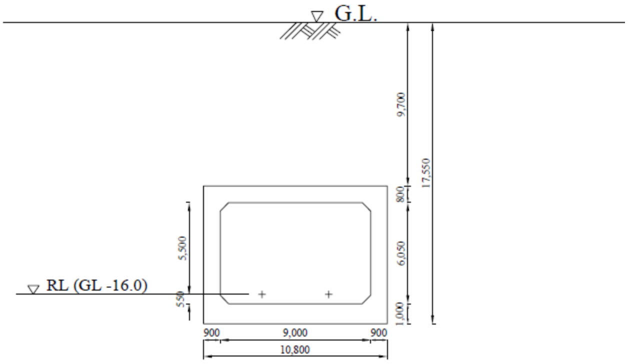
If the Airport Terminal 3 Station is shifted to the west side, it will be close to the airport on the west side.



A-A Section



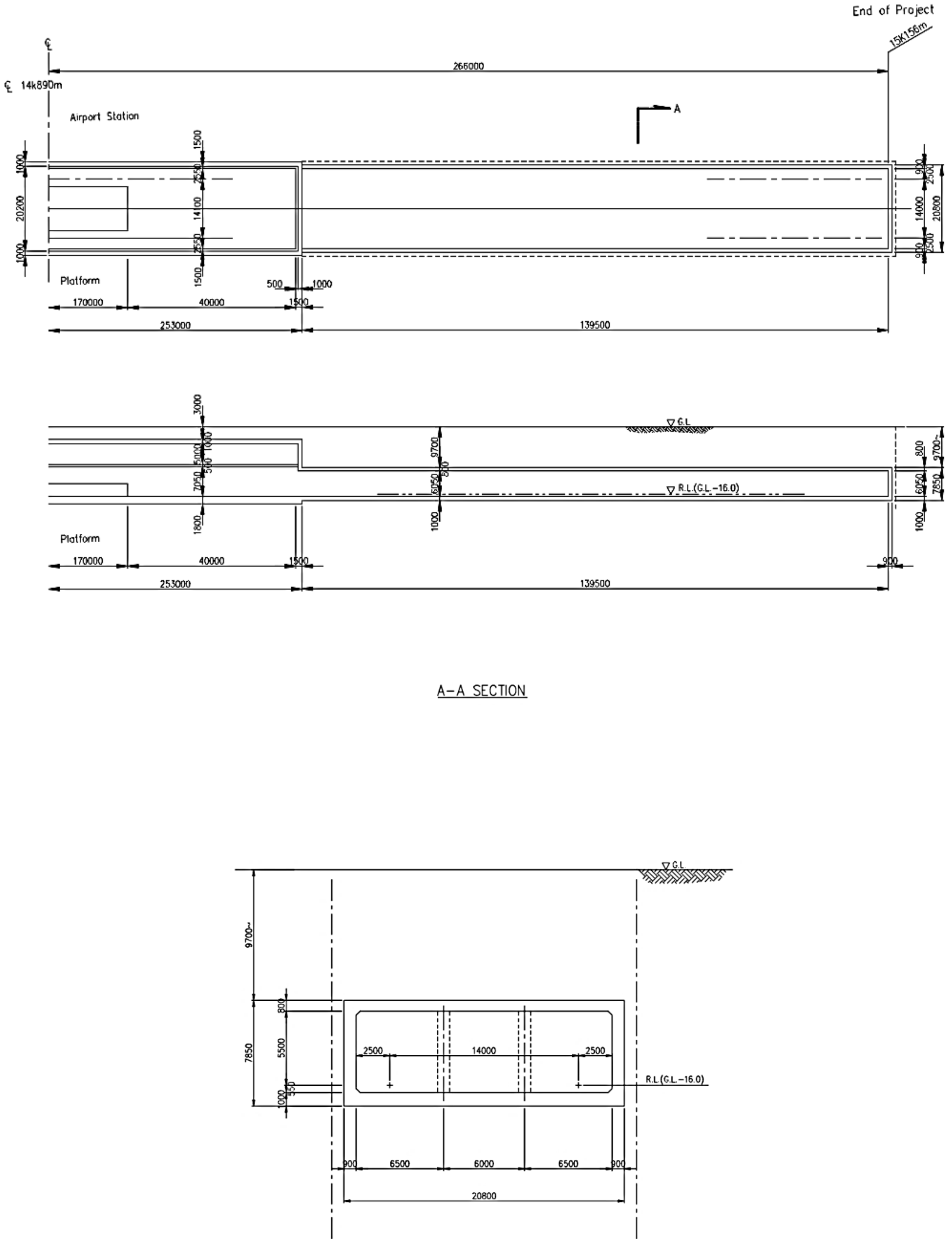
B-B Section



Sorce: JICA Study Team

Figure 4.5.24 Airport Terminal 3 Station - Airport Station

Figure 4.5.25 shows the northern part of Airport Station.



Source: JICA Study Team

Figure 4.5.25 Airport Station ~ Line Terminus

(5) Between Stations

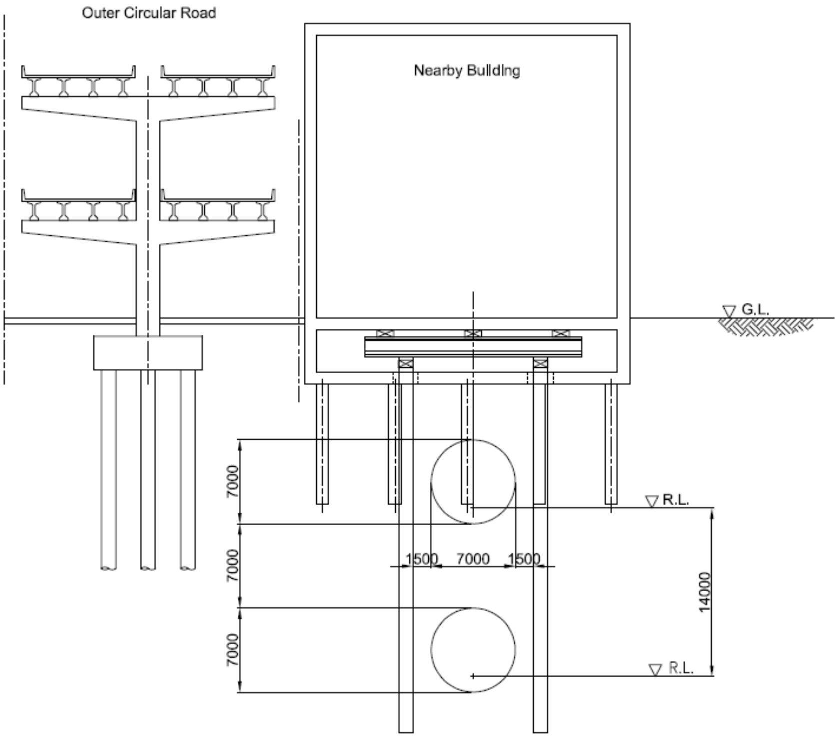
Tunnel boring machines will be used to build the tunnel between stations. There are two tunnels, and a single track. This section will discuss major issues to solve.

a. Rajarbagh Station - Malibagh Station

The tunnel boring started from Rajarbagh shaft at the same level and comes vertically parallel, keeping a 200m radius run under buildings, as shown in the drawing below. As discussed in section 4.2.3 (1), at present, detailed information of existing buildings is not available, but site observation indicates that these buildings are four layers and eight layers.

The surrounding area of the buildings is quite high, and it is hard to find land for underpinning temporary works. It is assumed that the buildings have a basement and that it would be available for temporary works.

In the plan, piles shall be driven from the basement by a pile driving machine with a restricted height. Upon completion of the piling, a rigid beam shall be inserted. The beam will support the existing buildings. Further detailed studies shall be done such as available height, availability of piling equipment, transport of equipment, and casting equipment. Information related to the existing buildings are inevitable. Figure 4.5.26 shows underpinning works.



Source: JICA Study Team

Figure 4.5.26 Concept of Protection of Existing Buildings

b. Notun Bazar Station - Future Park Station

Between Notun Bazar Station and Future Park Station, track alignments are changing, four TBMs initially of same level changes to vertically parallel. Intensive TBM operation is required.

c. Future Park Station - Bashundhara Station（Underground to Elevated Transition）

Purbachal Line to the east, which starts from Future Park station (underground station), passes through the many piles under the Kuril fly-over and goes out at the centre of Purbachal Road,　is shifted to an elevated track.

The connection part to the ground is around 100m ahead of where the fly-over slopes down, and a shaft, where TBMs arrive and TBMs are removed, will be set at that location. Then, the section is changed to be a box culvert with a retaining wall, and the elevated structure is on the ground level. Since the shielded tunnel reaches there by two single lines with 14m interval, the arrival shaft will be about 25m x 15m shape. The location of the shaft is set at around 11.9km from the starting point on the ground. Around the arrival shaft, construction techniques or soil improvement shall be considered because the depth of the TBM will be shallow.

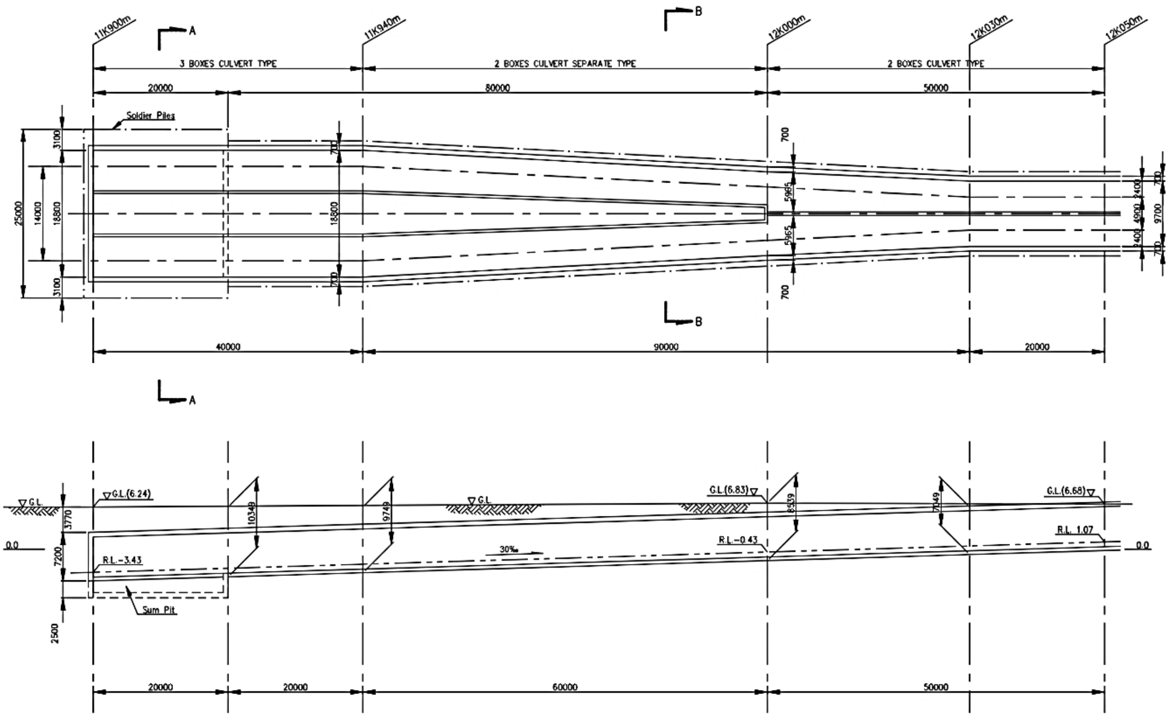
The distance between centres of the tracks is changed from 14m to 4.9m in the box culvert. A circular curve and transition curve is set and the reduced distance is set at about 150m. Since this section is in the longitudinal gradient section, the specific condition has to be satisfied.

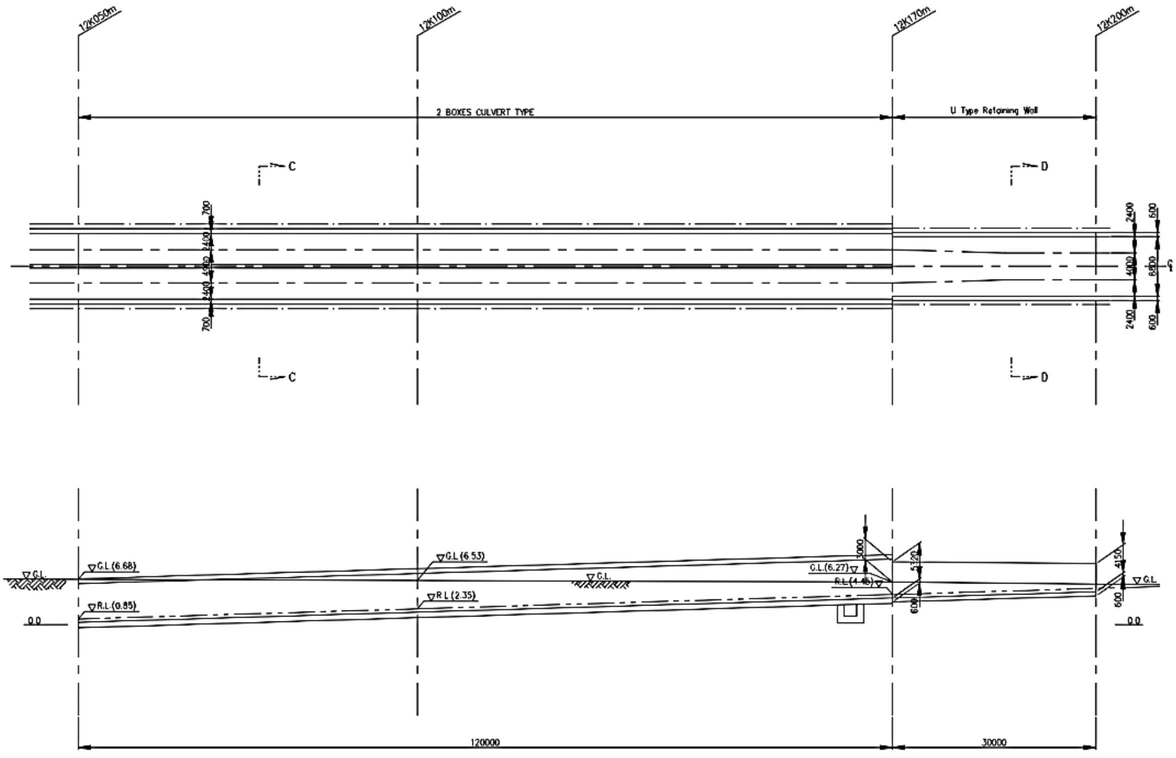
Installation of a drain pit shall be planned at the arrival shaft for TBMs at around 11.9 km.

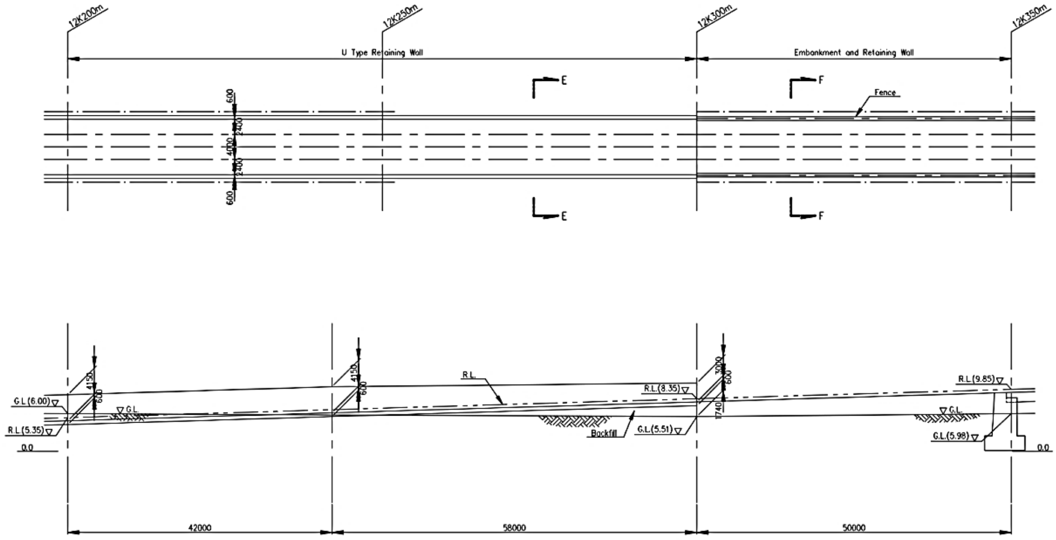
The earth retaining method is the steel sheet pile method, which is easy to construct, economical and has a short construction period.

The box culvert and U-shaped retaining wall are also constructed of steel sheet piles.

Although the construction area is located at the northern side of the road, road traffic on the existing road may be disturbed. Both sides of the existing road are to be expanded as temporary roads which dispenses with the management.

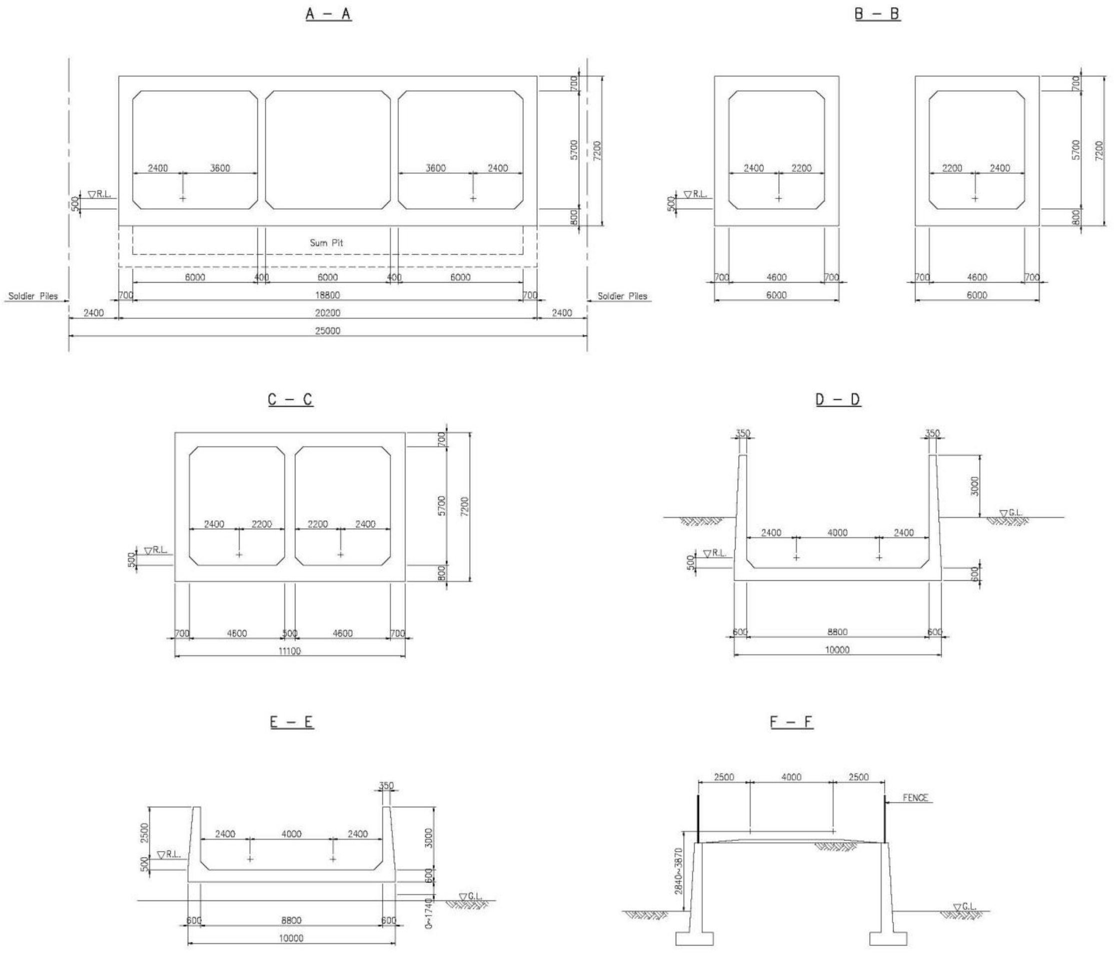

11K900m
11K940m
12K000m
12K030m
12K050m
A
B
3 BOXES CULVERT TYPE
2 BOXES CULVERT SEPARATE TYPE
2 BOXES CULVERT TYPE
20000
80000
50000
Soldier Piles
3100
25000
14000
18800
700
5965
3400
6900
9700
40000
90000
20000
G.L.
G.L.(6.24)
3770
10349
9749
G.L.(6.83)
8539
7049
G.L.(6.68)
0.0
7200
R.L.-3.43
30‰
R.L.-0.43
R.L. 1.07
Sum Pit
2500
20000
20000
60000
50000


12K050m
12K100m
12K170m
12K200m
2 BOXES CULVERT TYPE
U Type Retaining Wall
C
D
700
2400
4900
600
4900
8800
CL
G.L.
G.L.(6.68)
G.L.(6.53)
G.L.(6.27)
R.L.(4.15)
3000
5320
4150
600
R.L.(0.85)
R.L.(2.35)
0.0
120000
30000



Source: JICA Study Team

Figure 4.5.27 Plan and Profile at Transition Between Future Park Station - Bashundhara Station



Source: JICA Study Team

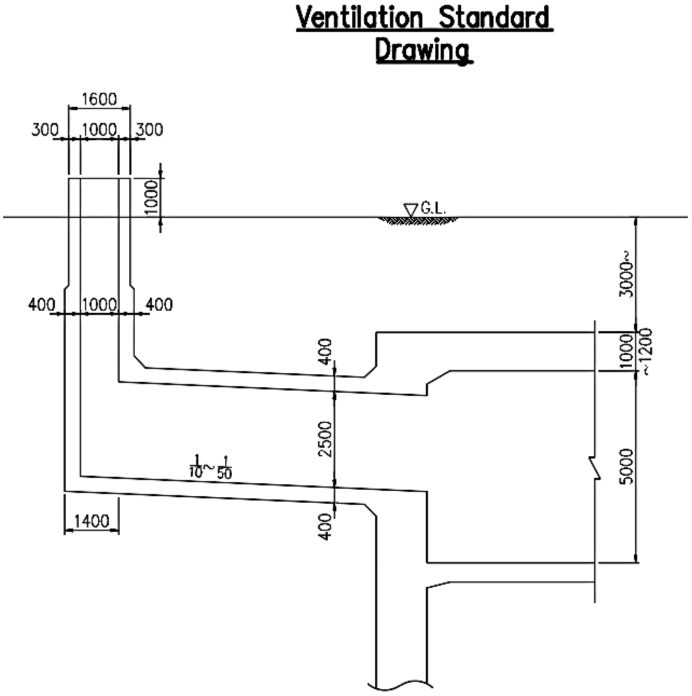
Figure 4.5.28 Cross Section of Transit between Future Park Station - Bashundhara Station

(6) Ventilation of Underground Station

In Japan a ventilation shaft is attached to an access/exit staircase, like what is shown in the photograph below, on the pedestrian passageway; but the street on which MRT Line 1 runs is not wide enough. JST looked for land where the ventilation tower shall be built.

Source: JICA Study Team

Figure 4.5.29 Ventilation Tower attached to Entrance



Source: JICA Study Team

Figure 4.5.30 Ventilation Duct and Tower

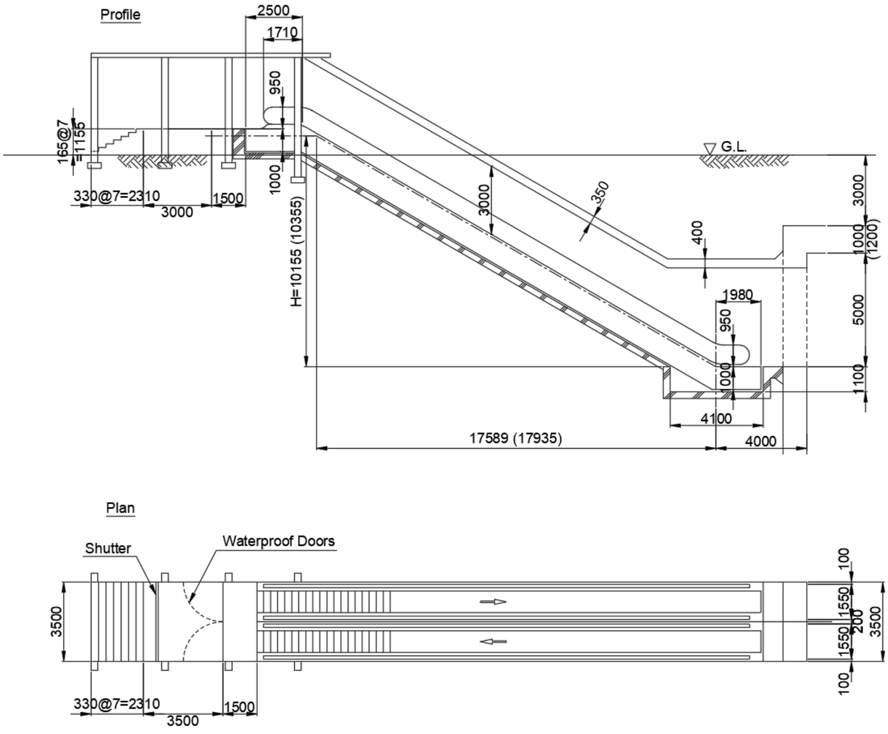
(7) Entrance

Entrances are provided on pedestrian passageways or to adjacent buildings according to site conditions. All entrances will be provided with elevators, and escalators will be installed, at least one per direction. But according to the site survey, it is not easy to provide both an elevator and escalator. Further study shall be made.

The following figure is an example of an entrance in Tokyo Subway.

Source: JICA Study Team

Figure 4.5.31 Entrance at Pedestrian Passageway



Source: JICA Study Team

Figure 4.5.32 Escalator Detail

(8) Connection with BR Kamalapur St.

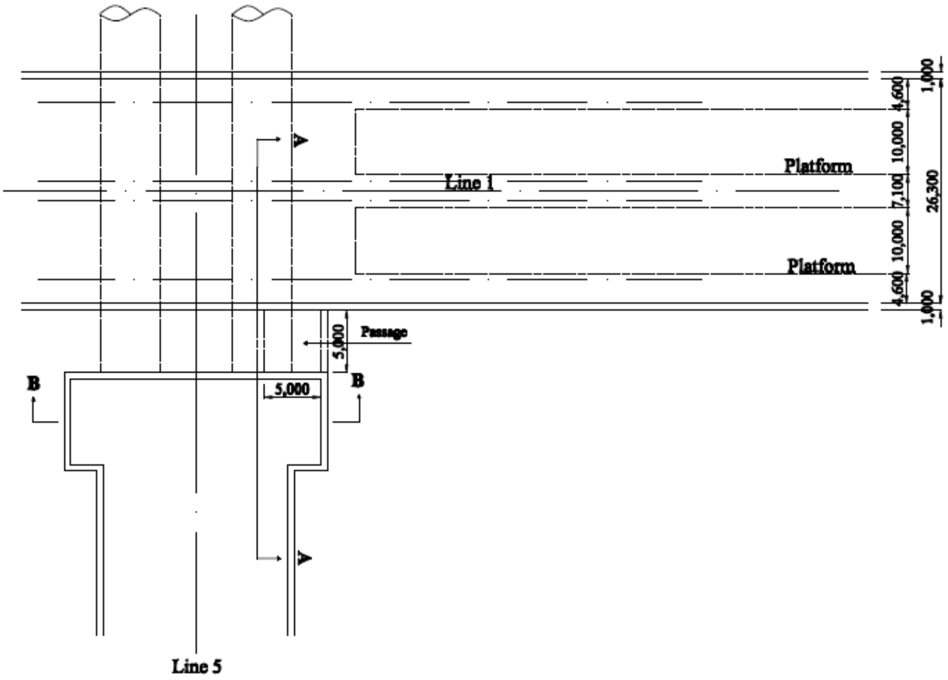
A special facility for transfer passengers is not considered. The present distance between the BR Main Entrance and MRT Line 1 entrance is some 50m. Passengers are requested to walk to shift to car mode on the ground level. The present green area in front of BR Regional Management Building may be developed as a multi-hub terminal, a transferring park in which other modes are available such as buses, taxis and rickshaws.

(9) Connection with MRT Line 5

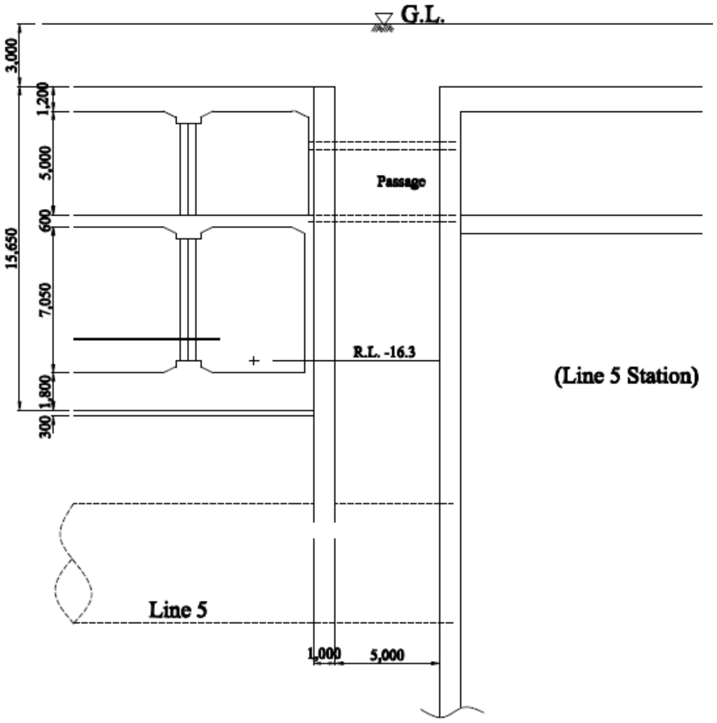
MRT Line 5 runs under MRT Line 1 at Notun Bazar. Underground passage will be provided. The passageway has a width of 5m and a height of 3m connecting the concourses to each other. The passageway shall be constructed with sheet piling system. At present, when writing this report, Line 1 shall be first built and Line 5 may follow. Therefore, the passageway shall be built in the Line 5 Construction project. Design of MRT Line 1 shall be implemented in considering the connection with the MRT Line 5.

The locations and sizes of the passageways are shown in the figures below.

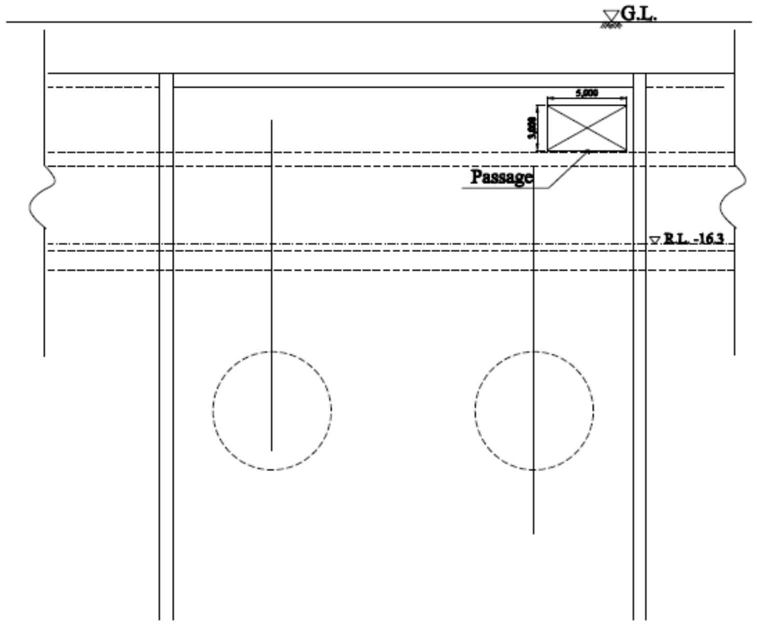
Passengers can transfer from/to line 1 and 5 by the passageway which connects at B1 concourse.



A-A



B - B



Source: JICA Study Team

Figure 4.5.33 General Layout of Passageway, Lines 1 & 5

(10) Connection with BR Airport Station

There is no special facility to connect MRT Line 1 and BR except an entrance in front of BR Airport Station.

(11) Flooding Prevention and Dewatering Plan

There should be flooding countermeasures in the design of the station building. Particularly, leakage from the river bed into the tunnel needs to be carefully managed so that the back-filling mortar is sufficiently covering the segment. Furthermore, covering the wall with a waterproof sheet should be considered.

Stations are expected to be flooded in five places: (1) station exits; (2) ventilation openings/ventilation towers; (3) entrances of tunnel; (4) river bottoms; and HatirJheel Station. Measures for (1) is to install a water stop panel or a waterproof gate at station exit. Measures for (2) is to equip the ventilation opening on ground level with a flood detector, resulting in automatic closing at rainfall time. Openings of ventilation towers for mechanical ventilation are installed high. Measures for (3) is to design a retaining wall in transition section from underground to viaduct that is long enough to prevent surrounding water from flowing into track. Rainfall in tracks is pumped out when needed. At present, the entrance of the tunnel (transit) is planned to be at PURABACHAL RAJUK Road adjacent to the reservoir regulator, and thus water is thought to run to the reservoir. In the case of (5), HatirJheel Station is in the immediate vicinity of Rampra Khal; therefore, it is necessary to consider enough waterproofing. In particular, leakage from the river bed to the tunnel must be carefully managed so that the backfill mortar sufficiently covers the segment. In addition, it is necessary to pay attention to covering the wall with a waterproof sheet so as to prevent leakage into the station.

The following measures can be considered for the facilities: (1) installation of a waterproof door, (2) installation of a camera that constantly monitors the level of the adjustment tank during heavy rain and floods, (3) installation of the pump power supply box at high altitude. Regarding these, capacities, places, numbers, etc., should be considered at the design stage.

Currently the electric current is often cut off. Thus, each station is provided with UPS and generators in order to continue the station operation for about two hours. The UPS/generator capacity makes possible the distribution of necessary power to continue air ventilations, emergency lights, illuminations, and station operation.

Daily station operation causes sewage water discharge from toilets and from cleaning. Generally, the sewage facility has to be designed based on regulations of sewage in Bangladesh. If the regulation does not exist, the Japanese design standard is applied after discussion with the client. The water volume used in toilets is calculated as the estimated number of passengers and then the septic tanks corresponding to the volume are planned. In Japan the sewage treatment capacity is high enough to run the sewage water directly to the public sewerage system; however, it is judged based on survey in Bangladesh whether the same method is applied or not. In detail, at the first existing network of sewage system shall be investigated, the purpose of the existing system i.e., only for rainfall water treatment or sewage water also being treated. And national standards, low and regulation and also practice for sewage shall be studied. Furthermore, the diameter of exiting pipes, and the capacity of the treatment plan.

According to subway construction projects in Southeast Asia in recent years, the sewage water discharged from toilets is designed to be separated from household sewage drainage, stored in pit under platform floor, pumped up, run through septic tanks installed on ground and finally run into public sewage. Sewage water discharged from cleaning, toilet sinks or kitchens runs to household sewage after confirming that its biochemical oxygen demand (BOD) is less than the amount regulated by law in Bangladesh. For example, BOD is regulated as less than or equal to 30 PPM in subway projects of Jakarta, Hanoi and Ho Chi Minh City but 50 PPM in elevated railways of Manila.

(12) Barrier Free Design

It is important that handicapped persons, the elderly, etc., are to be taken into account in station design. As a normal practice, a barrier free design and universal design are widely adopted in Railway Station Design (refer to section 4.6.16, Detailed Barrier Free Design).

In order to keep uniformity with MRT Line 6, which is an ongoing project, the same philosophy should be utilized. However, MRT Line 6 is an elevated railway system while Line 1 has underground segments. In designing underground stations, special attention to the handicapped people should be paid. Especially, an emergency manual tailor-made for this purpose should be prepared. Persons who cannot read shall be assisted using pictorial symbols and signage, especially for the escape route.

Furthermore, with regard to passenger safety and security, the MRT management and consultant shall plan for emergencies and conduct drills prior to service opening.

(13) Disaster Prevention Plan

a. Comparison between Article 29 of MLIT and NFPA 130

In Japan underground railway system design is implemented according to “Article 29 of Ministerial Ordinance of the Ministry of Land Infrastructure, Transport and Tourism” (hereinafter referred to as “Article 29 of MLIT). In this section, it is described about “NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail (hereinafter referred to as “NAPA 130”) issued by National Fire Protection Association (NFPA)comparing with Article 29 of MLIT, which is widely adopted in Metros in South and South East Asia such as India, Thailand, Singapore and Vietnam etc.

The main differences between Article 29 of MLIT and NFPA 130 are summarized in the following table.

Table 4.5.4 Comparison between Article 29 of MLIT and NFPA130

Items	Article 29 of MLITI	NFPA 130, 2017 Edition
Tunnel section at between stations	Tunnel is not used for evacuation passage of passengers except for emergency case.	Tunnel can be used for evacuation passage of passengers.
Fire control at between stations	Generally, train made of non-combustible material runs to next station.	It specifies evacuation method for passengers in case of tunnel fire to evacuate to outside of the burned tunnel on foot based on the concept that train has the potential to burn.
Tunnel structure	No requirement for cross passageways for twin bores and no requirement for fire walls for double line-single bore	-Cross passageways at 244m maximum interval are installed for twin bores having station distance is more than 762m. - A minimum 2-hr rated fire walls are installed for double line-single bore.

Items	Article 29 of MLITI	NFPA 130, 2017 Edition
Emergency exit signs	Mention	No mention
Smoke control equipment	It is required to install smoke control equipment except that sufficient flue gas is expected by natural ventilation opening. It can be used for mechanical ventilation equipment.	-A mechanical emergency ventilation system is installed to make provisions for the protection of passengers, employees, and emergency personnel from fire and smoke during a fire emergency. -An engineering analysis to determine the need for the mechanical emergency ventilation system is conducted where the length of the underground is greater than 61m.
Emergency facility design	• It is divided into an ordinary fire and a large fire (arson with 4 litres of gasoline). • In case of an ordinary fire at platform level, smoke density Cs shall be less than 0.1 (1/m). • In case of an ordinary fire at platform level, smoke diffusion volume shall be greater than the value derived from the evacuation time. • In case of a larger fire at platform and concourse levels, evacuation time shall be less than smoke descending time that is time for smoke descending to 2.0 (m) higher of the floor.	• The platform occupant load is specified. • <u>Platform Evacuation Time</u>: It is designed for sufficient egress capacity to evacuate the platform occupant load from the station platform in 4 minutes or less. • <u>Evacuation Time to a Point of Safety</u>: The station is designed to permit evacuation from the most remote point on the platform to a point of safety in 6 minutes or less. • <u>Travel Distance</u>: The maximum travel distance on the platform to a point at which a means of egress route leaves the platform is not exceed 100 m.

Source: Summarized by study team based on Article 29 of MLIT and NFPA130 2017 edition

Design philosophies for both standards are vastly different as mentioned the above table. While Article 29 of MLIT specifies rolling stocks to be made of non-combustible material and basically the tunnel between stations is not permitted to use for evacuation passage, NFPA130 allows to use the tunnel as evacuation passage considering possibility of burns.

Therefore, although Article 29 of MLIT does not specify for cross passageways for twin bores, NFPA130 stipulates cross passageways at 244m maximum interval for twin bores where station distance is more than 762m. The presence of cross passageways is often focused on as a difference for both standards.

b. Cross passageways specified by NFPA 130

NFPA 130 was often revised and details of cross passageways were also revised following the revisions as shown in Table 4.5.5, Figure 4.5.34 and Figure 4.5.35.

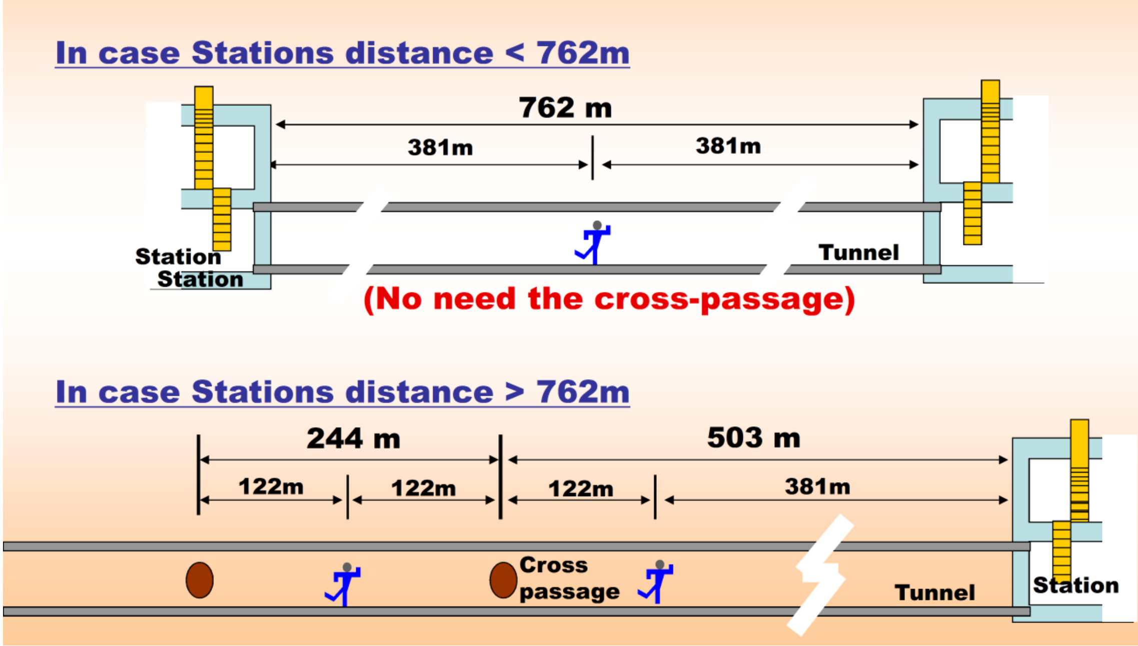
In more details, in 2007 edition, cross passageways was specified as “cross passageways shall not be farther than 244 m from the station or portal of the enclosed trainway.”, meaning it became restrictive compared to the previous revision.

However, the details of cross passageways have not been revised since the above revision.

Table 4.5.5 Standards for Emergency Exit for Underground Trainways by NFPA 130

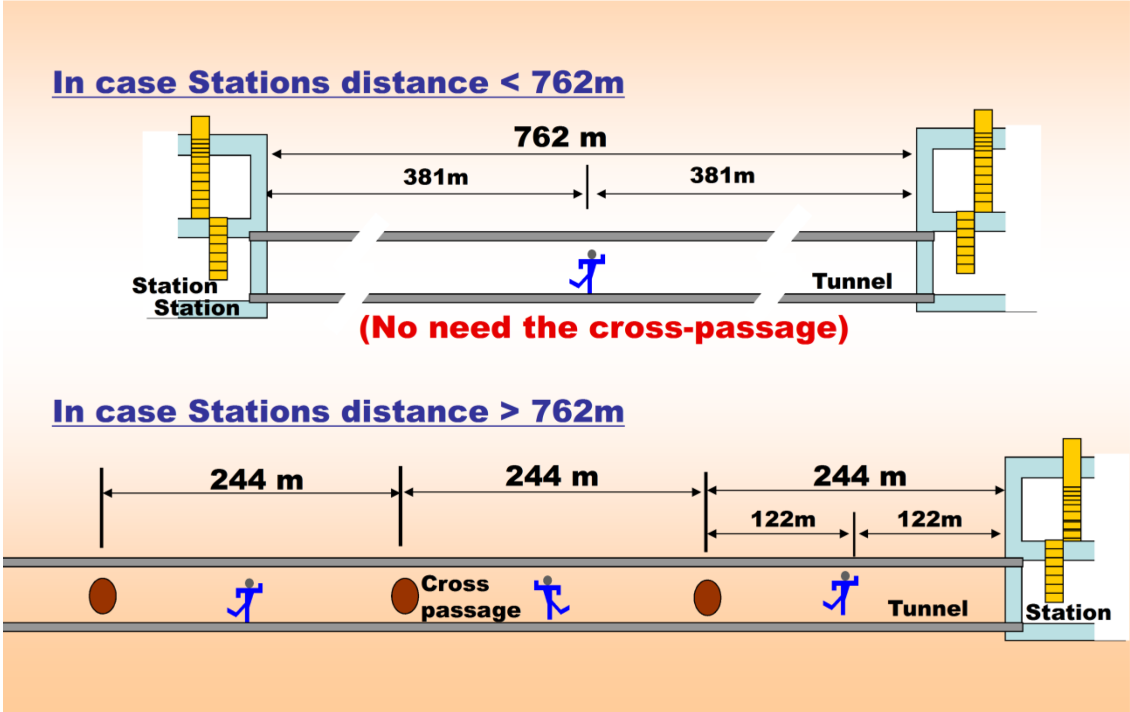
	Emergency Exit Details	Cross passageways utilized for emergency exit
1997 edition 2000 edition	3.2.4.2 Distance to an emergency exit <381m	3.2.4.3 Cross passageways <244m apart
2003 edition	3.2.4.2 Maximum distance between exits <762m	3.2.4.3 Cross passageways <244m apart
2007 edition 2010 edition	6.2.2.2.1 Maximum distance between exits < 762m	6.2.2.3.2(1) Cross passageways < 244m apart 6.2.2.3.2(2) Cross passageways from the station or tunnel portal <244m
2017 edition	6.3.1.4 Maximum distance between exits < 762m	6.3.1.6 (1) Cross passageways < 244m apart 6.3.1.6 (2) Cross passageways from the station or tunnel portal <244m

Source: Summarized by study team based on NFPA130 1997, 2000, 2003, 2007, 2010 and 2017 edition



Source: JICA Study team

Figure 4.5.34 NFPA130 1997 Edition



Source: JICA Study team

Figure 4.5.35 NFPA130 2010&2017 Edition

c. Considerations and Recommendations

It is often described differences between Article 29 of MLIT and NFPA130 as just focusing on the presence of cross passageways and concluded that NFPA130 is safer standard compared to Article 29 of MLIT.

However, since NFPA 130 is overall standard for railway fire protection and therefore it is described less information regarding station equipment compared with Article 29 of MLIT. For instance, it is not mentioned about emergency exit signs and less information for smoke control equipment, although Article 29 of MLIT describes details of these issues.

It should be noted again that both standards are different design philosophies as mentioned in (1) Comparison between Article 29 of MLIT and NFPA 130. Hence, it should be discussed which standard is adopted considering whole railway system including rolling stocks not focusing on specific items and discuss which standard is superior or safer.

This study recommends adopting excellent Japanese railway system. Therefore, it is highly recommended using the standard for railway fire protection by Article 29 of MLIT.

3) Construction Methodology

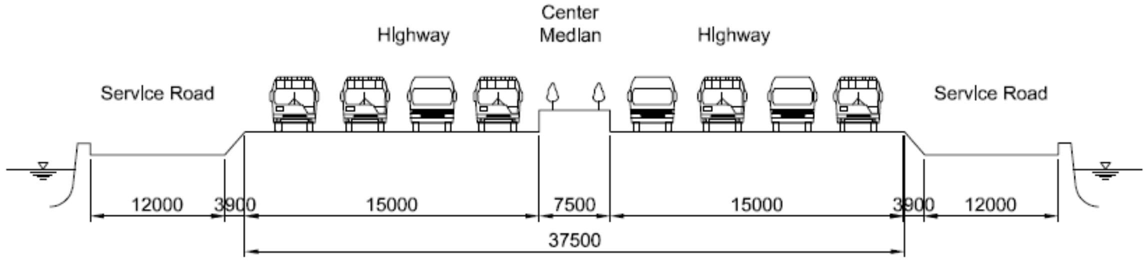
(1) Elevated Section

a. Piling and Substructure

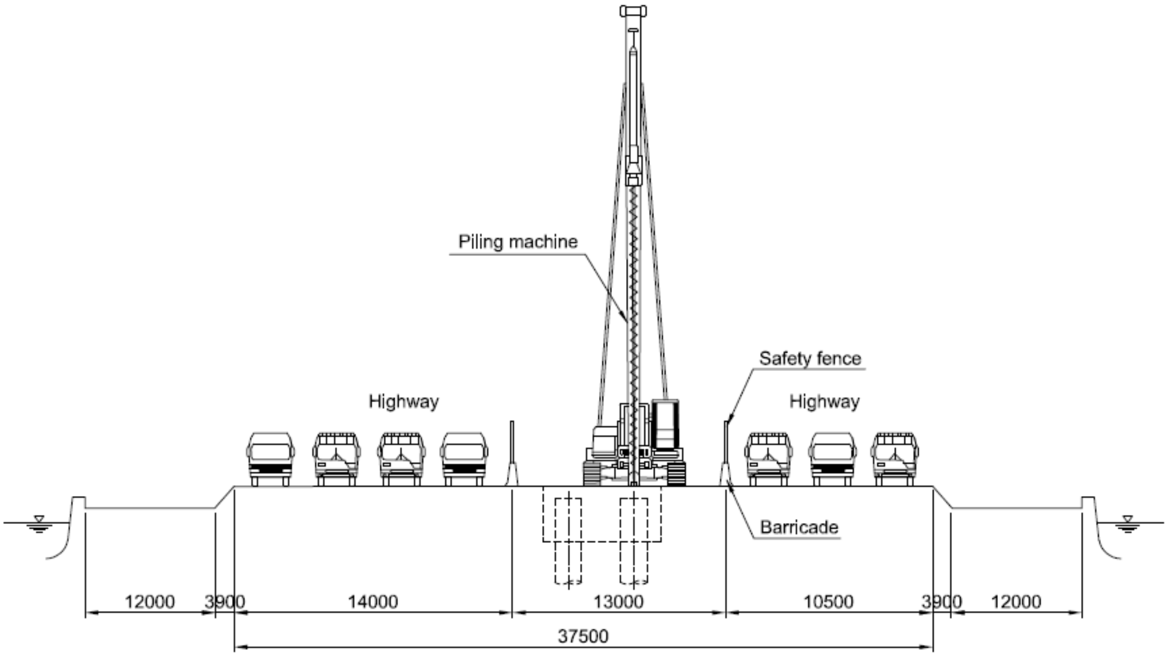
As discussed in section 4.5.1 1, Purbachal Road, which is 70m wide, contains a canal at both sides of the road. It is assumed that when viaduct construction starts, Purbachal Road will have been completed.

Since the viaduct is constructed at the centre of Purbachal Road, the lanes at each side are reduced by one during construction as shown in Figure 4.5.36.

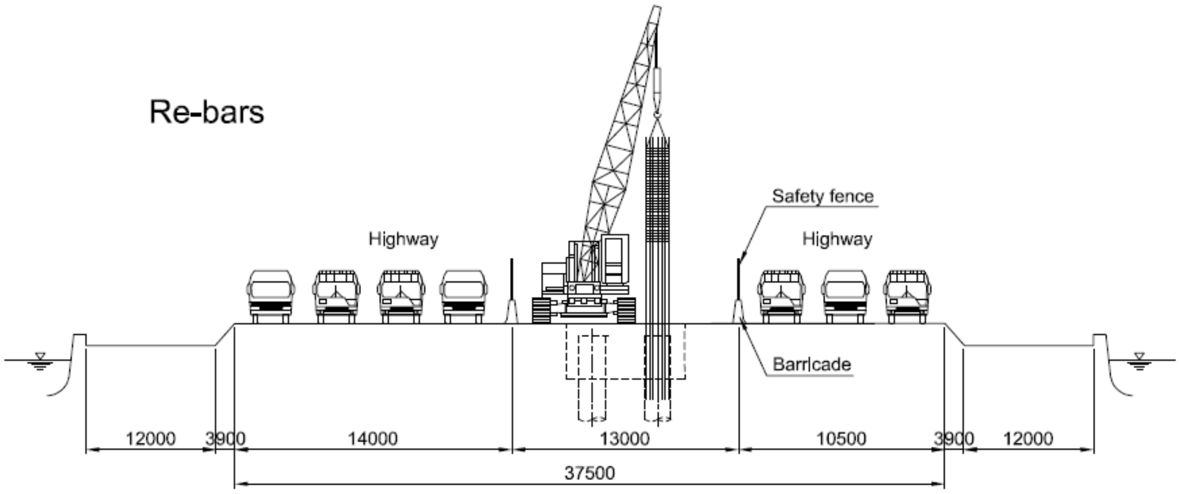
(a) Present



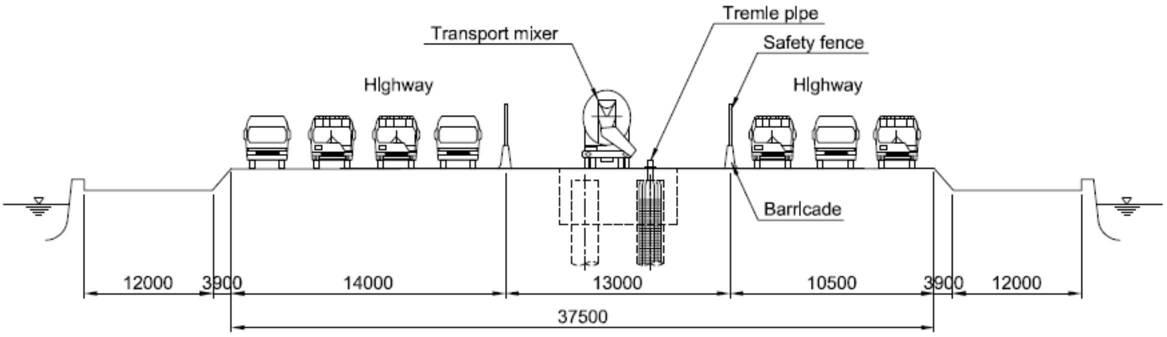
(b) Piling excavation works



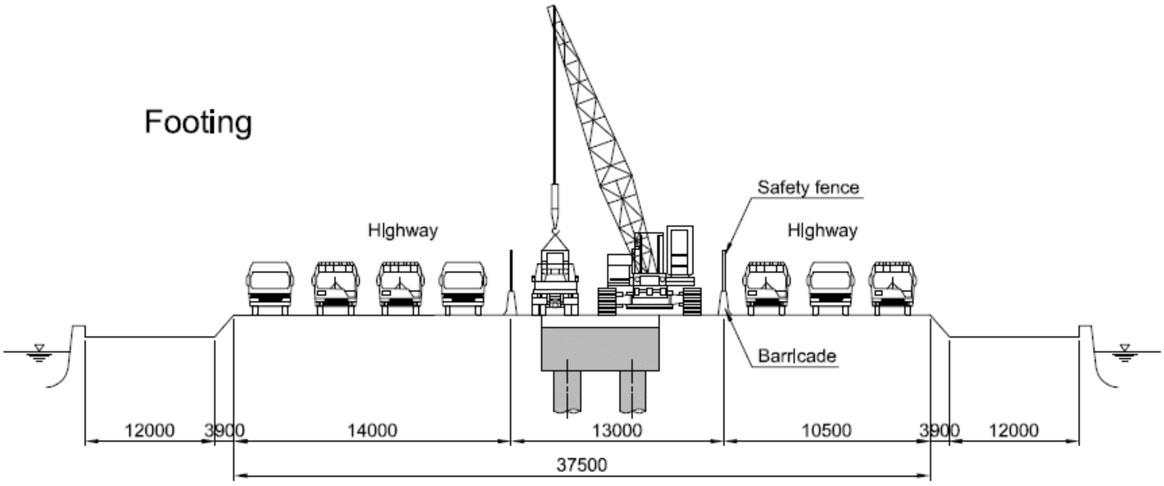
(c) Basket of Reinforcement put into hole



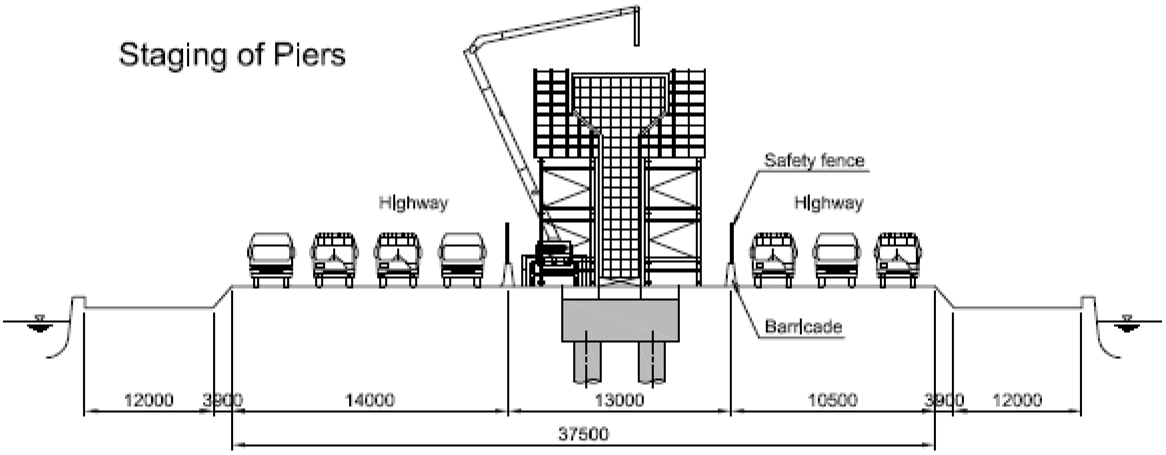
(d) Concrete Casting



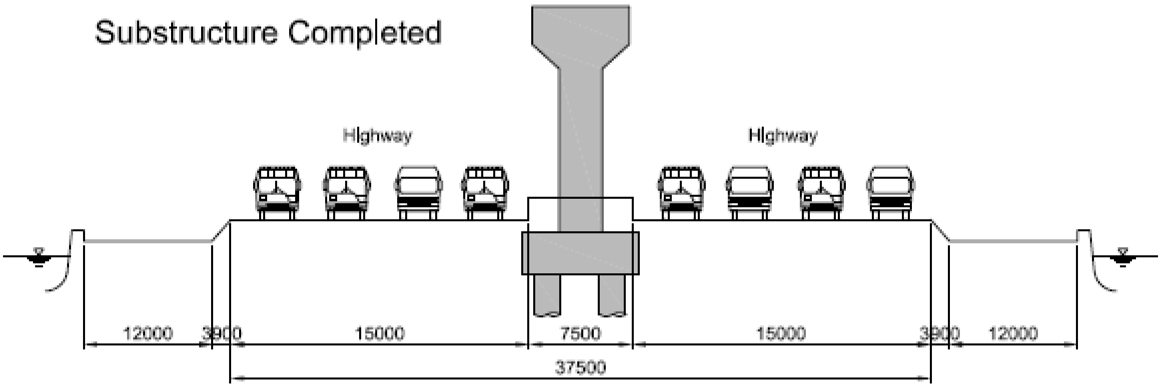
(e) Staging for column construction



(f) Casting Concrete to Substructure



(g) Completion of Substructure



Source: JICA Study Team

Figure 4.5.36 Piling Foundation and Substructure Construction

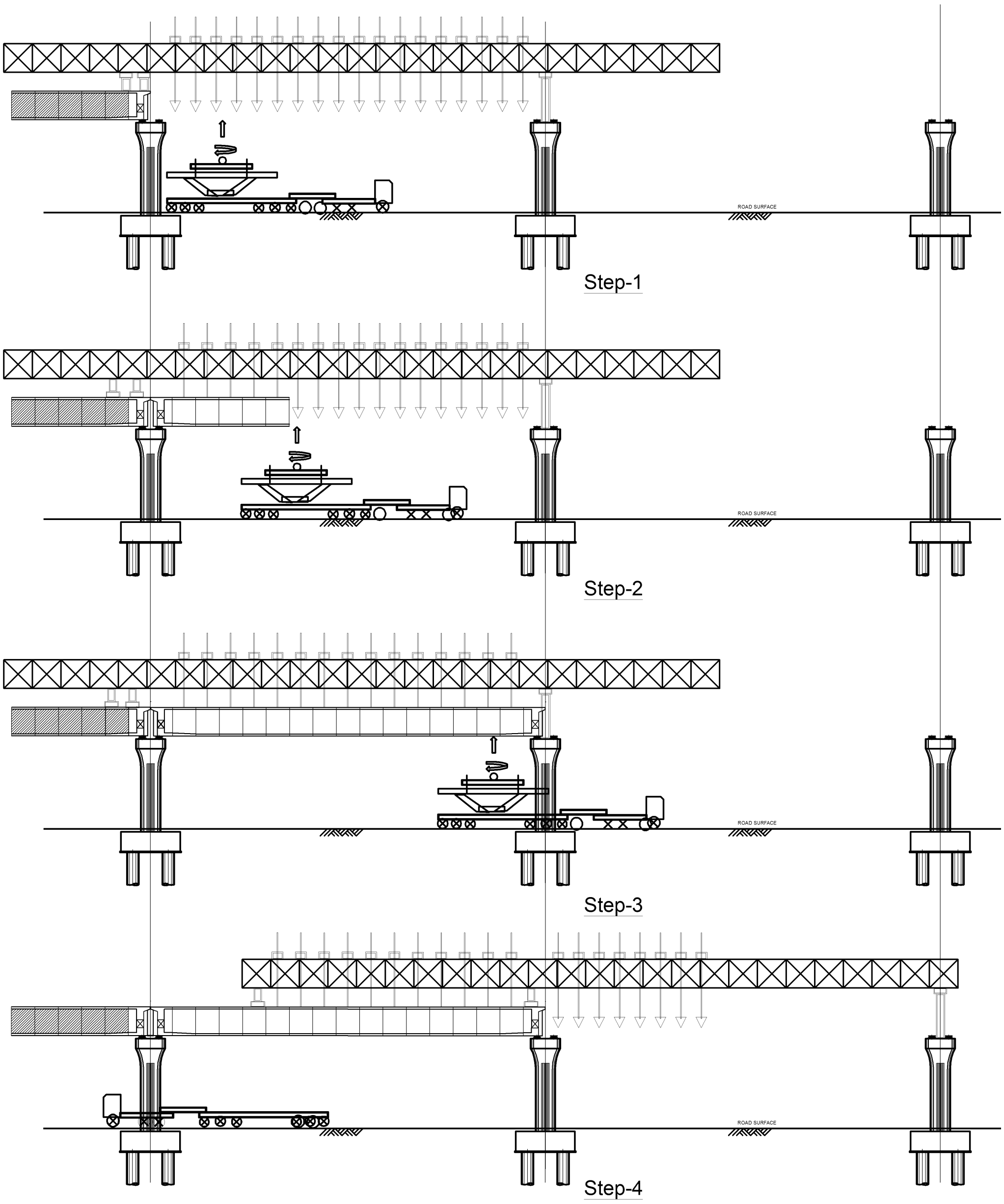
b. Superstructure

For minimizing the impact on surrounding traffic, it is preferable to apply a span by span construction method same as MRT Line 6. This is a construction method in which a precast block manufactured by a segment yard is lifted from the road by erection girder, installed in a predetermined position above the ground, and tensioned by a PC cable to be integrated. Construction and tension work is carried out in the air, so it is possible to minimize the construction yard on the road. In order to minimize the impact on existing traffic, it is desirable to transport the precast block to the site at night time. It is preferable to establish Girder Fabrication Yard near to construction site in order to minimize transportation. Fortunately, Purbachal Line will be built on the Purbachal Road which locates developing area, it is expected to find the fabrication site near such road.

The construction procedure is as shown below.

Source: http://www.fujips.co.jp/results/r-bridge/sub21090/2072

Figure 4.5.37 The Span by Span Method Girder Erection



Step 1 : Erection Girder (EG) is in position. 1st precast segment (edge segment) is transported by a long trailer from the construction yard and its position should be just under EG. The segment is hanged by suspension cables with EG and turned by 90 degree and is in placing.

Step 2 : 2nd segment also is repeatedly in placing and this segment is pulled and connected to the previous segment after application of epoxy resin to the joint of matched cast segment . This operation should be repeated up to the end of this span.

Step 3 : PC work should start and be complete for connection of all segments for single span girder. The girder should be lowering to the required position and level.

Step 4 : The rear leg of EG should be shifted to the end position of the girder completed and the front leg of EG will be shifted on to the next pier head and EG is in position for next span erection.

Source: JICA Study Team

Figure 4.5.38 Construction Method by Span by Span

(2) Underground Section

a. Cut and Cover Method for Station Box Construction

At the time of writing this report, the available geotechnical data is limited. This Study used the boring data obtained at Kuril. Once all boring survey and laboratory test data becomes available, this construction plan shall be reviewed.

Although SMW as an earth supporting system method has an advantage in economic aspect and construction duration, it requires a larger width, and the resulting noise and vibration from digging machine affects surrounding buildings. JST proposes a diaphragm wall (D-wall) which has enough rigidness. But to stop water from leaking within D-walls, a second wall 50cm thick will be provided. With regard to the procedure of construction, taking into account waterproofing during the operation phase, the open cut method (Bottom-Up Method) shall be applied instead of the Top-Down Method, which was adopted in the Delhi MRT construction. As discussed in 15.2 of chapter 12, JST recommended to adopt the SMW method as earth supporting system to the TBM launching shaft in order to accelerate TBM launching by about one month. The TBM launching shafts are constructed at Kamalapur, Badda (south and north).

The following table compares earth supporting systems.

Table 4.5.6 Comparison of Earth Supporting Systems

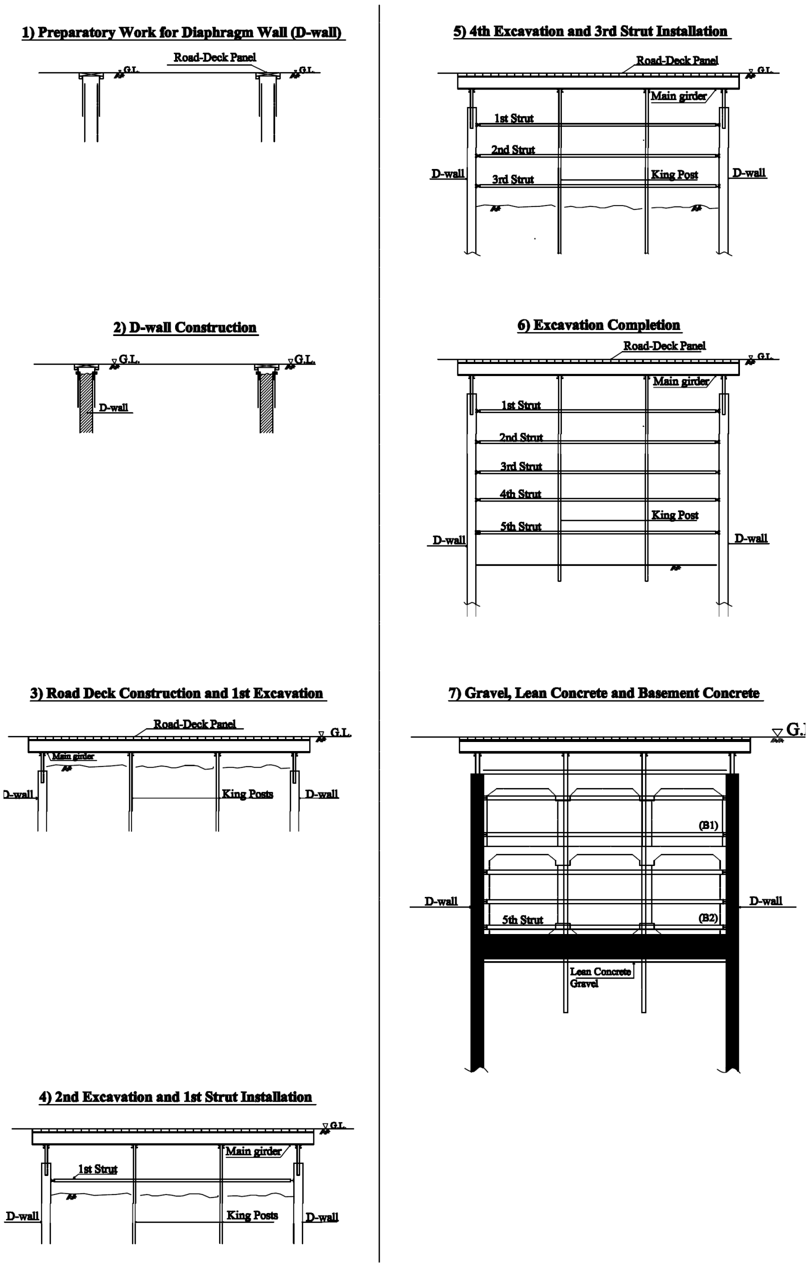
	RCD-Wall（Stand-alone）	RCD-Wall（Composite）	SMW
Design	**Structure** High rigidness is expected, design as permanent structure	**Structure** High rigidness is expected, design as permanent structure	**Temporary** Low rigidness, not permanent structure
Procedure of Const.	Top-down	Bottom-up	Bottom-up
Advantage	➢ Since the main frame is utilized, steel materials for temporary construction such as short struts and wailings are not necessary. ➢ Since temporary retaining walls are not necessary, sufficient space for utility diversion can be secured. ➢ Road will be opened to road traffic relatively earlier than bottom up method.	➢ Since the main frame is utilized, steel materials for temporary construction such as short struts and wailings are not necessary. ➢ Since second wall is provided within D-wall, leakage water can be prevented ➢ Recover quality that is a concern by inner wall. ➢ Durability of structure is high.	➢ Period for wall construction is relatively short. ➢ Since plant facility is simple and can be moved in accordance with the construction, a separate plant yard is not necessary. ➢ Since construction of permanent structure is done in site, quality is high. ➢ Relatively easy preparation works than D-Wall
Disadvantage	➢ Period for wall construction is relatively long. ➢ Casting concrete into muddy water, quality is a concern. ➢ Since plant facility is large and it is difficult to move during the construction, a separate plant will be necessary. ➢ Against heavy equipment, ground shall be improved by mortar concrete in wide area ➢ For digging the wall, a trench shall be constructed	➢ Period for wall construction is relatively long. ➢ Since plant facility is large and it is difficult to move during the construction, a separate plant will be necessary. ➢ Against heavy equipment, ground shall be improved by mortar concrete in wide area ➢ For digging the wall, trench shall be constructed by concrete	➢ This technique is very unique and only a special contractor can carry it out ➢ Rigidity is low, affects the surrounding building, or road surface is a concern.

	RCD-Wall（Stand-alone）	RCD-Wall（Composite）	SMW
	by concrete		

Source: JICA Study Team

There are three types of D-Wall: 1) Stand-alone type, 2) Composition type, and 3) Double Layer Type. Type selection shall be made according to soil condition, depth of excavation, shape and size of structure. This FS is based on the D-wall composition.

The following figure shows the construction procedure.



General practice of construction by Cut – Cover method

Prior to D-wall construction, underground utilities shall be protected or relocated by the owner.

First Step (figure 1 above) Preparation works for D-wall construction; to create working space road diversion is required.

Second Step (Figure 2 above) D-wall construction and drive H-shape steel which supports road deck panel.

Third Step (Figure 3 above) Road diversion and excavation work under deck panels by 1st slut system.

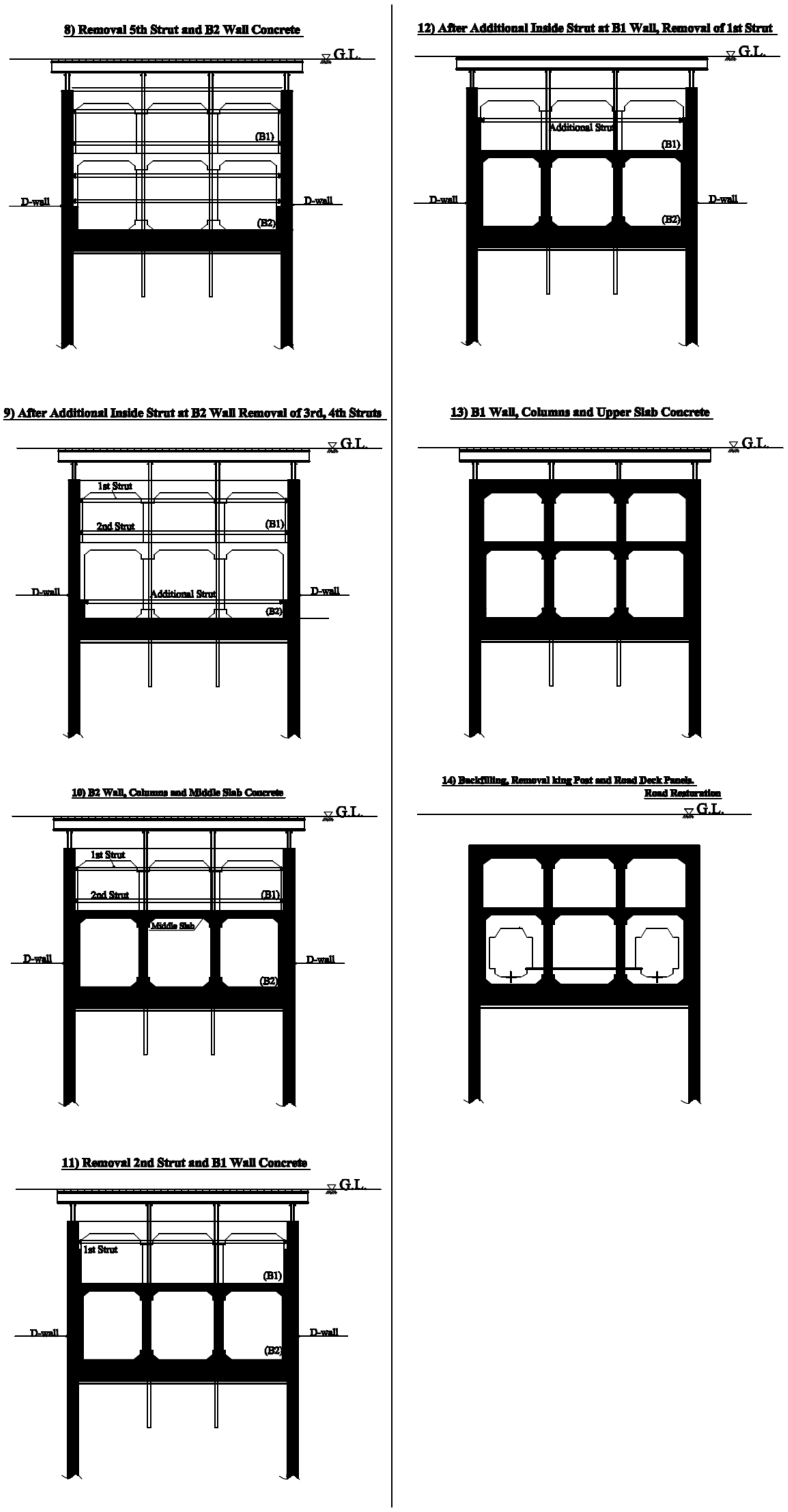
Forth Step (Figure 4 above) Excavation by 2nd slut.

Fifth Step (Figure 5 and 6 above) Excavation by designed bottom depth.

Sixth Step (Figure 7 above) Bottom concrete slab and wall construction.

Seventh Step (Figure 8 - 13 below) Casting concrete to concourse floor slab, and upper slab.

As Step 14 Complete Construction of Station Box.



Source: JICA Study Team

Figure 4.5.39 Proposed Station Box Construction Procedure

Timing of the second wall (inner wall) construction shall be made taking into consideration TBM launching/arrival time. JST proposes as a first priority to give the works of launching shaft construction. Upon completion the TBM launching shaft, TBM shall leave to arrival shaft. Station box shall be constructed with diaphragm which is designed as permanent structures. SMW for TBM launching shaft and diaphragm for station box, there two system for earth support, and result in one month time-save for construction of tunnel and underground station box. Breakdown of one month, are estimated as follows: 1) 2 – 3 weeks for ground improvement for heavy equipment, 2) 1 – 2 weeks for a concrete trench for D-wall excavation, 3) 1 – week for drilling and concrete casting. But as equipment for SMW is not available in Bangladesh, import from Japan is inevitable. This will result in a construction cost increase. Therefore in the detail design stage, the designer shall discuss with DMTC.

(a) Malibagh Station

Two shield machines collide at the eastside of the Malibagh Station end. The point of meeting is out of platform. Tunnel construction shall be done successively starting with the lower tunnel and then the upper tunnel to avoid affecting the work cycle in each tunnel. Taking into account the connection between the Station Box and Tunnels, the ductile segment, which would allow separation of the ring, shall be used where the separation is considered.

Soil improvement shall take place after completion of the station box. Upon confirming the ground conditions, from the station box, a beam is inserted into the tunnel, which shall have an inner supporting system. The work of separating the ductile segment and inserting a beam takes the same time. Also, the lower tunnel shall be connected with the station box first, then the upper tunnel.

After connecting the tunnel and station box, platform construction takes place. Detailed analysis is required prior to structural works to ensure safety.

(b) Notun Bazar Station

Tunnelling by 4TBMs starts north of the Notun Bazar Station. According to construction schedule, the intermediate two TBMs are going to launch first aiming at Future Park Station, Level 3; the outside two TBMs work toward Future Park, B2 level. Since the backyard of TBMs is quite large, it is expected to start shaft construction.

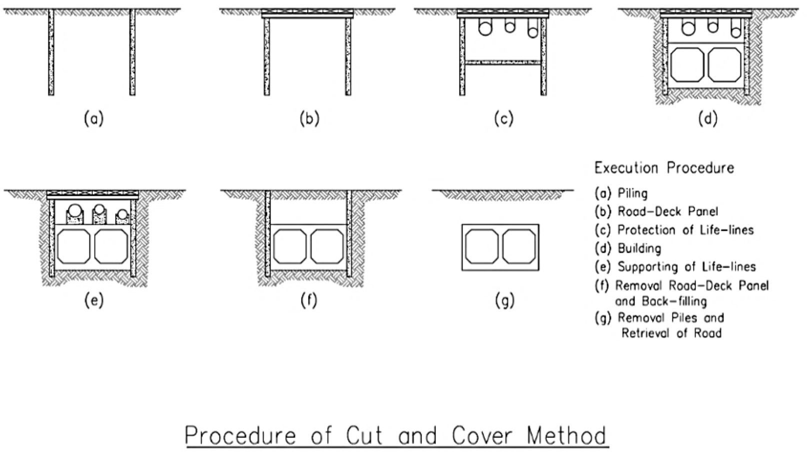
The station box connects at both sides with box culverts where tracks have crossovers. These are built by cut and cover method (refer to Figure 4.5.22).

(c) Future Park Station

After the arrival of two TBMs from the Notun Bazar Station end, B3 upper slab shall be built as soon as possible, and two other TBMs that will arrive shall be put to use for B2 level. From B3 level, TBM shall go to Khilket Underground Station; on the other hand, from B2 level, the two TBMs go forward to the transit provided in PURBACHAL Road. TBMs are pulled up at arrival shaft and then moved to the launching shaft provided at the opposite end of the station.

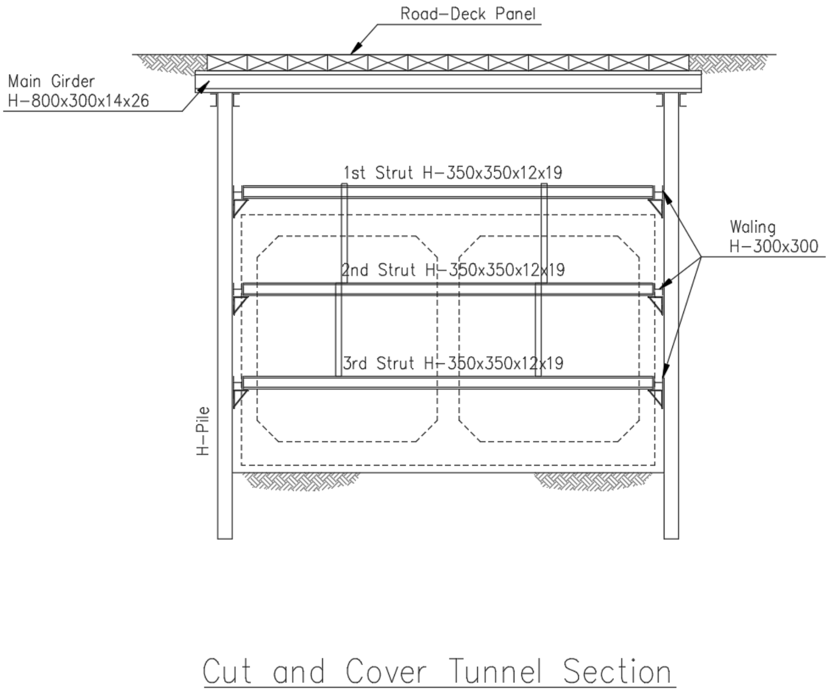
b. Box Culvert at Transit, U- Shaped Retaining Wall

Excavation for the construction of the box culvert and U-shaped retaining wall at transit shall use sheet piling method to support the earth. Between the TBM arriving shaft and the transit box, culverts of several sizes will be built due to track alignment, until finally reaching the U- shaped Retaining Wall which connects with viaducts. At U-shaped Retaining Wall, a dewatering facility is required. Figure 4.5.40 shows the procedure of cut and cover tunnelling.



Source: Sankaido Underground Railway Construction Method (1975)

Figure 4.5.40 Procedure of Cut and Cover Tunnelling



Source: Sankaido Underground Railway Construction Method (1975)

Figure 4.5.41 Cross Section of Cut and Cover Tunnel

c. Shield Tunnelling Method

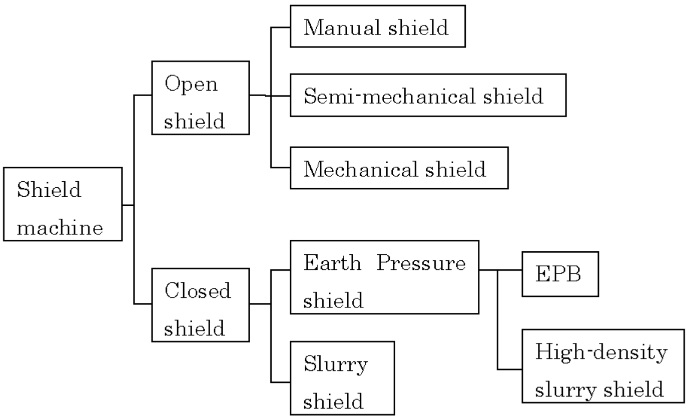
c.1 Selection of Tunnel Machine

MRT Line 1 construction requires highly skilled tunnelling machine operation to pass the circumstance such as existing buildings close to the alignment, parallel TBM arrangement, steep curvature, and passing between piles. The tunnelling machine shall be selected among several types of TBMs according to circumstance. In selecting TBM, priority shall be given to less settlement of ground.

c.2 Kinds of Shield Boring Machines and Selection for MRT Line 1

There are two types of shield machines: one is a closed type shield and the other is an open type shield. The open type shield can be used in the condition where there is no water in the ground and the face can be independently stable. However, this method affects the above ground level, and a slightly bigger settlement is expected. JST cannot recommend this type of shield machine. Studies about the Earth Pressure Shield method and Slurry Shield were compared.

Figure 4.5.42 shows the kinds of shield boring machines.



Source: JICA Study Team

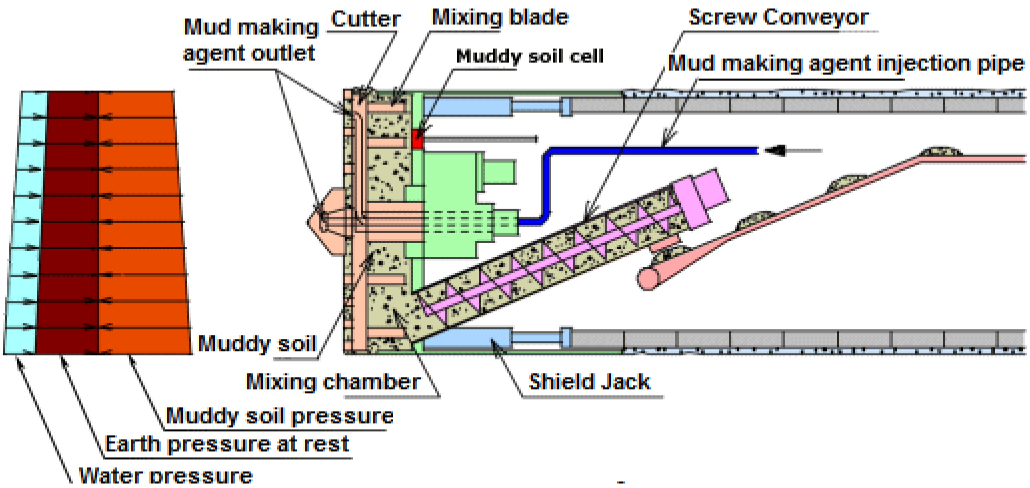
Figure 4.5.42 Kinds of Shield Boring Machines

(a) Characteristics of Earth Pressure Shield

Earth Pressure Shield machines excavate the ground while securing the face for stabilization by pressurizing the muddy soil inside the chamber with shield thrust force, and discharges the excavated soil with the screw conveyor. This type of shield machine can be categorized into two: Earth Pressure Balance (EPB) shield machine, which has an inlet for additives to improve the properties of excavated soil, and normal earth pressure shield machine, which is not equipped with the mechanism that EPB shield machine has. However, EPB shield machines are more popular regardless of the use of additives.

Characteristics of face stability mechanism for the earth pressure shield machine are as follows:

- For EPB, excavated soils are to be improved to contain plastic flow and water tightness by adding additives and by forcing to mix using the cutter head and blades. Additives will not be applied for normal earth pressure shield machines, only mixing is applied.
- The chamber and screw conveyor are filled with muddy soil, then the muddy soil is pressed by the thrust of a jack to resist earth pressure and water pressure acting on the face.



Source: Taiho Construction Company HP

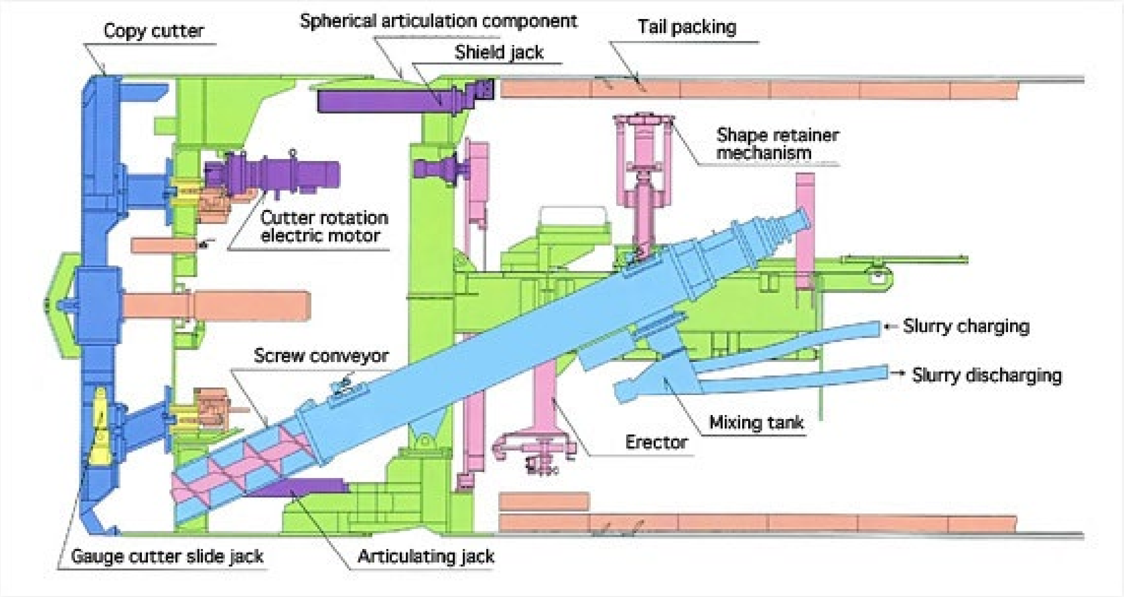
Figure 4.5.43 Overview of Earth Pressure Shield Machine

(2) Characteristics of Slurry Shield

Slurry shield machines excavate the ground while stabilizing the face by pressurizing the slurry inside the chamber using the fluid transporting pump through the discharging pipe, and discharges the excavated soil with the slurry inside the chamber through the discharging pipe.

Characteristics of face stability mechanism for the slurry shield machine are as follows:

- Impermeable mud film is formed on the face so that the pressure can effectively act on the face.
- The strength of the ground will be increased as the slurry penetrates the ground since the fine fractions such as sand and silt penetrate apertures.
- The slurry pressure more than the earth/water pressure applied to the face can stabilize the face while adjusting the speed of rotation for the fluid transporting pump.



Source: Nishimatsu Construction HP

Figure 4.5.44 Overview of Slurry Shield Machine

(3) Selection of TBM

JST proposes a slurry shield machine due to its operation ability. Because of some circumstances of MRT Line 1, sensitive TBM operation is required. However, this method contains several disadvantages compared with the earth pressure shield machine, as follows:

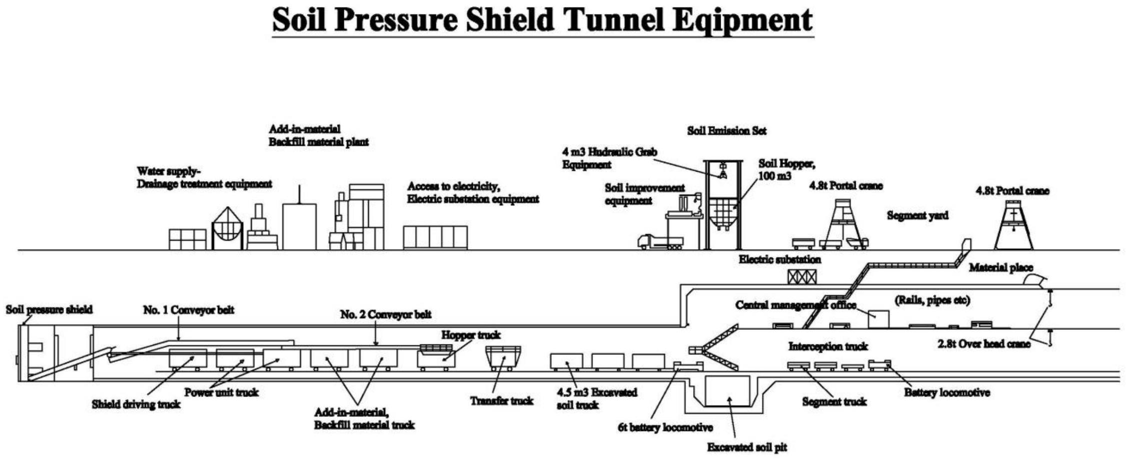
a) In the dry season, it becomes hard to keep the face stable; and
b) Backyard equipment is larger than EPB and requires wider space.

At the time of writing the report, the geological condition is not known. A detailed study is needed anew in the design stage taking into account geological condition, available working depot space, and the environment of the working site.

c.3 Method of Tunnelling By TBM

In general, two shields are arranged, i.e., an upper shield and a lower shield. The lower shield is constructed in order to avoid damage to other tunnelling works. After confirmation that no damage is expected, a later tunnel machine shall be dispatched. Ground settlement shall be within an allowable range and further analysis shall be carried out.

The following shows the general arrangement of the shield machine.

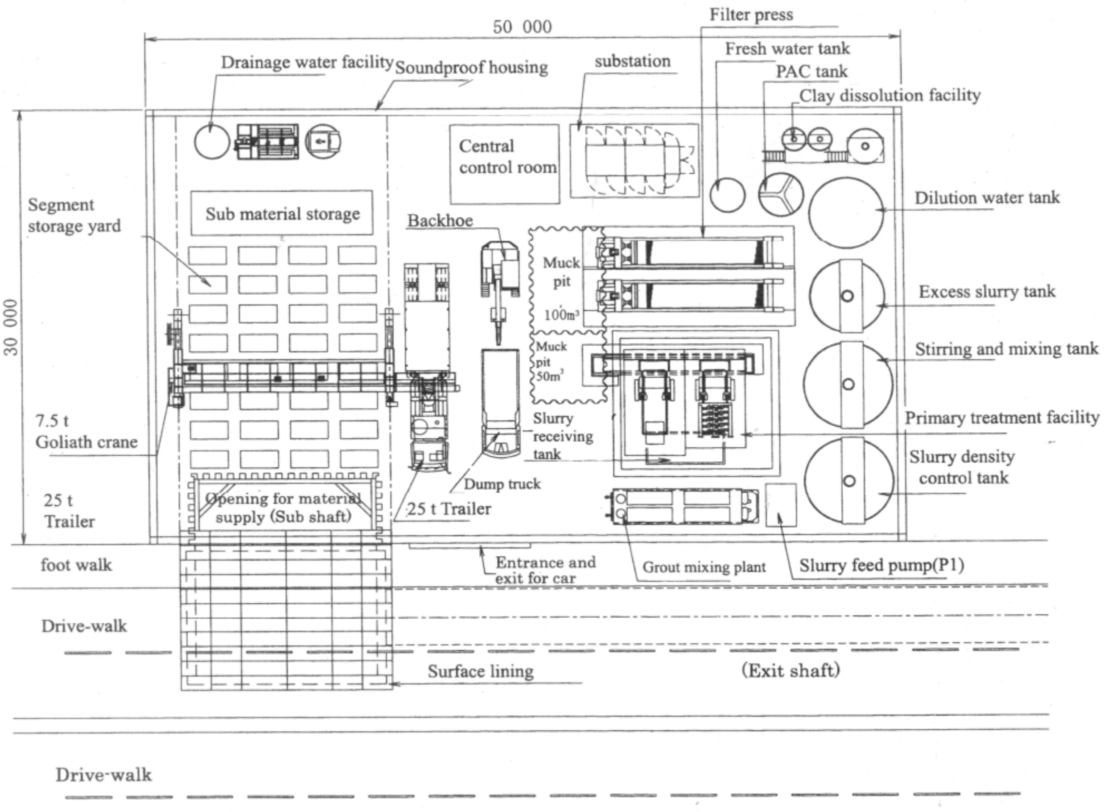


Source: HP Nishimatsu Construction Company

Figure 4.5.45 Sample of Back Yard Facility (Slurry Shield Machine)

d. Work Depot

Following figure shows general layout of TBM Operation Yard which requires about 30m width x 50m length.



Source: OCG Archives Hanoi Line 2 Basic Design Report

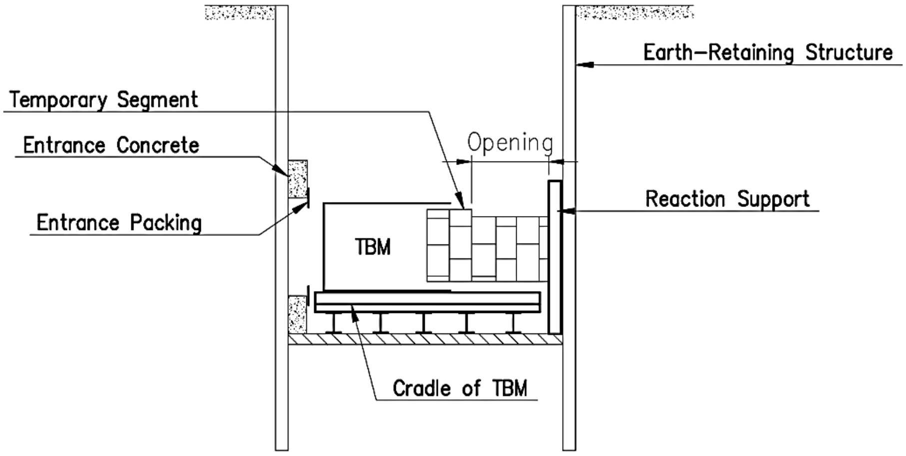
Figure 4.5.46 Example of Arrangement of Surry Shield Tunnelling Ground Facility (Japan Civil Engineering Society)

e. Protection of Launching and Arriving Shaft

The launching/arriving shaft requires space that is some 1.5–2.0m wider than that for the ordinary station box. When the TBM is dispatched, the diaphragm wall shall be removed after confirming that the face is stable or that the TBM can break directly through the diaphragm wall. The Study Team recommends the former because of its economic advantage.

The Jet Grouting Method was studied in this FS.

The equipment that is dispatched along with the TBM consists of TBM Support, reaction receiver and entrance packing, etc., as shown below.



Source: JICA Study Team

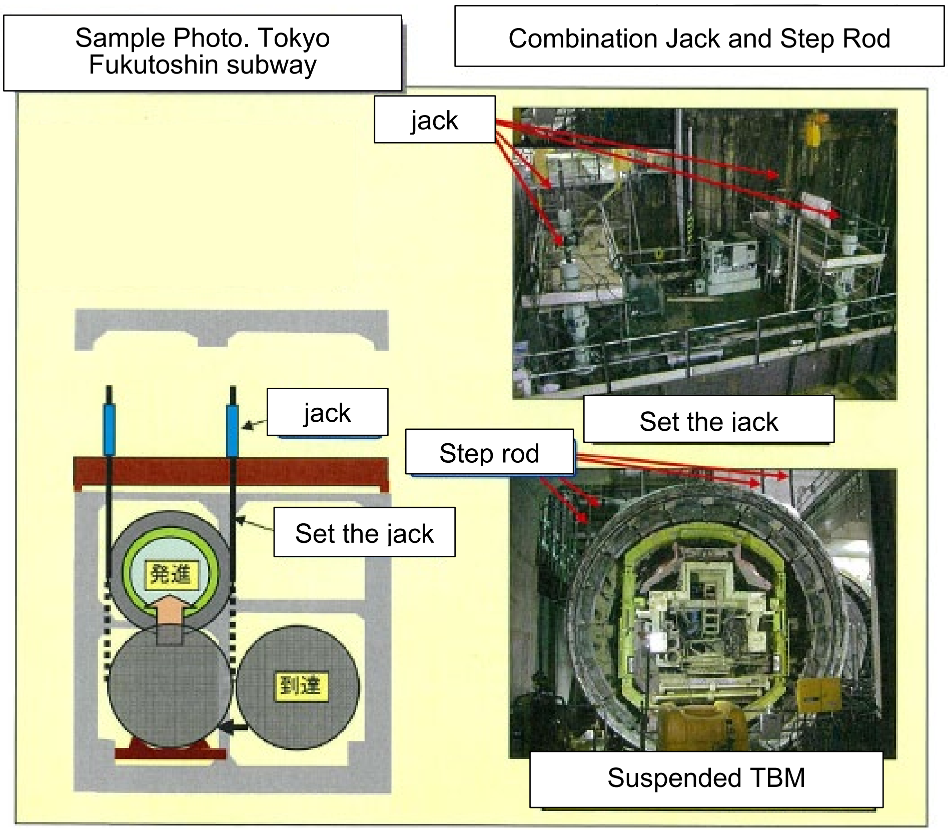
Figure 4.5.47 TBM Launching Shaft

f. TBM Transportation between Arrival Shaft and Launching Shaft

When TBM reaches the arrival shaft, the machine is transferred to the launching shaft, which is provided at the opposite side of the station box. There are two ways to move the TBM: one way is to pull it out from arrival shaft and then transport it to the launching shaft; another way is to move it in the station box by a TBM mover. A study on which method is adequate shall be made in such aspects as financial, construction schedule, and ground conditions.

In the case of transporting the machine in the station box, enough space to move shall be provided and structures shall be designed accordingly. In general, the track level space needed is about 7.8m, and vertical struts are not available within this area. The diaphragm shall be designed considering this issue. JST was concerned about the reinforcement volume and the structure becoming bigger. Reinforcement in the diaphragm restricts workability of concrete casting. There is much concern about the quality of the diaphragm which leads to future water leakage.

Accordingly, JST recommends moving TBMs on ground. Now this method is thought to be applied at Rajarbagh, Rampura, Hatir Jheel, Uttara Badda, and Future Park. The following figure shows an example of how this is done.



Source: Tokyo Metro

Figure 4.5.48 An Example:
TBM outer radius 6.7m, weight 360t was lifted up by 6.2m with 4 x 150t jacks

JST has an idea that two 200-ton cranes will pull out the TBM, which is some 350t after removing inside equipment. Expected weight of TBM is 180t – 120t. The pulled out TBM is transported by trailer to the opposite side and set down to the position required by two 200-ton cranes.

g. Production of RC Segment

The RC segments will be produced at pre-fabrication factories in Bangladesh; however, steel works such as formworks, bolts and nuts, and ductile segments shall be brought from abroad. JST developed the MRT Line 1 project scheme so that existing facilities shall be utilized as much as possible. With regards to the Concrete Segment which may be produced by present pre-fabrication factories which produce PC piles or PC panels. However since the concrete segment is required to have high strength, high level quality control is required.

Since lots with 5 segments are needed concurrently, it is highly possible that the factories will be far from Dhaka City. However, the transportation distance will not affect the work schedule much. This is because the segments necessary for a few days will be stocked near the launching shaft. Normally, 10 rings will be necessary per day, thus a minimum for 2 days should be stocked. There is also the option to temporary place at the depot and transport to each construction site, but loading and unloading of the segments to trailers will occur 2 times in this case, so it is not efficient. Also, a considerable number of vehicles will enter and leave the depot for works such as track circuit construction after land reclamation or building construction. On the other hand, the access road which will be made along the Approach Line will be used as the access road to the depot. A facility for

Padma Oil will be built nearby and access of large trailers may be restricted, thus it is not appropriate to store the segments in this area. There are examples that segments produced near Utsunomiya were used for shield construction in Tokyo, thus the distance between the factories and the construction site will not affect the work much. However, it is recommended that materials for works of 3 to 5 days to be stocked near the launching shaft.

h. Adjacent Structure Protection

As a normal practice, prior to construction work commencement, all adjacent structures including houses, buildings, flyovers, infrastructures and wells, etc. are recorded in detail to document their existing status. Scope of study is inclinations of houses, cracks on wall and well-water levels. Photos of the existing status are taken before construction commencement. After completion of construction, they will be investigated for any change/alteration.

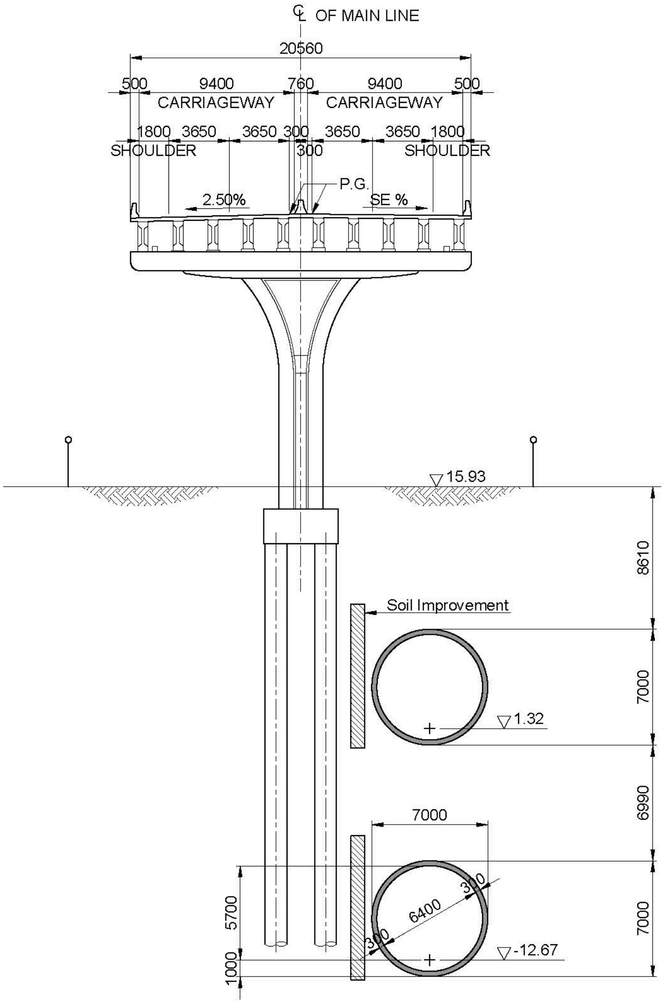
If necessary, adjacent buildings, bridges, and houses are to be equipped with devices to measure any movement, such as subsidence, inclination, et al. The status prior to construction commencement is studied; besides, the impact after construction completion is expected. Hence, the periodic measurement is implemented during the Defects Liability Period. That is written in tender documents.

Special investigation may be required for the following sites.

1) Highway Fly-over between Rajarbagh Station and Malibagh Station, and existing buildings, and existing railway,
2) Rampura Bridge
3) Kuril Fly-over, and
4) Buildings adjacent to underground stations

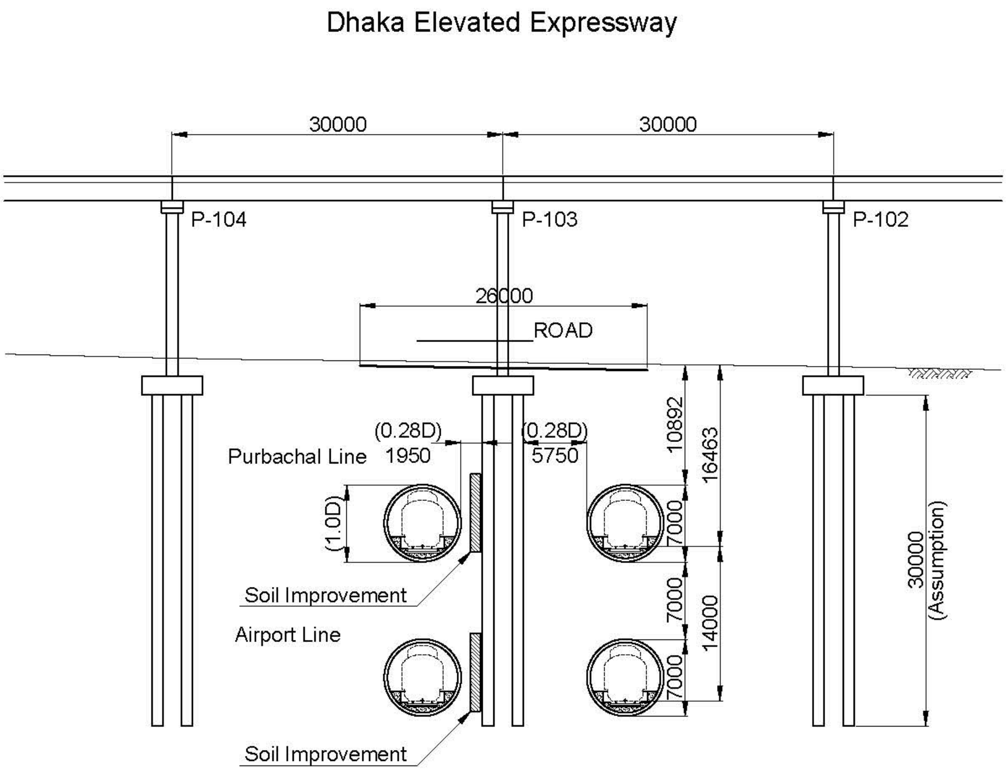
As example, prior to design settlement caused by tunnel construction shall be analyzed by FEM Analysis Method. Figures below are sample of Protection by soil improvement.

2K500m



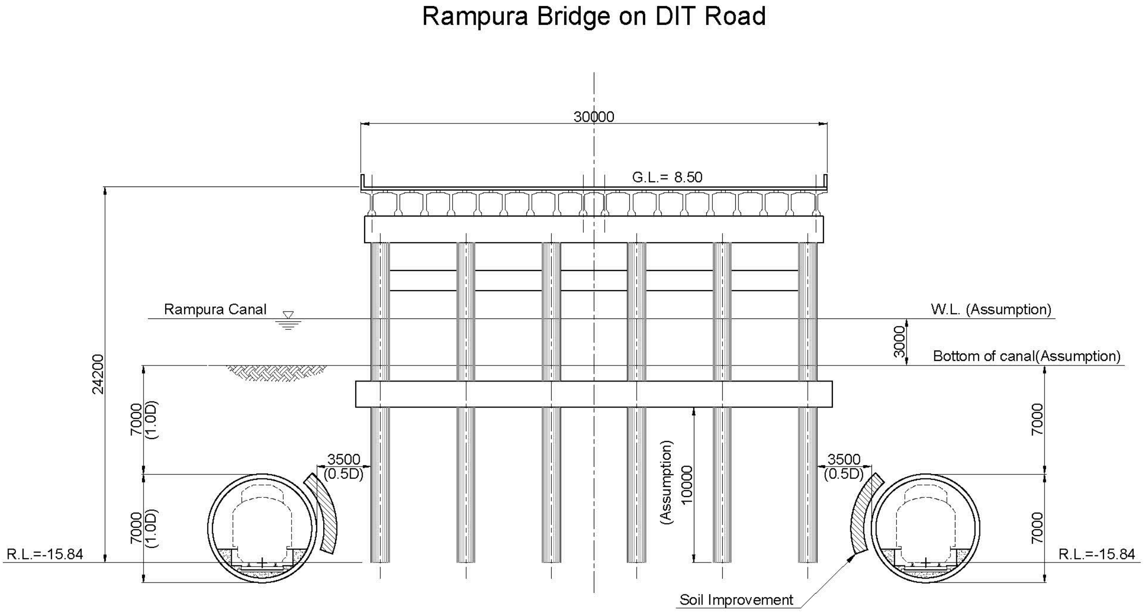
Source: JICA Study Team

Figure 4.5.49 Protection of Viaduct at 2K500m



Source: JICA Study Team

Figure 4.5.50 Protection of Rampura Brigde



Source: JICA Study Team

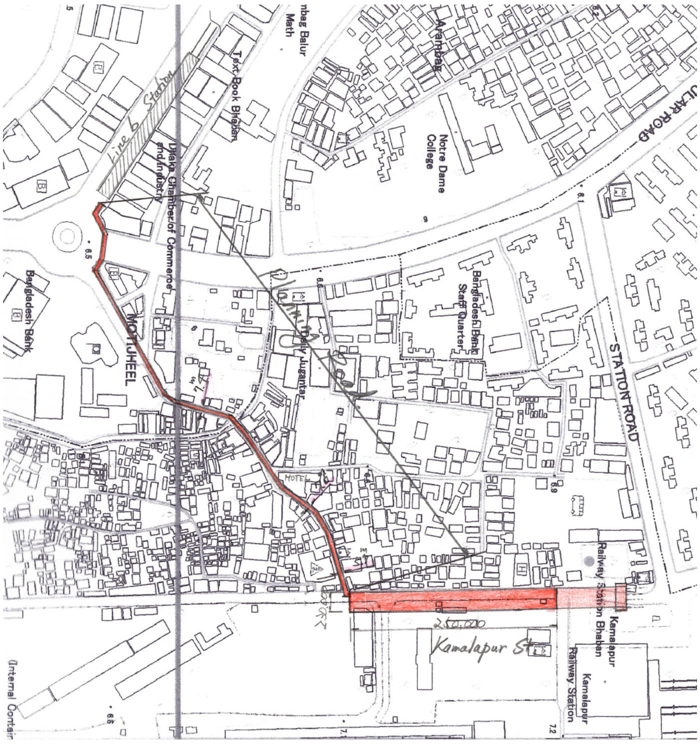
Figure 4.5.51 Protection of Kuril Fly-over

(3) Connection with MRT Line 6

a. Introduction

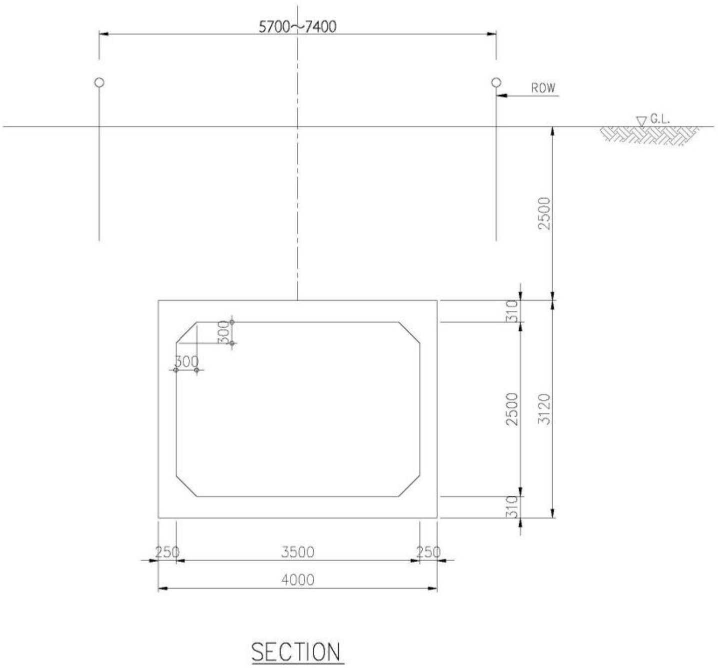
In MRT Line 1, the Airport Line will be constructed underground, while MRT Line 6 is under construction with an elevated system. The MRT Line 6 nearest station is the Motijheel and the JICA Study Team of Line 1 tried to connect Lines 1 and 6. As a result of several studies, connecting both lines appears to be difficult. But the Study Team recommends constructing an underpass beneath the Kamalapur road with concrete box culverts some 650m long, as shown below. The underpass will be constructed with pre-cast concrete materials.

b. Location and Size of Box Culvert



Source: JICA Study Team

Figure 4.5.52 Connection With MRT Line 6 by Underpass



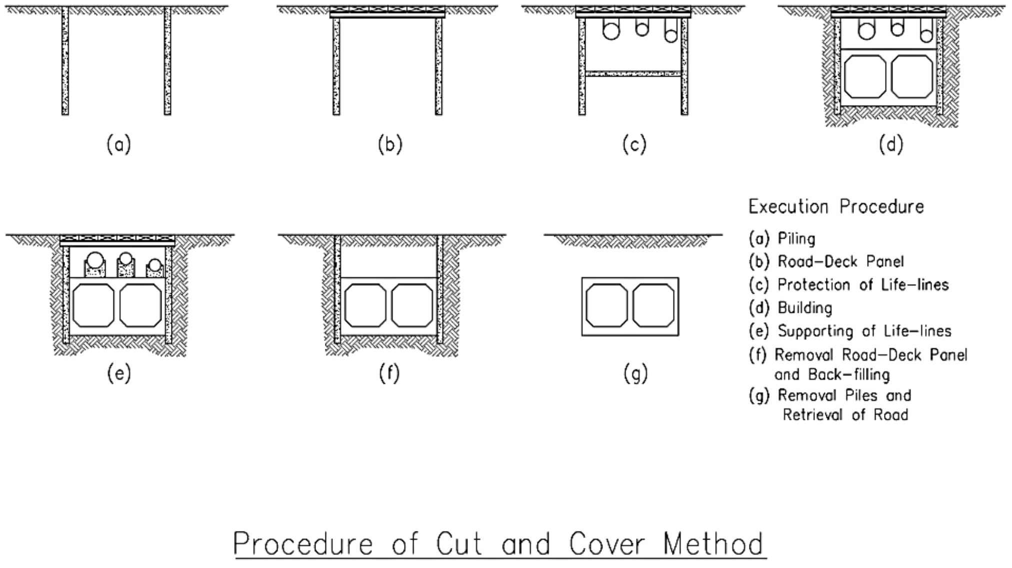
Source: JICA Study Team

Figure 4.5.53 Box Culvert Cross Section

c. Construction Plan

(a) Method

The generally utilized open cut method shall be applied. But the underpass construction works will take place at night, in consideration of the effects on the surrounding residences, retail shops and traffic above. Figure 4.5.54 shows the procedure of construction.



Source: Sankaido Underground Railway Construction Handbook

Figure 4.5.54 Procedure of Construction Box Culvert

(b) Quantities

As far as can be determined from the drawings available, an underpass with a length of about 650m is expected.

Excavation: V=19,240m^3

Concrete Volume: V= 2,542m^3

Backfilling: V=19,240m^3

Steel Sheet Piling (Type Ⅲ、L=8m): n=3,250 pieces

(c) Expected Schedule

Site works expected are as shown in the figure below.

Pre-cast concrete box culvert shall be separately manufactured at the concrete factory in advance.

Schedule of the connection between Line 1 and Line 6

ITEM		1 year												2 year												3 year		
	M	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
Temporary Works	1.0	━																										
Buried pipes and culverts, Diversion, Guard	3.0		━	━	━																							
Steel Sheet Piles	7.0					━	━	━	━	━	━	━																
Road Deckings	1.0												━															
Excavation, Earth-Retaining Structure	6.0													━	━	━	━	━	━									
Installation of Boxculverts	4.0																			━	━	━	━					
Backfilling	1.0																							━				
Removal of Road Deckings	1.0																								━			
Clearance	1.0																									━		

Source: JICA Study Team

Figure 4.5.55 Schedule of Underpass Construction

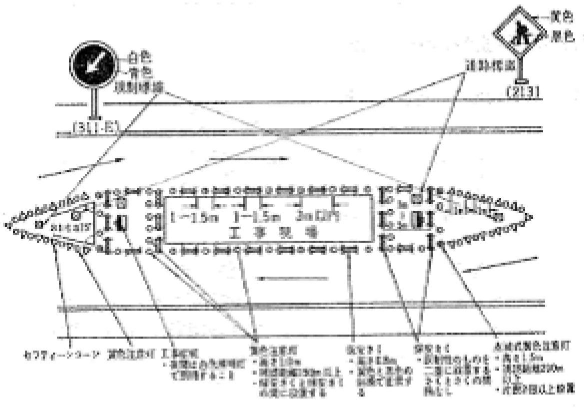
(4) Traffic Management Plan and Safety Management

a. Traffic Management Plan

As the first step, in order to keep car lanes open for road traffic, the existing pedestrian path shall be reduced in its width to 1.0m. Before work commencement, necessary announcements shall be made to the residents and workers. Also, car parking shall be restricted along the corridor not only where the road is directly affected but also the detour roads. Existing traffic lanes shall be kept during construction. For example road deck panels installation is a commonly used method world-wide. The deck panels may be used for long duration, and it is difficult to repair or replace during construction. The deck panel installation working method shall be studied in detail with discussion with related authorities such as police and road owners. The construction of the diaphragm wall shall take place at night, and the road traffic lanes shall be kept open as much as possible at daytime. The works shall be limited to available works in the central working area shown below. Traffic controllers are required at both sides of the working area. Further, it is important to coordinate with adjacent sites to minimize traffic-related construction problems.

Without the Airport Road the width of the road above MRT Line 1 is approximately 30 to 40 meters including pavements. In order to build a central working island (about 10m wide by 65m long) as shown in the figure below, it is required to narrow pavements to make space for roadways. Furthermore, an additional space of roadway shall be ensured by narrowing the width of the existing single lane road from 3.6 ± 1 to 2.75 meters. If the reduction on the number of lanes is unavoidable, the plan is that at least a single lane on each side is ensured. As mentioned above, the open cut excavation in station section shall take place with road decking panels during night time in order to minimize the negative impact to road traffic. Additionally, it is necessary to let road users take a detour by providing them with information.

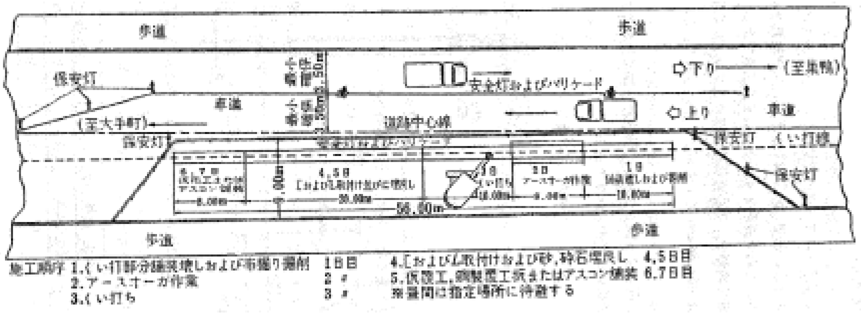
〈Working Island provided at Centre of Road〉



Source: Sankaido Underground Railway Construction Handbook

Figure 4.5.56 Central Working Island

〈One side Working Island〉



Source: Sankaido Underground Railway Construction Handbook

Figure 4.5.57 One side Working Island

b. Safety and Security Management Plan

The contractor shall respect all Bangladesh laws and practices related to construction works, safety and environmental management. Related laws and practices shall be studied by the consultants who are engaged in the engineering services. Lack of safe practices shall be found and reported to the Client for necessary actions. With regard to safety regulations and practices for underground works, a new regulation will be required. In Bangladesh, there is no experience of underground facility construction such as underground railway, underground shopping complex or underground utility, new practice/standard shall be established in prior to construction of MRT Line 1. In the project of MRT Line 6, tailor made safety manual has been created and provided to the Contractors as guideline to establish Contractor's Safety Plan. Such manual has been made according to Bangladesh Labor Act and Labor Low in adding British Standards EN, US Standards, NFPA, IIEC (International Electro Technical Commission), and OSHA

(Occupational Health and Safety Management System, USA) concerned articles related to viaduct construction. In construction MRT Line 1 JST recommend to add to this MRT line 6 Safety Manual following subjects related to Underground Works.

- Prevention of deficiency of oxygen
- Water Pollution Prevention
- Waste Control/Management
- Chemical Grouting, and
- Safety of Third Parties

Risk analysis shall be conducted prior to the commencement of the works. Emergency practices shall also be established.

The Construction Safety Manager shall be given enough power by management to ensure that health and safety standards are respected. The Safety Manager and his staff shall patrol every site and working place every day. All safety activities shall be recorded and regularly reported to the Company Management.

According to the project survey conducted by JICA, “The Guidance for the Management of Safety for Construction Works in Japanese ODA Projects”, the trend of safety management is as follows:

In developing counties, laws and regulations of the country in order to establish a safe and health-conscious working environment have been improved. However, in an actual construction project, the laws regarding construction or management standards, which are the base for safety management, are not implemented enough. Then, since there are only a few experts who have been in charge of big projects such as ODA construction projects, in reality it is difficult in the construction field for the knowledge or data regarding safety management from one project to be taken over to the next project. Under these circumstances, the role of a consultant, who manages a project instead of the local government, is crucial to implement the ODA construction project smoothly. On the other hand, the implementing body, in this case the local government, has to fully understand the importance of safety management to enhance a consciousness of safety management at a construction site.

The first responsibility belongs to the contractor, but, in order to minimize the number of accidents, the Client, consultants and contractor shall develop the safety management system and implement it.

The ES consultants will prepare the “Safety Management Guidelines” during the ES and these will be incorporated into the Bidding Documents. The contractor shall include an Initial Safety Management Plan in bid submission.

In order to ensure the safety of project personnel, it is necessary to establish and operate safeguards for both the temporary office, which will be fixedly used, and for construction sites, which will move according to the progress of the project.

【Temporary Office】

- In order to prevent easy breakthrough even from external attacks using rifles or explosives, walls of 30 cm in thickness and more than 2.0 in high shall be established around the temporary office (1,500 m in total circumference), and a fence (more than 1.5 m in height) with barbed wire with a diameter of more than 0.5 m shall be placed within.

- Two entrances shall be established for the temporary office, with security guards at all times with entries and exits controlled.
- Three escape doors shall be established for escape outside in case of emergencies.
- Monitoring towers shall be established at four corners of the outer fence, with security guards placed and CCTV cameras installed to constantly monitor along the outer wall and far off.
- A total of twelve CCTV cameras shall be installed along the outer fence, entrance and within the office to monitor day and night in the security control room, with the video recorded (at least for 30 days), and control and operate the guards in case of emergencies.
- Six guards shall be arranged at all times, controlling entries and exits, monitoring and taking care of incidents.

【Construction Site】

- Two facilities (Base Camp and Sub Camp) shall be established at the construction site, with a fence (more than 1.5 m in height) with barbed wire with a diameter of more than 0.5 m surrounding a space of 250m×25m shall be placed within with six guards at all times to protect them.

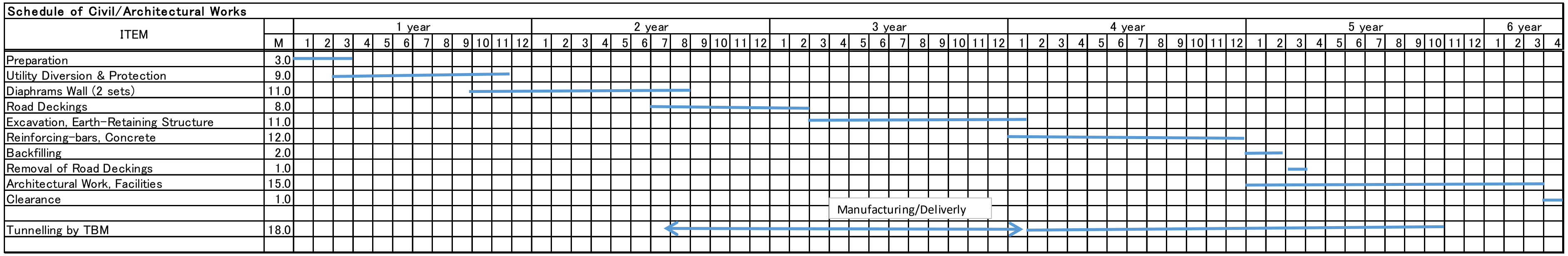
c. Water management during construction

The following matters must be stated in the bidding document. Prior to the start of the construction work, the constructor must conduct a water quality inspection for the existing well and record the water level. Furthermore, it is necessary to regularly observe the water quality and water level according to the progress of construction. Regarding the definition of the distance from the tunnel and the underground station and the range within which the impact can be tolerated, the case of foreign countries shall be examined and decided.

(5) Underground Section Construction Schedule

In making the Construction Plan, the Station Box (TBM Dispatch Shaft) and Shield Tunnelling were separately studied. There are twelve underground stations, and some stations contain a scissors crossing or a crossover. There are two-level and three-level stations. In this FS, the standard type of underground station was the subject of the study. With regard to shielded tunnelling, the Study Team assumed one contractor would construct 2.5 km with two TBMs. In the construction of an ordinary underground station, the Study Team assumed two groups of workers and 2-shift system. To meet the schedule for the standard underground stations, the number of workers per group shall be increased.

With regard to the transition where the underground track rises up to the ground level and then to the elevated level, other groups of workers shall be engaged. Therefore, this transition construction is not critical.

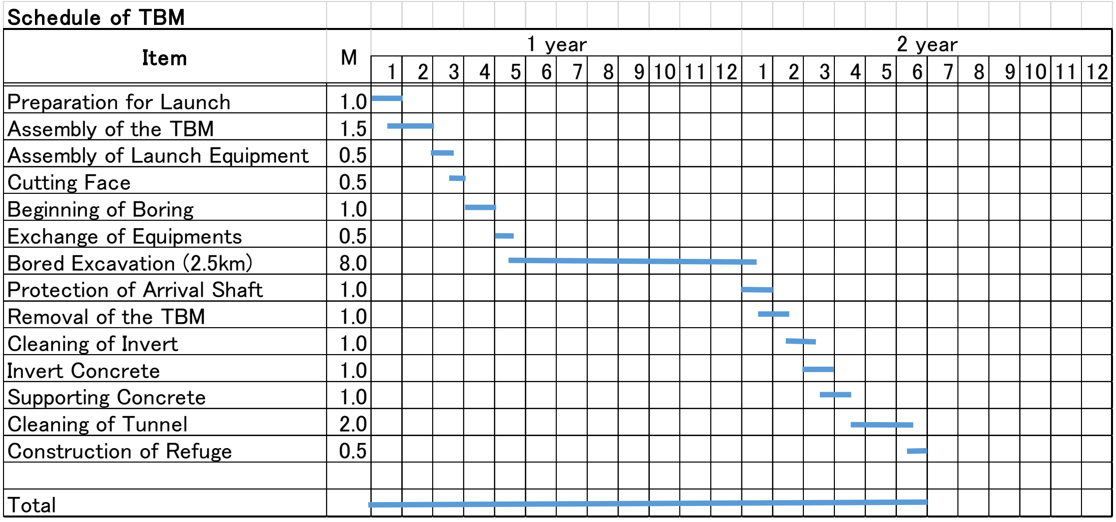


Schedule of Civil/Architectural Works

ITEM	M
Preparation	3.0
Utility Diversion & Protection	9.0
Diaphrams Wall (2 sets)	11.0
Road Deckings	8.0
Excavation, Earth-Retaining Structure	11.0
Reinforcing-bars, Concrete	12.0
Backfilling	2.0
Removal of Road Deckings	1.0
Architectural Work, Facilities	15.0
Clearance	1.0
Tunnelling by TBM	18.0

Source: JICA Study Team

Figure 4.5.58 Underground Civil Works Construction Schedule



Schedule of TBM

Item	M
Preparation for Launch	1.0
Assembly of the TBM	1.5
Assembly of Launch Equipment	0.5
Cutting Face	0.5
Beginning of Boring	1.0
Exchange of Equipments	0.5
Bored Excavation (2.5km)	8.0
Protection of Arrival Shaft	1.0
Removal of the TBM	1.0
Cleaning of Invert	1.0
Invert Concrete	1.0
Supporting Concrete	1.0
Cleaning of Tunnel	2.0
Construction of Refuge	0.5
Total	

Source: JICA Study Team

Figure 4.5.59 Tunnel Construction Schedule by TBM

(6) Rough Estimation of Quantities

Major works of construction underground section is summarized in the following table:

Table 4.5.7 Major Works Quantities

Calculation of Quantity

St. Type	Chainage	Station Name	Length(m)	Segments L(m)	O Width(m)	O Length(m)	Depth(m)	D-wall Plan L(m)	Exc Volume(m3)		Concrete V(m3)
Standard	0k125	Kamalapur St.	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8		19,630
			874	874	–	–	–	–	67,268.9		
Standard	1k249	Rajarbagh St.	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8		19,630
			1,856	1,856	–	–	–	–	142,850.3		
Special	3k355	Malibagh St.	250	–	14.55	253.0	27.00	531.1	85,765.4		
		Ductile Segments	–	250	–	–	–	–	19,241.7		
			702	702	–	–	–	–	54,030.7		
Standard	4k307	Rampura St.	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8		19,630
			933	933	–	–	–	–	71,810.0		
Standard	5k490	Hatir Jheel St.	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8		19,630
			811	811	–	–	–	–	62,420.0		
Standard	6k551	Badda St.	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8		19,630
			782	782	–	–	–	–	60,188.0		
Standard	7k583	Uttar Badda St.	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8		19,630
			595	595	–	–	–	–	45,795.2		
Special	8k568	Notun Bazar St.	530	–	38.3, 43.1	530.0	18.95, 20.45		370,472.5		
			1,194	1,194	–	–	–	–	91,898.3		
Special	10k152	Future Park St.	250	–	22.4, 27.2	253.0	26.70, 28.20	566.0	141,029.6		
			2,215	4,430	–	–	–	–	170,481.4		
Standard	12k617	Khilkhet St.	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8		19,630
			1,177	1,177	–	–	–	–	90,589.9		
Standard	14k044	Airport Terminal 3	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8		19,630
			596	596	–	–	–	–	45,872.2		
Standard	14k890	Airport St.	250	–	22.2, 27.0	253.0	18.65, 20.15	565.6	97,861.8		19,630
			141								
		Sub Total	15,156	13,950					2,400,470		176,670

Source: JICA Study Team

(7) Other Issues to Study in ES

a. Excavated Soil Disposal

Principally, the excavated soil shall be utilized by other consumers. There is a possibility that the soil produced by the shielded tunneling will contain contaminants and will not be suitable for re-use. At present, we have not done a soil investigation yet. The ES consultants shall carry out detailed soil investigations and establish waste control plans.

Excavated soil shall be treated on site before bringing it out from the site. The method of treatment shall be carefully studied in accordance with geological practices, method of transportation and availability of land for a treatment plant.

As a method of treatment, there are two types: physical treatment (like dewatering, natural air drying, compel type, etc.) and chemical treatment such as mixture with chemical materials (cement, lime and highly polymerized compound, etc.).

JST considers that the excavated material from the underground station could be brought to a temporary stock yard and re-used as backfill.

Excavated material is expected to be suitable for backfilling; they shall be utilized for other projects. Once there is no possible project, such material shall be brought to the candidate site for expansion of depot and used as pre-loading. If such material is deemed contaminated by Bangladesh laws on environmental protection, the material shall be correctly treated. A more detailed study shall be made at the period of Engineering Service.

Since the excavated soil may contain wastes, the soil is tested periodically and then discarded in accordance with the regulation of Bangladesh.

b. Coordination between Airport Terminal 3 Station and MRT 1 Underground Station

There is a plan for a Dhaka International Airport Terminal 3 Construction Project.

For airport passengers and employees of the airport, MRT 1 Underground Station is recommended by JICA. Accordingly, the JICA Study Team studied the location and size of such underground station.

At present, Airport Terminal 3 is planned at the south of the existing international airport and is connected with MRT Airport Terminal 3 Station under the Airport Road. As the convenience of airport users with baggage is considered, people movers and lifts and escalators in stations should be installed.

c. Underground Structure and Alignment

A detailed study at some locations shall be carried out when the topographic survey data is available. There are concerns about land acquisition and difficulty of construction. During the engineering survey, the existing alignment plan shall be reviewed.

d. Track Alignment

At the time of writing this report, the topographic survey remains to be done. In ES stage, a detailed survey is inevitable. The Study Team is concerned that structures provided within road ROW encroach private land and results in additional land needed.

e. Ready Mixed Concrete/ Concrete Production Plant

Since concrete volume required is so much, it is concern to meet the demand by existing ready mixed concrete factories near Dacha. Even they produce enough ready mixed concrete, traffic condition in Dacha is one big issue. In order to meet specification requirement, the ready mixed concrete shall be delivered to the site within specified time. Further ready mixed concrete mixing vehicles may cause traffic congestion in the city. Then JST propose that the contractors shall have own concrete plants near the site.

4.6 Station Architectural Works and Facility Plan

4.6.1 Architectural Works Plan

Condition of Station Planning

Passenger stations are planned considering demand forecast, car numbers, track alignment, civil structure, mechanical and electrical facilities, O&M planning, city planning and intermodal access. This section discusses the conditions and basic ideas related to the station architectural works.

1) Station Size

Station size is basically defined according to the following criteria:

- Concourse floor length is designed in consideration of accumulated dimension of minimum concourse length + station office + E/M rooms + station tunnel ventilation rooms and praying facility.
- Platform length is designed in consideration of train length+5m of clear space at both ends of the platform.
- Platform width is an accumulation of minimum stairway width + Escalator + wall + reasonable width between stairway walls to Platform Screen Doors (PSD) (Minimum of 2.0m)

Station size including platforms, concourse, stairs, and ticket gate numbers is basically defined to keep passengers' safety, comfort and serviceability at peak hour. In MRT Line1, PSD are planned to be installed in every station. PSDs can secure passenger safety, but a congested platform tends to cause troubles and delays in train operation. Vertical access routes between concourse and platforms shall have adequate capacity, so that passengers can move out of the platform before the next train arrives, and at the same time, the platform shall have enough space to accommodate passengers waiting for next trains.

2) Ticket Gates and Security Check Gates Planning

There are four main access routes from the street level to the B1 concourse level designated at both sides of public area (layout is shown in section 4) of 4.6.1There is one ticket gate at the centre of the concourse. Entrance and exit are clearly separated. Number of ticket gates will be calculated based on demand forecast, and it shall be later verified by final demand forecast for each station. In this study, width of ticket gates is planned based on the MRT 6 station plan.

If necessary, provide a security check gate which has an area of 2.5m x 3.5m to arrange the gate checking itself plus security staff and baggage check table. Basically 2 check gates should be provided at each entrance. There should be wide space not only in front of ticket gates, but also at security check gates as queues at check gates are expected.

3) Station Office and Ticket Machines

The station office area is planned based on the MRT Line 6 station plan. There are the control room, station office, station master room, security guards room, maintenance room, staff mess, prayer room, first aid room, staff toilet, storage, etc.

The size of the area is estimated to be 450m^{2}including corridors.

4) Public Toilet

Passenger toilets shall be provided in paid areas in every station. Men’s toilet, women’s toilet and a toilet that caters to the needs of physically challenged persons will be provided.

5) Elevators and Escalators

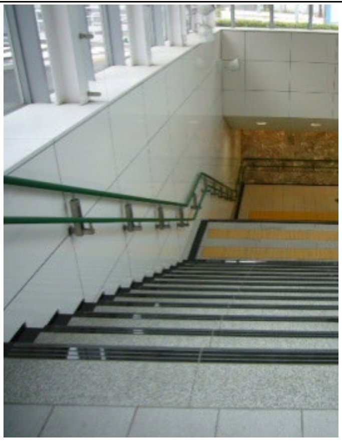
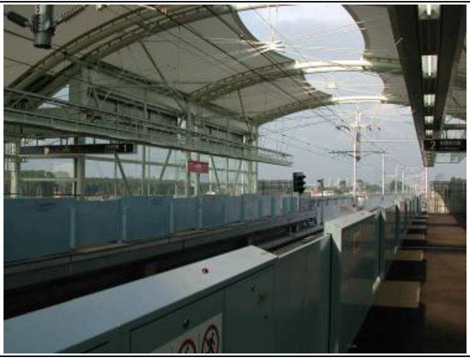
Escalators shall be provided in every station from the ground level to the concourse level, one at the north side and another one at the south side of the street. At least one set of up-down escalators shall be provided from concourse level to platform level.

At least one elevator shall be provided from ground level to concourse level and concourse level to platform level for physically challenged persons.

Stations with large numbers of passengers and for transfer stations, more escalators and elevators will be provided. The number of escalators and elevators will be determined by the passenger demand.

6) Barrier Free/ Universal Design

Stations, as part of public transportation system, need to be more disabled-friendly by means of installing facilities that will provide easier access to passengers with physical and visual disabilities. Disabled-friendly design shall basically be performed in accordance with the Bangladesh Code; and the design can be further improved by applying advanced design concepts, referring to “Barrier-Free Design Guidelines (Passenger Facilities Edition)” by the Ministry of Land, Infrastructure, Transportation, and Tourism of Japan. Related features are shown in figures below.

	
Automatic Escalator with 3 flat steps	Guiding/ Warning Blocks for the blind
	
Level of handrails and colour of nosing	Elevator with wheelchair turning space
	
Half-height platform screen Door	Low height counter at ticket gate
	
Level of bench	Toilet with equipment and accessories for Physically Challenged Persons

Source: JICA Study Team

Figure 4.6.1 Barrier – Free Design Related Features

(1) Access to Stations

Each station shall have at least one designated barrier-free route. This is a route with an elevator allowing passengers in wheel chairs to move smoothly between the ground level and platform level. The approach to the elevator at the ground level should have a ramp or a ramp plus stairway installed. Guiding blocks for visually impaired persons shall be installed along the barrier-free route.

(2) Concourse

The concourse floor should not have a floor level gap, but if a floor gap is unavoidable, a ramp shall be provided which complies with the barrier-free guidelines. The floor surface of a concourse should be made of non-slip material.

(3) Ticket Gates

At least one of the ticket gates should be wide enough to allow wheelchair users to pass through easily.

(4) Automatic Ticket Vending Machines

The coin slot should be at a suitable height for easy insertion of coins by wheelchair users. A knee recess beneath the ticket vending machines should be provided.

(5) Stairways

The stairways for passengers should have two levels of handrails which comply with the barrier-free guidelines and match the universal design concept.

(6) Platforms

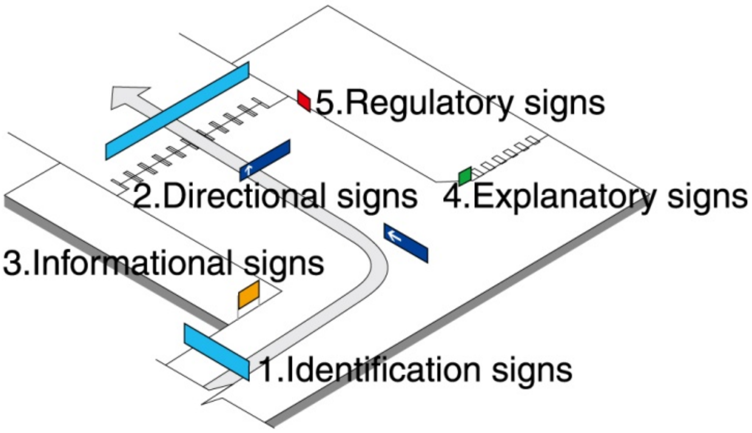
At platforms at least one designated route with guiding blocks for a visually impaired person shall be provided. The surface of the platform must be made with a non-slip material.

(7) Signage Design

In railway stations, signage shall be easy to understand for various passengers. Signage such as direction, indication, and information signs should be located at the proper places and should be clearly recognized. Types of signage and their examples are given in the following Figure 4.6.2.

(8) Pray Room

This capacity and required facility should be decided in agreement with owner.



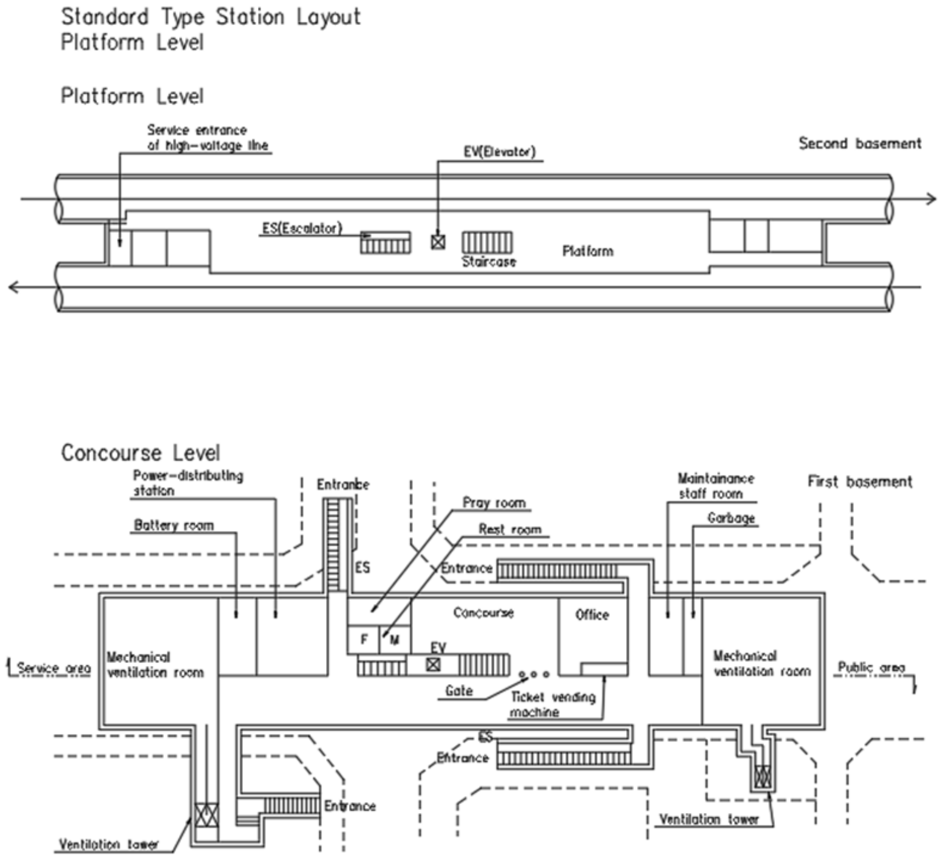
1	Identification Signs	Identify facilities
2	Directional Signs	Direct passengers to platforms, etc.
3	Informational Signs	Provide information about station facilities
4	Explanatory Signs	Train Maps, Fare Chart, etc.
5	Regulatory Signs	Prohibitions, Rules

	
Informational sign	Train operation sign
	
Ceiling mounted directional sign	Standing directional sign

Source: JICA Study Team

Figure 4.6.2 Type of Signage

A standard station layout is shown below.



Source: JICA Study Team

Figure 4.6.3 Standard station layout

4.6.2 Mechanical Facilities

1) Air-Conditioning Facilities

(1) Introduction

The purpose of air-conditioning facilities is to provide comfort in the station. However, the structure of the station is different from a normal building and the method of air-conditioning is also different. The station is an elongated structure in a longitudinal direction. In addition, the platform and concourse are connected to the outside through the exit/entrance and the efficiency of air-conditioning is decreased by these circumstances. The design heat load per unit area is bigger than that of normal buildings. In addition, the air-conditioning system in the station should be a simple component and structure, taking into consideration the ease of operation and maintenance work.

(2) Cooling Method

a. Central Cooling System

The central cooling system is applied for large spaces such as the platform, concourse and station offices.

b. Stand-Alone Cooling System

The stand-alone cooling system is basically applied for the electric and communications facility rooms (substation, signalling equipment room, and communications equipment room). These rooms are very important for train operations and refuge guidance in case of emergencies. Thus, standby facilities are used as emergency backup.

(3) Air-Conditioning Method

a. Unit Duct System

The unit duct system is used for large spaces such as the platform and concourse.

b. Fan Coil Unit System

The fan coil unit system uses a central cooling system and is locally controlled. It is applied in the station office and rooms where station staff stays.

c. Package Air-Conditioning System

The package air-conditioning system is a stand-alone system. Therefore, it could be used separately from the central cooling system, which is stopped when the train is not in operation. It is applied for electrical facility rooms (substation, signalling equipment room and communications equipment room) and rooms related to station operations. This system is also applied to the elevated stations.

2) Ventilation System

(1) Introduction

The purpose of ventilation is to provide comfortable and hygienic space in the station by taking in fresh air from outside the station, and removing polluted air from inside the station. Ventilation is also purposed to control the temperature inside the station, which is raised by the heat emitted by passengers, trains and other facilities. Mechanical ventilation is used for the project. In the stations where full-height platform screen doors are applied, the ventilation system of the platform is separated from that of the tunnel. Therefore, such ventilation systems are designed as separated and segregated systems.

(2) Ventilation Method

a. Ventilation Method of Platform

The purpose of ventilation in the platform is to provide fresh air from outside and provide comfortable and hygienic conditions for passengers, and to exhaust heat generated in the platform. Based on the structure of the station and the requirements of the huge volume of fresh air, the Type 1 ventilation system is applied and the ventilation system doubles as an air-conditioning system.

b. Ventilation Method of Concourse

The system for ventilation of the concourse is the same as that of the platform.

c. Ventilation Method of Station Office, etc.

The ventilation of the station office and other rooms where the station staff stays longer is planned to meet the requirement of Japanese and local standards as well as other related standards or regulations.

d. Ventilation Method of Tunnel

The purpose of ventilation of the tunnel is to provide fresh air from outside and to draw out the heat in the tunnel. In the mechanical ventilation method, the air in the tunnel is supplied and exhausted mechanically by fans. This method has the advantage of having a high capability of ventilation for the huge amount of generated heat in the tunnel as compared with the natural ventilation method.

3) Smoke Exhaust System

(1) Introduction

In the event of accidental fires in the station and tunnel, the smoke exhaust is one of the essential factors for passenger evacuation and fire fighting. The smoke exhaust system is designed based on Japanese Standards (the Standard of Fire Safety Management for Subway Station, etc., Ministerial Ordinance of the Ministry of Land, Infrastructure, Transportation and Tourism, Japan), and other related standards or regulations. The dedicated exhaust duct and fans are provided for these areas.

(2) Smoke Exhaust Method

a. Smoke Exhaust for the Platform

The volume of the smoke exhaust is large and it is not economical to install the air duct only for the purpose of smoke exhaust. In addition, the space above the platform level is limited. Thus, it is reasonable and economical to use the ventilation system for the smoke exhaust in case of an accidental fire. The basic policy of the smoke exhaust is as follows:

- Shared use of exhaust duct
  Type 1 ventilation (mechanically supplied and exhausted) is applied for the ventilation of the platform. Therefore, the exhaust duct for the ventilation is used for the exhaust of smoke in case of fire.
- Exhaust Mouth in Residential area
  If the mouth of the exhaust shaft is located in the residential area, the air supply duct will be used for the smoke exhaust after the duct is turned and the direction of air flow is reversed.

b. Smoke Exhaust Method of the Concourse

The smoke exhaust system is designed based on the volume of diffused smoke.

c. Smoke Exhaust Method of the Station Office and Other Rooms where the Station Staff or the Passengers stay longer

The smoke exhaust system is designed based on Japanese and local standards, and other related regulations. The dedicated exhaust duct and fans are provided for these rooms.

d. Smoke Exhaust Method of the Tunnel

In case of an accidental fire in the tunnel, the tunnel ventilation fans are used for the exhaust of smoke. The air speed for the smoke exhaust has to be smooth in order to secure the safety of passengers and to help in fire fighting. The power of the exhaust fans is to be designed considering that the smoke exhaust system doubles as a ventilation system.

4) Water Supply & Drainage and Fire Fighting System

(1) Water Supply System

The amount of water supply in the station is determined by the number of passengers in the station, the number of station staff and the requirements for air-conditioning. The following are the three main types of water supply system:

a. Direct connection to public water supply pipe

Water pressure is influenced by the fluctuation of water pressure of the public water supply pipe, and it is necessary to connect it with a large diameter pipe in order to secure the large demand of water during peak time. Moreover, this system does not have a local storage water tank in the station, and there is a possibility that the water supply is stopped due to a stoppage in the public water supply. Therefore, this system is not suitable for water supply of the station.

b. Domestic water supply with the gravity tank

It is difficult to secure enough space in the ground level for the installation of a gravity tank. Therefore, this system is not suitable for water supply of the station.

c. Domestic water supply with the pressurized tank

This system is suitable for the stable water supply of the station.

(2) Drainage System

The metro station is located underground. Thus, drained water is collected in the storage tank and pumped up to the ground level. Drained water is classified into two systems: one is wastewater and the other is rainwater and groundwater.

a. Wastewater

Wastewater is collected from many places in the station and the length of the pipe tends to be longer. In order to secure appropriate hydraulic gradient, the station will be divided into several zones and the storage tank will be assigned in the appropriate position. Sewerage treatment facilities will be required for effluent to be discharged into public sewage based on local standards.

b. Rainfall and Groundwater

Rainwater and groundwater from the tunnel are collected at the end of the platform where the storage tank is installed.

(3) Fire Fighting System

In order to prevent and minimize accidental fires, the following fire fighting systems will be installed:

- Hydrant for platform, concourse and other areas
- Automatic sprinkler for station staff room, etc. and storage room
- Water supply pipe and hydrant in the tunnel
- Special fire extinguishing equipment for facilities vulnerable to water damage such as substations and signalling and telecommunications system

5) Station Electric Works

(1) Power Supply System

The switchboards, as part of the power supply system, will be installed at appropriate locations in the station in order to supply power to where it is needed. The types of power using items are categorized as lighting fixtures, emergency lights, socket outlets, air conditioning, ventilation, water supply and drainage, fire protection facilities, and so on. The main line and branch cables will distribute power to each piece of electrical equipment. The cables will be installed on cable trays or cable racks.

(2) Lighting equipment

The type, size and shape of lighting fixtures will be determined depending on the buildings and locations. Detailed arrangement will be coordinated in the architectural design phase. Surface mounted lighting fixtures, recessed mounted lighting fixtures and downlights shall be installed in the area with ceilings. High Illumination Discharge (HID) lighting fixtures shall be installed in high ceiling areas.

(3) Socket Outlet System

General socket outlets will be installed where necessary. Types of socket outlets are AC230V and 2P+E. The number of socket outlets for a single circuit will be a maximum of 6, and the capacity will be 6A and 16A, but not limited to these values when it is not applicable. Embedded socket outlets will be supplied in rooms for workers and exposed socket outlets will be supplied for other rooms.

(4) Fire Alarm and Detection System

Fire Alarm and Detection equipment are for the protection of life and property from disaster; thus, certain effective equipment is necessary. Fire alarms are effective for the early detection of fire. The fire alarm equipment is a system that perceives heat and smoke generated by a fire at the early stage and puts out an alert by the sound device in the station.

4.7 Track Plan

4.7.1 Design Standard of MRT Line 6

As proposed by RSTP, the Dhaka MRT line will be connected to other MRT routes and to other modes of suburban transportation networks such as BRT and BR. The plan is to have all routes of the MRT system under a single operator, i.e. DMTC.

Therefore, it is desirable to keep the specification consistent on each line for the track structure from the viewpoint of equipment and maintenance.

MRT Line 6, which is currently under construction, adopted the following track specifications, and it is also recommended that MRT Line 1 adopt the same specifications.

Table 4.7.1 Specifications of Track Structure

Item	Specification	Applicable Section
Gauge	1,435mm	All Track
Track Structure	Concrete bed track (Slab Track or Plinth Track)	Main Line (Elevated, Underground), Depot Access Line
	Concrete vibration-reducing bed track (Slab Track or Plinth Track)	Main Line (Steep curve section / Noise and vibration-reducing point)
	Ballasted track	Depot
Track width	Concrete bed track 2,060mm (Plinth Track)	Main Line
	Ballasted track 4.440mm	Depot
Thickness of Track	Concrete bed track 600mm (Including drainage concrete)	Main Line
	Ballasted track 600mm (Ballast bed depth 250mm)	Depot
Classification of Rail	UIC 60, Head-hardened Rail	All Track
Welding of Rail	Flash butt welding or Alumino-thermic welding	Main Line
Rail fastening device	Wire spring type or Plate spring type	All Track
Sleeper	Concrete bed track, PC Sleeper or Monoblock	Main Line
	Ballasted track, PC Sleeper	Depot
Simple turnout	1 in 7 type or T1 in 9 type Turnout	All Track
Crossover	Ditto	All Track
Scissors crossover	Ditto	All Track
Expansion Joint	UIC 60 type	Continuous welded rail section of Main line
Car stop	Buffer type	All Track

Source: Modified by JICA Study Team from MRT Line 6 Design Report

4.7.2 Specifications of Track Materials

1) Direct-Fixation Track

Not only Japanese Railway Companies but also many countries with MRTs have adopted the Direct-Fixation Track System (DFTS) for reducing maintenance costs. However, many track experts are of the opinion that the DFTS causes higher noise levels and bigger vibrations to the surrounding area compared with the ballasted track. Recently a new type of DFTS has been developed in which elastic mats are inserted underneath the concrete slab in order to protect the ballast and reduce noise and vibration.

The Japanese Government has recently set new environmental quality standards for noise in which the allowable noise level is 60dB for day time while 55 dB at night time. This new standard shall be applied in new railways including the MRT.

In order to meet this level, a new type of DFTS was developed by the Railway Technical Research Institute (RTRI) of Japan. Details are shown in Figure 4.7.1 below. This track system has advantages not only in vibration aspect but also in noise reduction. In comparison with conventional ballastless track systems, the new DFTS has the following characteristics that make it suitable to be adopted in MRT Line 1:

- About 20% cost reduction for construction and maintenance
- Easy to replace track consumables
- Easy adjustment, realignment due to spacers inserted underneath and at the side of sleepers
- In conventional ballastless tracks, under the slab asphalt concrete was poured, and this work require a big plant. With the new type of DFTS, only normal concrete casting is required.
- Conventional ballastless tracks need a wide area for storing RC Slabs, while with the new type of DFTS, a smaller area is required for piling up concrete sleepers.

Non-Ballast Concrete Bed with PC Sleeper embedded in half of the Rubber Box

Conventional Slab Track

Source: JICA Study Team

Figure 4.7.1 Direct-Fixation Track System

<u>Ballast Track</u>

In case where the geological condition is bad and the large settlement of structure is expected in future (the settlement is more than the allowable range for adjustment limit of the concrete slab), ballast track structure should be adopted instead of concrete slab track.

For the ballast track structure, the elastic rubber mat shall be installed between under ballast surface and the top surface of the structure.

The minimum thickness of ballast from the sleeper bottom to the roadbed top shall be 250mm. In the depot, the thickness of ballast shall be 250mm.

In the depot, a PC sleeper and ballast track structure is proposed, but as in the car washing track and inspection & repair track, a non-ballast concrete bed structure is preferred from the viewpoint of work enforcements.

In addition, as the structure of the repair track in the rail car plant, a pit structure shall be applied for inspection and repair and wood block paved track structure is recommended to carry out examinations of dismantled parts that are sensitive.

(1) Rails and Turnout

a. Rails for Main Line

UIC 60 rails should be used as the rail of the main line and the sub-main line. The length of the single track rail should be 18m. In addition, as the inner and outer rails of a section with less than 400m of curve radius, a quenched rail should be used in order to prevent rail wear.

b. Siding and Depot

Since the UIC 60 rails were adopted in the MRT Line 6, Line 1 was planned with the same type of rail, but JST recommends that UIC 54 be used for the siding and depot rail. Although the length of single rail was 13m in the MRT Line 6, JST recommends a length of 25m in order to reduce rail welding works. In addition, as the inner and outer rails of a section with less than 400m of curve radius, a quenched rail should be used in order to prevent rail wear.

c. Turnout

The turnout installed in main line, siding and depot is 1:9 type ordinal turnout of UIC 60 and 1:9 type scissors crossover of UIC 60; thus, the turnout installed in the safety siding should be 1:7 type continuous rail frog of UIC 60.

As the sleeper for turnout, plastic sleepers or the same quality of sleeper as the plastic sleeper should be used, and rubber sheets should be used under the sleepers in order to prevent noise and vibration in case of non-ballast track structure. In the depot, as the tracks have ballast, the vibration and resulting noise around the area are to be taken into consideration. Installation of the rubber sheet (thickness t≒25mm) under the ballast should also be considered.

d. Continuous welded rail

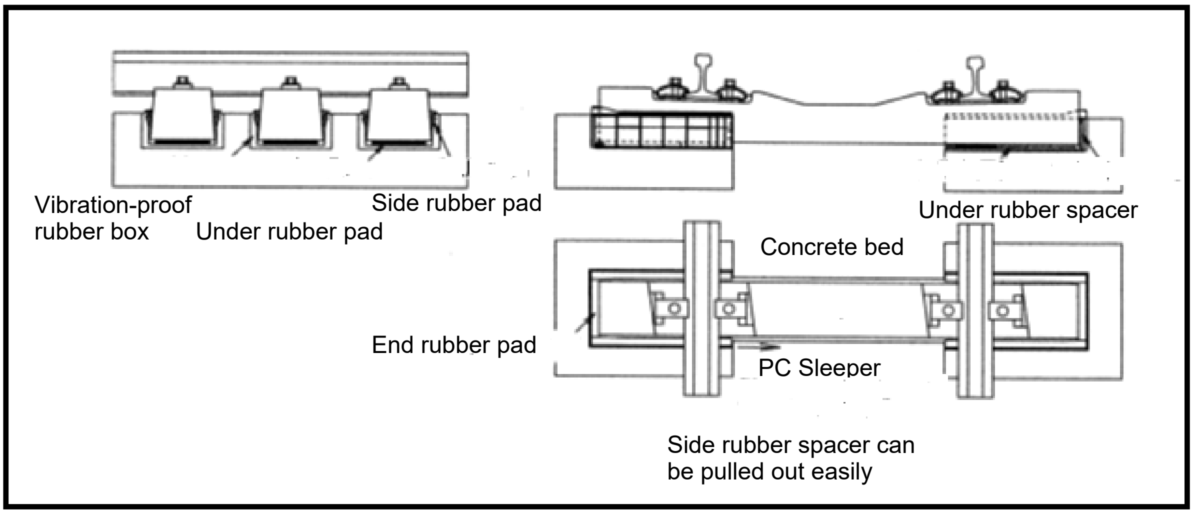
Continuous welded rail (CWR) shall be installed as far as possible for improvement of the riding comfort of the passenger, prevention of the noise and vibration from the train operation, and the reduction of the track maintenance cost.

However, as the rail in the curve section less than 400m of curve radius tends to wear out extremely fast and needs to be changed frequently, the single rail 18m long which is quenched should be used and normal butt joint type should be applied.

In case of welding the rail, the normal rail without being quenched should be used because the welding process of the quenched rail is complicated.

The structure of the "Non-ballast concrete bed with PC Sleeper in Rubber Boxes" is shown in Figure 4.7.2. Although the new type of DFTR has advantage, ballast track shall be applied at the location where the over the allowable settlement level is expected. The allowable settlement level shall be set upon in the Detailed Engineering Study stage. In generally settlement of the structure exceeds the range of adjustment that can be achieved by the spacers which are installed under the sleeper or at the side of the sleeper. A rubber ballast mat of thickness 25mm should be installed between the structure surface and the bottom of the sleeper in order to prevent noise and vibration.

The Pandrol fastening device or equivalent device shall be applied. In addition, a fastening device with which slack of 5mm can provide in the tight curve section of R less than 260m.



Source: 2011 Track Material (Tetsudo Gengyosya)

Figure 4.7.2 The Structure of the "Non-Ballast Concrete Bed with PC Sleeper in a Rubber Box"

Buffering Section

Generally, there is a big difference in the spring constant (the track softness) between the concrete slab track and ballast track, and the rolling of the vehicle grows in a structural change point that can easily become the track's weak point.

Therefore, buffering sections of more than 5m each side from the structure border should be set in order to change the track's general spring constant in stages (to keep the difference of the track's general spring constant within 2.5 times)

(2) Concrete bed

Fiberglass is used in the roadbed construction. It is mixed with concrete to make the roadbed more durable, preventing drying and cracking.

(3) Expansion joint for continuous welded rail

Expansion joints should be installed in the necessary points. As the sleeper of the expansion joint, plastic sleepers, or another sleeper type with the same quality as the plastic sleeper's, should be used attaching a protection device against vibration similar to non-ballast type turnouts.

2) Track Laying

Prior to track laying, the track centreline shall be set on the viaduct structure/ tunnel invert concrete marking the track centreline (the distance between the centreline and wall of civil structure and the height of rail surface should be written on the walls of the civil structure).

(1) Transport track materials and Track Laying

With regard to the tunnel section, the usual method is to have a crane waiting at the entrance to transport the rail to the site on the ground level.

The most suitable method shall be established by the Contractor, who shall take into account the availability of his resources like manpower and equipment, and site conditions.

About the viaduct section, a railroad crane is used to handle the rail.

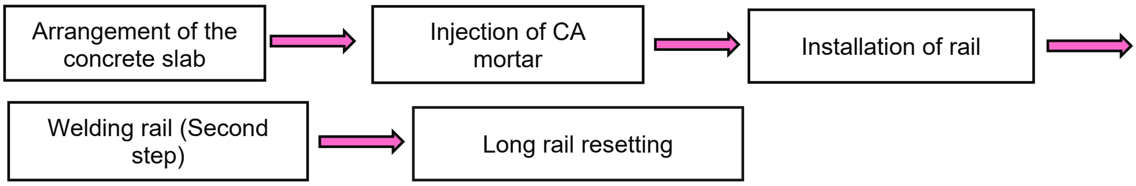
It is very convenient to use a forklift for short distance transportation and rail laying arrangement.

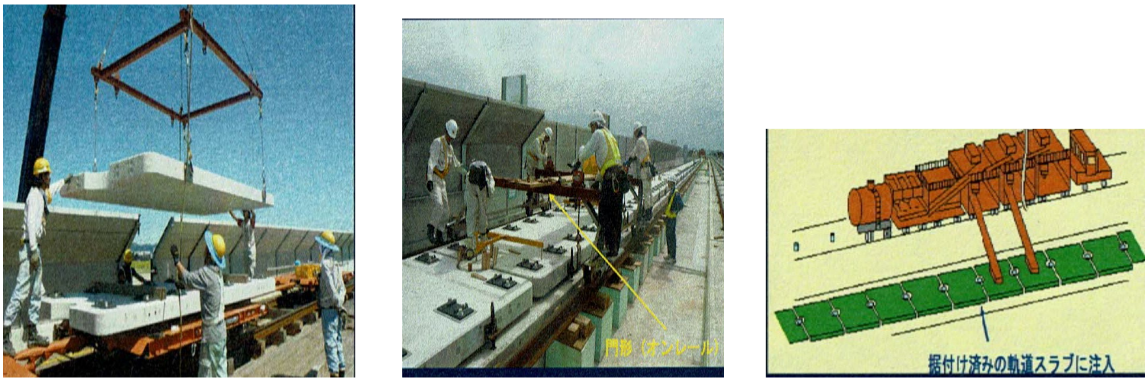
With regard concrete slabs, fastenings, other track materials and temporary tools, these are brought to the track level from the entrance by crane. It is normal working method to use a forklift for their short distance transportation and track laying.

Concrete slab arrangement, Concrete Asphalt Mortal casting

After the transporting and track laying, the concrete slab track panels fabricated in the plant shall be transported near the material transport entrance, then gathered and brought to the track floor. For the viaduct section, it is very easy that concrete slabs are loaded directly onto the trolley by the crane.

After this work stage, the track laying will be carried out by the following procedure.





Lifting up concrete slab and loading onto the trolley

Laying the concrete slab

Pouring CA mortar

Rail installation by portal cranes

Rail welding

Rail Setting and installation of insulation joint

Source: JICA Study Team

Figure 4.7.3 Construction Procedure

(2) Rail welding

Flash butt welding or gas pressure welding is basically desirable for the rail welding from the point of view of quality after the welding work; but even thermite welding shall be limited to the site where flash butt welding and gas pressure welding would be difficult to perform.

(3) Re-alignment of Track

The concrete slab track has been considered as the labour saving track, where little maintenance input was paid in the past. Maintenance work to the concrete slab track was not easy such as the ballast track, but recently maintenance philosophy has been changed in order to meet heavy traffic and speedy train operation. The standard values of track operation shall be kept as indicated in Table 4.7.2.

Table 4.7.2 Maintenance Standard of the Track in Japanese Railway Companies

(Unit: mm)

Kind of track irregularity	Gauge	Level	Longitudinal level	Alignment	Twist
Criteria (mm)	0〜−3	Within ±2	Within ±2	Within ±2	Within ±4

Note: These values were measured statistically by a 10m cord.
Twist value contains gradual decrease value of the cant.

Source: JICA Study Team

(4) Casting Track Bed Concrete

An example of the mixing ratio of the track bed concrete is shown in Table 4.7.3. The strength of the concrete is the same value as the concrete strength of the civil structure.

Table 4.7.3 Example of Mixing Ratio of Track Bed Concrete

Strength name (N/mm^2)	Kind of cement	Maximum diameter of coarse aggregate (mm)	Slump range (cm)	Air quantity range (%)	Maximum W/C (%)	Quantity of glass fibre (㎏/㎥)
24	N	25	18±2.5	4,5±1.5	55	9.1

Source: JICA Study Team

(5) Safety Facilities for track inspectors

For the purpose of track inspection, a staff passage is needed along the whole line. The passage is made by plate made of steel, etc. The track contains a rubber mat between passage plate and sleeper in order to reduce the noise and vibration from the train passing.

(6) Anti-derailment guard rail

Guard rails for derailment prevention should be installed at the inner rail side in the section where the curve radius is less than 300m and the transition curve which has the cant competes with the vertical curve.

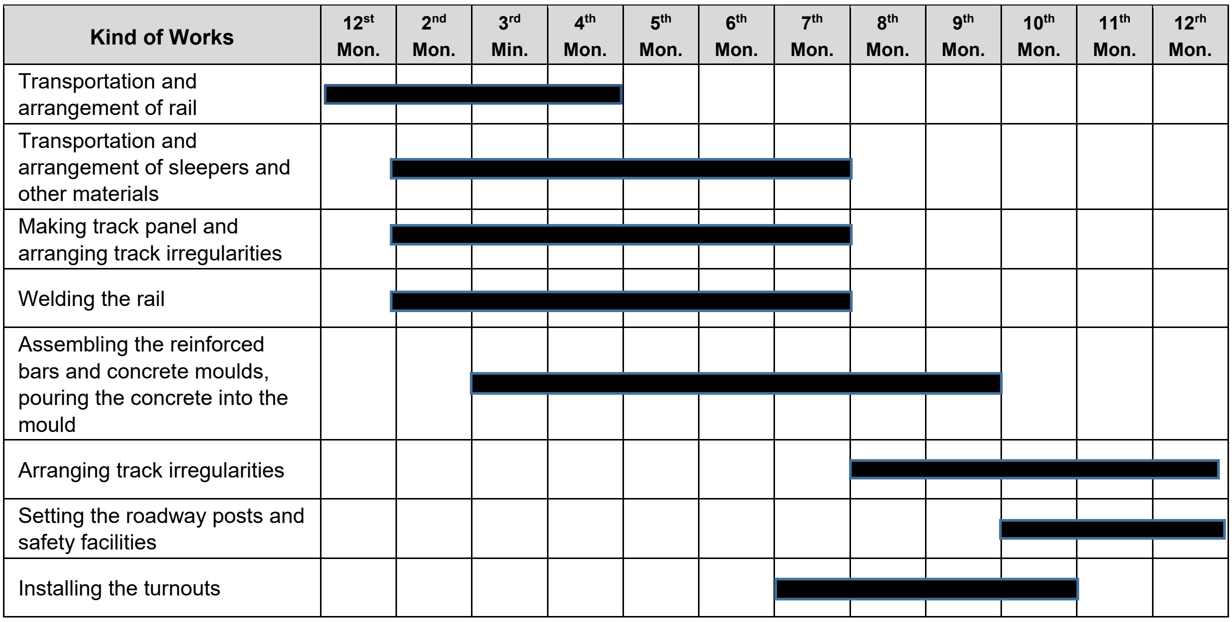
(7) Track side Signage

Individual signs for distances in kilometers, gradient, curve, versing and cant reduction, overhead clearance, etc., should be installed at the designated point.

4.7.3 Track Laying Schedule

Normally the duration of track construction is estimated at about one year as shown in Figure 4.7.4. Upon completion of civil structures, track laying is started. However, it is not uncommon that the construction schedule becomes so tight inevitably requiring a time extension owing to delays related to land acquisition or coordination with related authorities such as utilities agencies.

There are several examples of track laying work undertaken under reduced working period to meet project key dates. Therefore, other approaches should be studied and considered to catch up with the schedule.



Source: JICA Study Team

Figure 4.7.4 Normal Schedule of Track Works

4.8 Operation Planning

4.8.1 Operation Planning Data

The train operation plan must be a plan that can cope with peak traffic volume based on the passenger demand forecast. The data necessary to prepare the plan is as follows:

1) Passenger Demand Forecast

The forecast demand during peak hours and Passengers per Hour per Direction (PPHPD) are shown in Table 4.8.1. The PPHPD is used to set the number of required trains for the peak time and the number of procured trains.

Table 4.8.1 Max PPHPD

Peak Hour	2025		2035	
Airport Line	North Bound (Down)	South Bound (Up)	North Bound (Down)	South Bound (Up)
Airport	18,400	20,300	36,660	36,530
Airport Terminal 3	21,100	20,300	36,660	36,530
Khilkhet	20,400	23,100	47,970	47,060
Future Park	26,500	20,800	42,250	43,940
Notun Bazar	26,500	20,600	42,250	43,940
Uttr Badda	26,100	20,600	40,820	41,990
Badda	23,600	20,400	29,640	29,510
Hatir Jheel	23,600	23,700	28,990	28,990
Rampura	23,200	23,500	25,740	25,220
Malibagh	19,800	19,800	14,430	14,040
Rajarbagh	6,100	4,900	26,260	25,220
Kamalapur				

Peak Hour	2025		2035	
Purbachal Line	West Bound (Down)	East Bound (UP)	West Bound (Down)	East Bound (UP)
Future Park	20,700	20,000	26,000	25,090
Bashundhara	20,700	20,000	27,300	25,350
POHS	20,700	20,000	27,300	25,350
Mastul	16,000	12,500	17,680	18,720
Purbachal West	16,000	12,500	17,420	17,420
Purbachal Central	16,000	12,500	17,420	17,420
Purbachal Sector 7	7,600	6,400	9,230	9,750
Purbachal Terminal				

年	2025	2035
PPHPD（Pax）	26,500	47,970
	Notun Bazar ～ Future Park	Future Park ～ Khilkhet

Source: JICA Study Team

2) Transportation Capacity

Maximum transportation capacity for meeting the passenger demand, namely, the carrying capacity of each EMU, is 1,738 people in a 6-car formation and 2,332 people in an 8-car formation according to the specifications of the Rolling Stock plan of MRT Line 6, assuming the congestion rate is 180% as shown in Table 4.8.2.

Table 4.8.2 Capacity of EMU

T	End Car	Seated	45 pax		
		Standing	108 pax		
		Total	153 pax		
M	Middle Car	Seated	54 pax		
		Standing	111 pax		
		Total	165 pax	Congestion Rate	Capacity of EMU
6 car formation		4M2T	966 pax	180%	1,738 pax
8 car formation		6M2T	1,296 pax	180%	2,332 pax

Source: JICA Study Team

3) Headway

Headway is the interval time between preceding and following trains in a certain section. The headway is determined by comprehensively examining the stopping time at the station, the acceleration, and deceleration performance, the operation speed of the train, the length of the train, the function of the signal, and the like.

Stopping Time

Table 4.8.3 shows the classification of stopping time at each station according to the standards of MRT Line 6.

Table 4.8.3 Stopping Time at Station

Daily Passenger	Stopping time
Over 100,001	45 sec.
70,001 - 100,000	40 sec.
40,001 - 70,000	35 sec.
20,001 - 40,000	30 sec.
Under 20,000	25 sec.

Breakdown of Stopping time

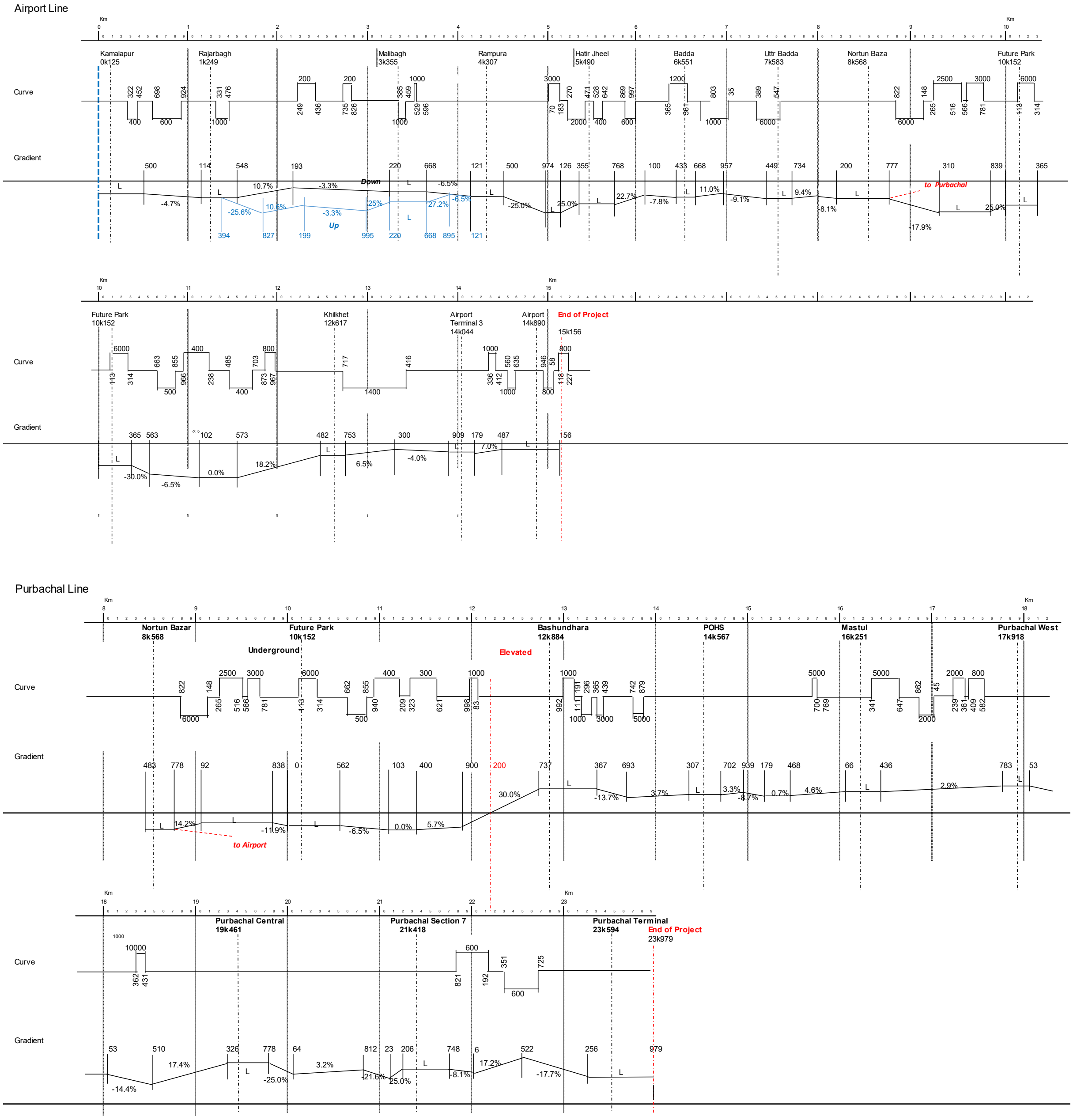
Daily Passenger Over 70,000	Time Required
- Position confirmation by driver	2.5 sec.
↓	
- Opening car and PSD door	2.5 sec.
↓	
- Passenger getting off and on	35.0 sec.
↓	
- Closing car and PSD door	2.5 sec.
↓	
- Safety confirmation by driver	2.5 sec.
Total	**45.0 sec.**

Source: JICA Study Team

4.8.2 Running Time

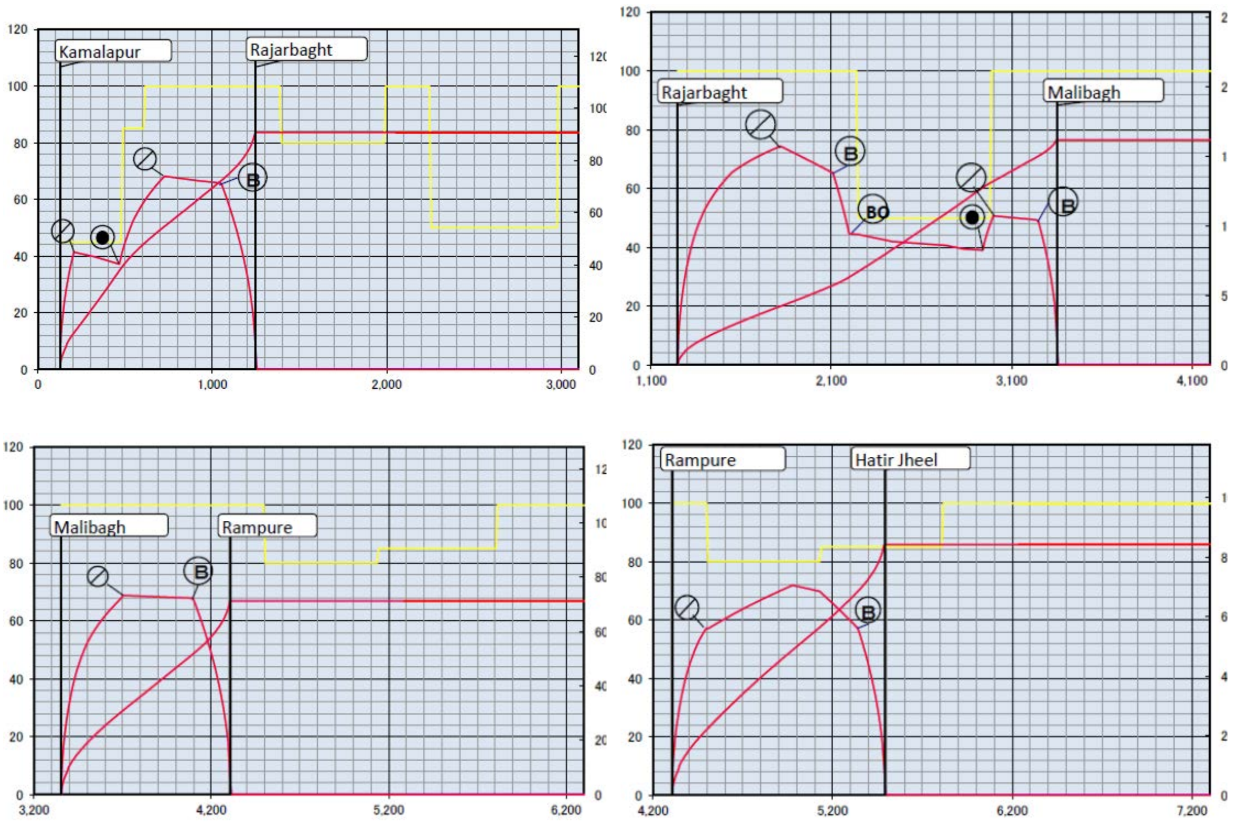
The trains carry passengers to their destinations by running through curves and going up and down slopes as shown in Figure 4.8.1, which is drawn according to the project profile. An efficient operation plan for the trains is created by using the operation curve in which the elapsed time and the speed are continuously calculated and graphed according to the change of the running position of the train. It is created taking into consideration the conditions of the rail and equipment, the vehicle performance, etc. In some sections, the changes in speed at each point when travelling are expressed as shown in Figure 4.8.2 while performing acceleration and deceleration so that the required time becomes the shortest within the range of the speed limit.

The running time for creating the train diagram is calculated by adding the margin time to the running time obtained from the operation curve.



Source: JICA Study Team

Figure 4.8.1 Railway Sketch



Source: JICA Study Team

Figure 4.8.2 Operation Curves (Example)

4.8.3 Operation Guide

The operating speed and travel time from the start point to the end point are shown in Table 4.8.4 in consideration of the travel time and the stopping time between the stations obtained by the aforementioned operation curve.

Table 4.8.4 Operation Guide

	Track Length			Outbound						Inbound					
				Operation Speed		Operation Time	Morning Peak Hour			Operation Speed		Operation Time	Morning Peak Hour		
	Accm. km		Interval km	Ave. km/h	Max. km/h	Asess. mm:ss	Stopping Time ss	Arrv. Time mm:ss		Ave. km/h	Max. km/h	Asess. mm:ss	Stopping Time ss	Arrv. Time mm:ss	
Purbachal Terminal	23.5	15.0					-	20:40	36:10				-		-
			2.2	54.6	90	02:25				52.8	85	02:30			
Purbachal Sector 7	21.3	12.8					40	17:35	33:05				40		02:30
			1.9	57.0	85	02:00				57.0	95	02:00			
Purbachal Central	19.4	10.9					45	14:50	30:20				45		05:10
			1.6	57.6	95	01:40				57.6	85	01:40			
Purbachal West	17.8	9.3					35	12:35	28:05				35		07:35
			1.6	54.9	90	01:45				57.6	90	01:40			
Mastul	16.2	7.7					35	10:15	25:45				35		09:50
			1.7	58.3	90	01:45				58.3	95	01:45			
POHS	14.5	6.0					45	07:45	23:15				45		12:10
			1.7	55.6	85	01:50				58.3	90	01:45			
Bashundhara	12.8	4.3					35	05:20	20:50				35		14:40
			2.7	57.2	80	02:50				58.9	85	02:45			
Future Park	10.1	1.6					45	01:45	17:15				45		18:00
			1.6	54.9	85	01:45				54.9	85	01:45			
Notun Bazar	8.5	—					—	—	14:55				—		20:30
Airport	14.8						-		24:20				-	-	-
			0.9	43.2	70	01:15				40.5	60	01:20			
Airport Terminal 3	13.9						40		22:25				40	01:20	-
			1.4	53.1	85	01:35				53.1	85	01:35			
Khilkhet	12.5						30		20:20				30	03:35	-
			2.4	59.6	85	02:25				59.6	85	02:25			
Future Park	10.1						45		17:10				45	06:30	-
			1.6	57.6	90	01:40				54.9	90	01:45			
Nortun Bazar	8.5						35		14:55				35	09:00	20:30
			1.0	40.0	70	01:30				37.9	65	01:35			
Uttr Badda	7.5						30		12:55				30	11:10	22:40
			1.0	45.0	75	01:20				45.0	75	01:20			
Badda	6.5						30		11:05				30	13:00	24:30
			1.1	49.5	75	01:20				49.5	80	01:20			
Hatir Jheel	5.4						45		09:00				45	14:50	26:20
			1.2	48.0	75	01:30				48.0	80	01:30			
Rampura	4.2						30		07:00				30	17:05	28:35
			0.9	43.2	75	01:15				43.2	75	01:15			
Malibagh	3.3						40		05:05				40	18:50	30:20
			2.2	48.0	80	02:45				45.3	75	02:55			
Rajarbagh	1.1						45		01:35				45	22:25	33:55
			1.1	41.7	75	01:35				44.0	75	01:30			
Kamalapur	—						-		-				-	24:40	36:10

	Section	Inbound	Outbound
Schedule Speed km/h	Kamalapur～Airport	36.5	36.0
	Kamalapur～Purbachal Terminal	39.0	39.0
	Notun Bazar～Purbachal Terminal	43.5	43.9

Source: JICA Study Team

1) Travel Time and Arrival Time

The travel time and the arrival time between the stations are shown in Table 4.8.5 based on the value calculated according to the operation guide.

Table 4.8.5 Travel Time and Arrival Time

Stopping Time	**Purbachal Terminal**	02:25	05:05	07:30	09:50	12:10	14:45	18:10	20:40		—	—	—	—	—	22:45	24:35	26:25	28:40	30:25	33:50	36:10	Stopping Time
40	02:30	**Purbachal Sector 7**	02:00	04:25	06:45	09:05	11:40	15:05	17:35		—	—	—	—	—	19:40	21:30	23:20	25:35	27:20	30:45	33:05	40
45	05:10	02:00	**Purbachal Central**	01:40	04:00	06:20	08:55	12:20	14:50		—	—	—	—	—	16:55	18:45	20:35	22:50	24:35	28:00	30:20	45
35	07:35	04:25	01:40	**Purbachal West**	01:45	04:05	06:40	10:05	12:35		—	—	—	—	—	14:40	16:30	18:20	20:35	22:20	25:45	28:05	35
35	09:50	06:40	03:55	01:40	**Mastul**	01:45	04:20	07:45	10:15		—	—	—	—	—	12:20	14:10	16:00	18:15	20:00	23:25	25:45	35
45	12:10	09:00	06:15	04:00	01:45	**POHS**	01:50	05:15	07:45		—	—	—	—	—	09:50	11:40	13:30	15:45	17:30	20:55	23:15	45
35	14:40	11:30	08:45	06:30	04:15	01:45	**Bashundhara**	02:50	05:20		—	—	—	—	—	07:25	09:15	11:05	13:20	15:05	18:30	20:50	35
45	18:00	14:50	12:05	09:50	07:35	05:05	02:45	**Future Park**	01:45		—	—	—	—	—	03:50	05:40	07:30	09:45	11:30	14:55	17:15	45
—	20:30	17:20	14:35	12:20	10:05	07:35	05:15	01:45	**Notun Bazar**		—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—		**Airport**	01:15	03:30	06:25	08:50	10:55	12:45	14:35	16:50	18:35	22:00	24:20	—
40	—	—	—	—	—	—	—	—	—		01:20	**Airport Terminal 3**	01:35	04:30	06:55	09:00	10:50	12:40	14:55	16:40	20:05	22:25	40
30	—	—	—	—	—	—	—	—	—		03:35	01:35	**Khilkhet**	02:25	04:50	06:55	08:45	10:35	12:50	14:35	18:00	20:20	30
45	—	—	—	—	—	—	—	—	—		06:30	04:30	02:25	**Future Park**	01:40	03:45	05:35	07:25	09:40	11:25	14:50	17:10	45
35	—	—	—	—	—	—	—	—	—		09:00	07:00	04:55	01:45	**Nortun Bazar**	01:30	03:20	05:10	07:25	09:10	12:35	14:55	35
30	22:40	19:30	16:45	14:30	12:15	09:45	07:25	03:55	—		11:10	09:10	07:05	03:55	01:35	**Uttr Badda**	01:20	03:10	05:25	07:10	10:35	12:55	30
30	24:30	21:20	18:35	16:20	14:05	11:35	09:15	05:45	—		13:00	11:00	08:55	05:45	03:25	01:20	**Badda**	01:20	03:35	05:20	08:45	11:05	30
45	26:20	23:10	20:25	18:10	15:55	13:25	11:05	07:35	—		14:50	12:50	10:45	07:35	05:15	03:10	01:20	**Hatir Jheel**	01:30	03:15	06:40	09:00	45
30	28:35	25:25	22:40	20:25	18:10	15:40	13:20	09:50	—		17:05	15:05	13:00	09:50	07:30	05:25	03:35	01:30	**Rampura**	01:15	04:40	07:00	30
40	30:20	27:10	24:25	22:10	19:55	17:25	15:05	11:35	—		18:50	16:50	14:45	11:35	09:15	07:10	05:20	03:15	01:15	**Malibagh**	02:45	05:05	40
45	33:55	30:45	28:00	25:45	23:30	21:00	18:40	15:10	—		22:25	20:25	18:20	15:10	12:50	10:45	08:55	06:50	04:50	02:55	**Rajarbagh**	01:35	45
—	36:10	33:00	30:15	28:00	25:45	23:15	20:55	17:25	—		24:40	22:40	20:35	17:25	15:05	13:00	11:10	09:05	07:05	05:10	01:30	**Kamalapur**	—

Source: JICA Study Team

2) Number of Trains and Cycle Time

The number of trains shows the required number operated on one route, and it is decided by the distance of the route, the operation interval, the turn-back time, and so on. In urban railways, the shortest operation headway is required at morning rush hour when the number of trains reaches the maximum number on that route. The number of cars to be used is calculated from the total number of trains multiplied by the number of train sets.

Table 4.8.6 Number of Trains and Headway (All Train Go to Kamalapur Station)

Year **2025**	Most Congested Section	PPHPD (pax)	Capacity 180% (pax)	Number of Trains (No.)	Headway (mm:ss)	Congested Ratio (%)
	Notun Bazar → Future Park	26,500	**1,738**	17	03:40	161.4
6	POHS → Bashundhara	20,700		13	04:40	164.9
Cars	Kamalapur→Nortun Bazar			30	**02:00**	

Year **2025**	Most Congested Section	PPHPD (pax)	Capacity 180% (pax)	Number of Trains (No.)	Headway (mm:ss)	Congested Ratio (%)
	Notun Bazar → Future Park	26,500	**2,332**	14	03:40	146.1
8	POHS → Bashundhara	20,700		10	04:40	159.8
Cars	Kamalapur→Nortun Bazar			24	**02:30**	

Year **2035**	Most Congested Section	PPHPD (pax)	Capacity 180% (pax)	Number of Trains (No.)	Headway (mm:ss)	Congested Ratio (%)
	Future Park → Khihket	47,970	**2,332**	21	03:40	176.3
8	Mastul → POHS	27,300		12	04:40	175.6
Cars	Kamalapur→Nortun Bazar			33	**01:50**	

Source: JICA Study Team

Table 4.8.7 Number of Trains and Headway (Some Trains Return from Notun Bazar)

2025 (6 cars)

2025	Most Congested Section			PPHPD (pax)	Capacity 180% (pax)	Number of Trains (No.)	Headway (min:sec)	Congested rates (%)
6cars	Nortun Bazar	→	Future Park	25,600	1,738	17	03:40	156
	POHS	→	Bashundhara	22,300		13	04:40	178
	Kamalapur	→	Nortun Bazar	23,800		20	03:30	123

*10 Trains on Purbachal Line shall return from Nortun Bazar

2025 (8 cars)

2025	Most Congested Section			PPHPD (pax)	Capacity 180% (pax)	Number of Trains (No.)	Headway (min:sec)	Congested Ratio (%)
8cars	Nortun Bazar	→	Future Park	25,600	2,332	12	5:00	165
	POHS	→	Bashundhara	22,300		10	06:00	172
	Kamalapur	→	Nortun Bazar	23,800		15	04:00	123

*7 Trains on Purbachal Line shall return from Nortun Bazar

2035 (8 cars)

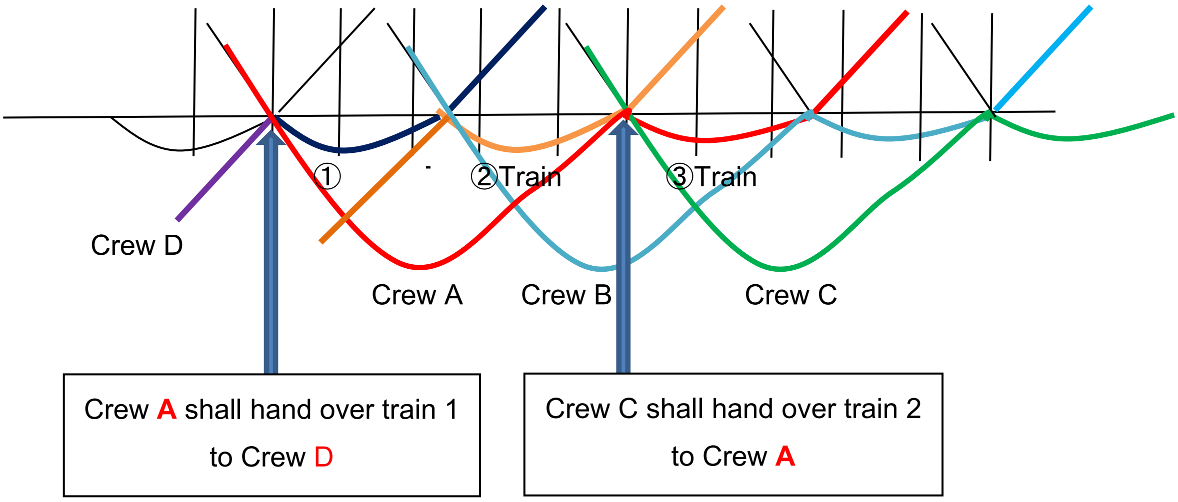
2035	Most Congested Section			PPHPD (pax)	Capacity 180% (pax)	Number of Trains (No.)	Headway (min:sec)	Congested Ratio (%)
8cars	Nortun Bazar	→	Future Park	47,970	2,332	21	03:40	176
	POHS	→	Bashundhara	27,300		12	04:40	162
	Kamalapur	→	Nortun Bazar	42,250		24	02:30	136

*10 Trains on Purbachal Line shall return from Nortun Bazar

In order to meet the 2035 forecast passenger demand, 13 trains consisting of 8 cars would operate per hour in each direction between Purbachal and DBC. Of the 13 trains, 10 trains may be returned to Notun Bazar Station according to the demand. But at Kamalapur Station trains should leave every 2 minutes 30 second interval. It is quite Sevier manner. At detailed engineering stage more detailed analysis shall be under taken, taking into vertical alignment, location of the turnout and scissors crossing, train stopping time at stations and EMU performance.

- As shown in the figure below which describes the turn back at Kamalapur Station in the 2 minutes 30 seconds headway timetable, the conductor A in charge of train ① shall hand over the train to conductor D, and crew train ③ which arrives two trains later (taking over after conductor C).

Kamalapur

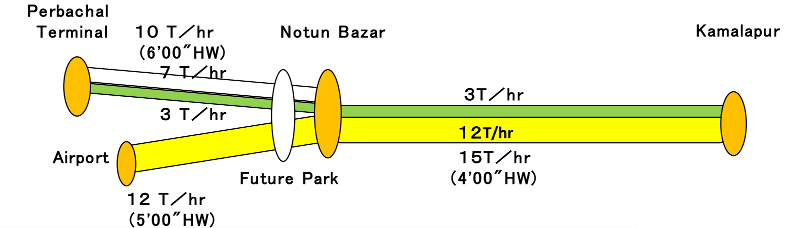


4.8.4 Number of Cars to be Formed and the Required Number of Train Sets

1) Operation Plan

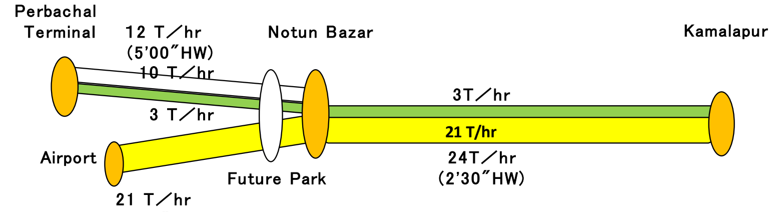
Table 4.8.8 shows the operation plan at the peak hours on weekdays for each car formation in each year.

Table 4.8.8 Operation Plan 2025 (8 Cars)

2025 (1 Train:8 cars)		Normal Day							
		AM Peak one Hour							
Image									
Section		Kamalapur～Airport		Kamalapur～Perbachal Terminal		Notun Bazar～Perbachal Terminal		–	
Kilimetage (km)		14.8		23.5		15.0		–	
Number of Trains		12		3		7		–	
Head (Min:Sec)		05:00		20:00		08:30		–	
	Kamalapur～Notun Bazar	04:00				–		–	
	Notun Bazar～Perbachal Terminal	–		06:00				–	
Average (Min:Sec)	Up Direction	24:40		36:10		20:30		–	
	Down Direction	24:20		36:10		20:40		–	
Average (km/h)	Up Direction	36.0		39.0		43.9		–	
	Down Direction	36.5		39.0		43.5		–	
Turn Back (Min:Sec)	Purbachal Terminal	–		03:40		05:50			
	Airport	07:00		–		–			
	Notun Bazar	–		–		04:00			
	Kamalapur	04:00		04:00		–			
Required Time for 1Cycle(Hr:Min:Sec)		1:00:00		1:20:00		0:51:00		–	
Number of Trains	Composition (Car)	8						–	
	Commercial Operation	12	96	4	32	6	48	22	176
	Standby	–		–				3	24
	Total	–		–				25	200

Source: JICA Study Team

Table 4.8.9 Operation Plan 2035 (8 Cars)

2035（1 Train:8 cars）		Normal Day AM Peak one Hour							
Image									
Section		Kamalapur～Airport		Kamalapur～Perbachal Terminal		Notun Bazar～Perbachal Terminal		－	
Kilimetage (km)		14.8		23.5		15.0		－	
Number of Trains		21		3		10		－	
Head (Min:Sec)		02:50		20:00		6:00		－	
	Kamalapur～Notun Bazar	02:30				－		－	
	Notun Bazar～Perbachal Terminal	－		04:40				－	
Average (Min：Sec)	Up Direction	24:40		36:10		20:30		－	
	Down Direction	24:20		36:10		20:40		－	
Average (km/h)	Up Direction	36.0		39.0		43.9		－	
	Down Direction	36.5		39.0		43.5		－	
Turn Back (Min：Sec)	Purbachal Terminal	－		5:10		4:20			
	Airport	05:10		－		－			
	Notun Bazar	－		－		02:15			
	Kamalapur	02:30		02:30		－			
Required Time for 1Cycle(Hr：Min：Sec)		0:56:40		1:20:00		0:48:00		－	
Number of Trains	Composition (Car)	8						－	
	Commercial Operation	20	160	4	32	8	64	32	256
	Standby	－		－				4	32
	Total	－		－				36	288

Source: JICA Study Team

2) Rolling Stock Procurement Plan

The number of required rolling stock per year based on the above operation plan is shown in Table 4.8.10 and is a reference for the rolling stock procurement plan.

Table 4.8.10 Rolling Stock Procurement Plan

Year		2025		2035	
Number of Cars	Fleet (Car)	8		8	
	Required Trains fleet/car	22	176	32	256
	Stanby fleet/car	3	24	4	32
	Total fleet/car	25	200	36	288

Source: JICA Study Team

As reserved train set, JST estimated one fleet for emergency, 2 – 3 fleets for regular inspection & maintenance and one fleet for repair for accident.

4.8.5 All Day Operation Headway and Number of Trains (Weekdays)

Table 4.8.11 shows the all-day operation headway including peak hours in the morning and the evening and off-peak hours in the early morning and late night and the required number of trains.

Table 4.8.11 All Day Operation Headway and Number of Trains

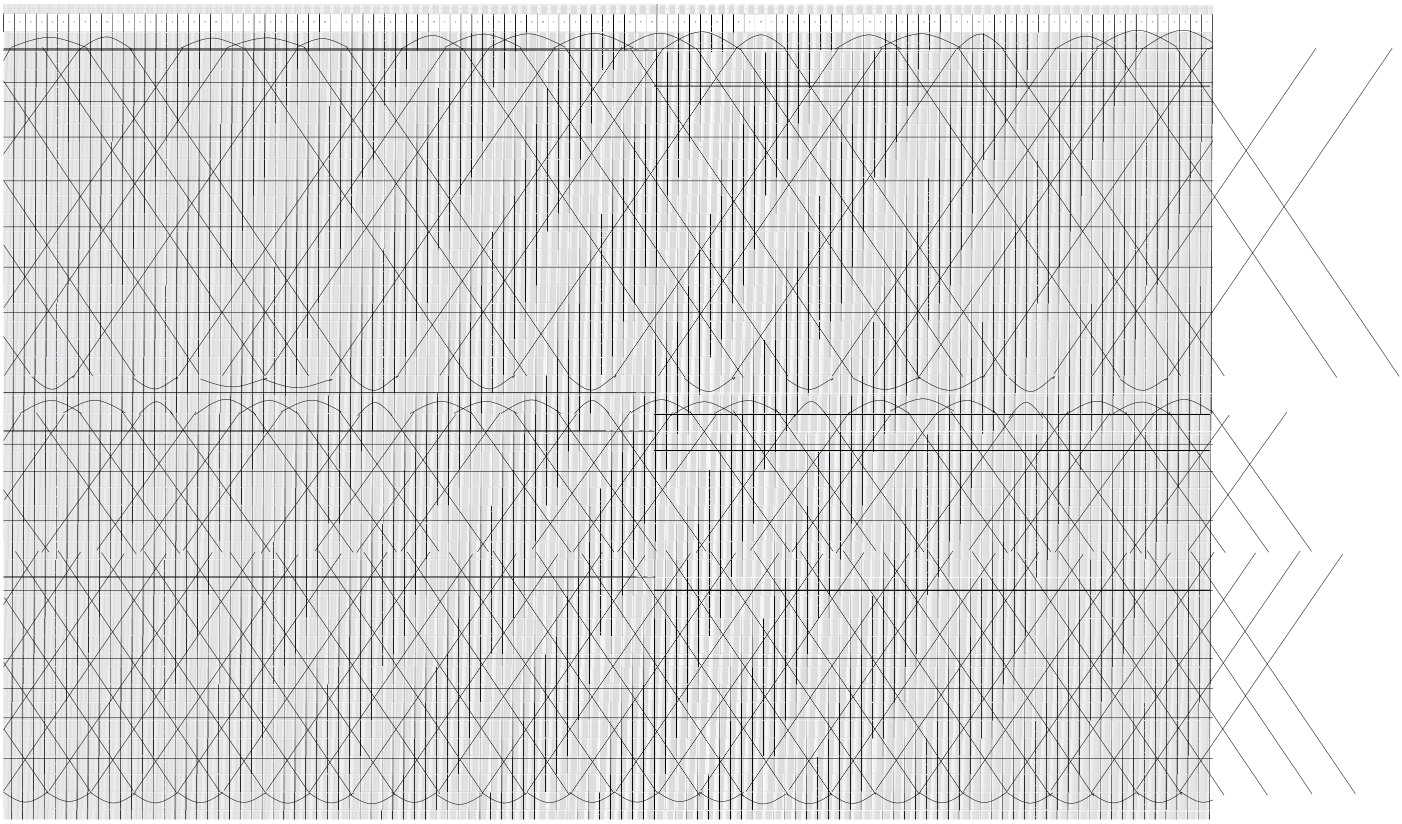
Upper: Headway, Lower: Number of Trains

Year		Section	5:30	8:00	10:30	16:30	19:00	24:00	All Day
2025	6cars	Nortun bazar - Airport	6’40″ 22 Nos	3’40″ 42 Nos	6’40″ 54 Nos	5’00″ 30 Nos	6’40″ 45 Nos		193
		Nortun Bazar - Purbachal	10’ 00” 14 Nos	4’ 40” 32 Nos	10’ 00” 36 Nos	7’30″ 19 Nos	10’ 00” 30 Nos		131
		Kamalapur - Norton Bazar	5’ 00” 29 Nos	3’00″ 49 Nos	5’ 00” 72 Nos	4’ 00” 37 Nos	5’ 00” 60 Nos		247
	8cars	Nortun bazar - Airport	8’30″ 17 Nos	5’00″ 30 Nos	8’30″ 42 Nos	6’40″ 22 Nos	8’30″ 35 Nos		146
		Nortun Bazar - Purbachal	10’ 00” 14 Nos	6’ 00” 24 Nos	10’ 00” 36 Nos	8’30″ 17 Nos	10’ 00” 30 Nos		121
		Kamalapur - Norton Bazar	6’ 00” 24 Nos	4’00″ 37 Nos	6’ 00” 60 Nos	5’ 00” 29 Nos	6’ 00” 50 Nos		200
2035	8cars	Nortun bazar - Airport	6’00″ 25 Nos	2’50″ 52 Nos	6’00″ 60 Nos	4’00″ 37 Nos	6’00″ 50 Nos		224
		Nortun Bazar - Purbachal	10’ 00” 14 Nos	4’ 40” 32 Nos	10’ 00” 36 Nos	7’30″ 19 Nos	10’ 00” 30 Nos		131
		Kamalapur - Norton Bazar	4’ 40” 32 Nos	2’30″ 59 Nos	4’ 40” 78 Nos	3’ 20” 44 Nos	4’ 40” 65 Nos		278

Source: JICA Study Team

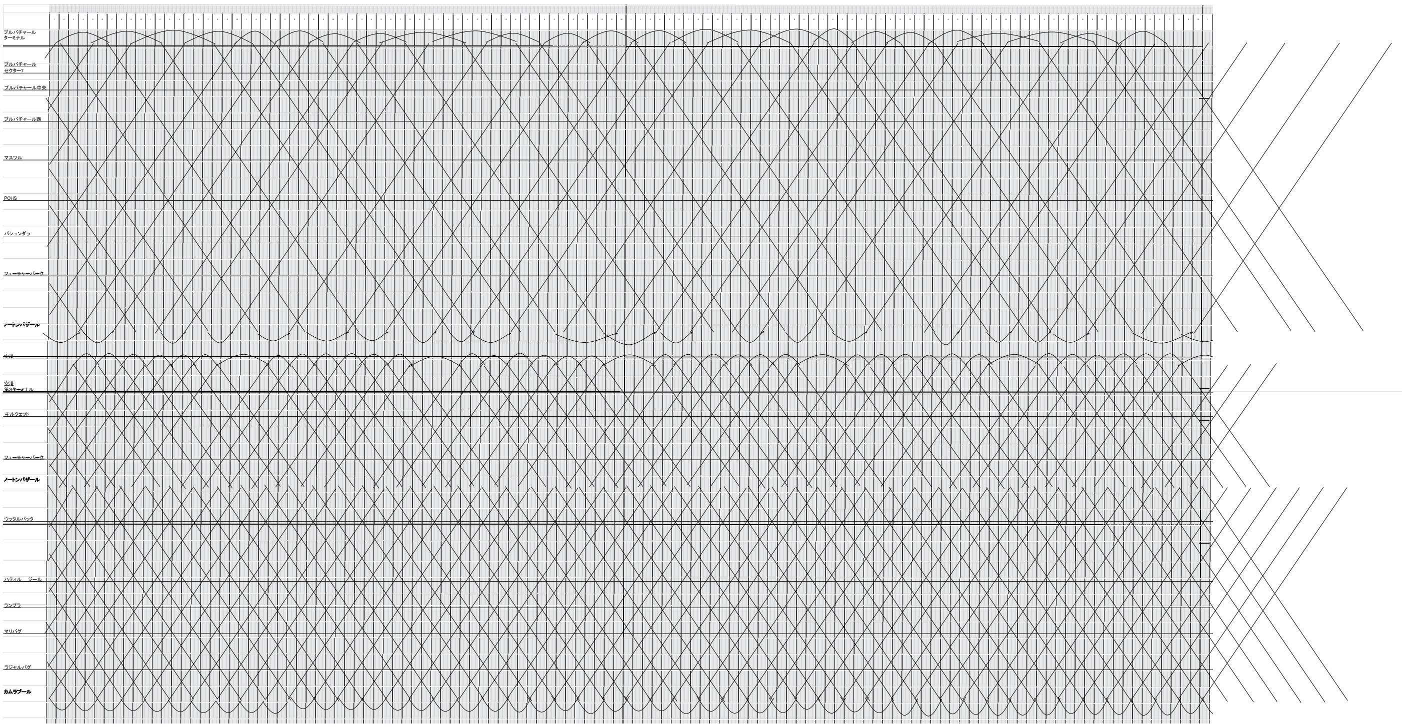
As reserved train set, JST estimated one fleet for emergency, 2 – 3 fleets for regular inspection & maintenance and one fleet for repair for accident

4.8.6 Peak Hour Diagram 2025 (8 Cars)



Source: JICA Study Team

Figure 4.8.3 Peak Hour Diagram 2025 (8 Cars)

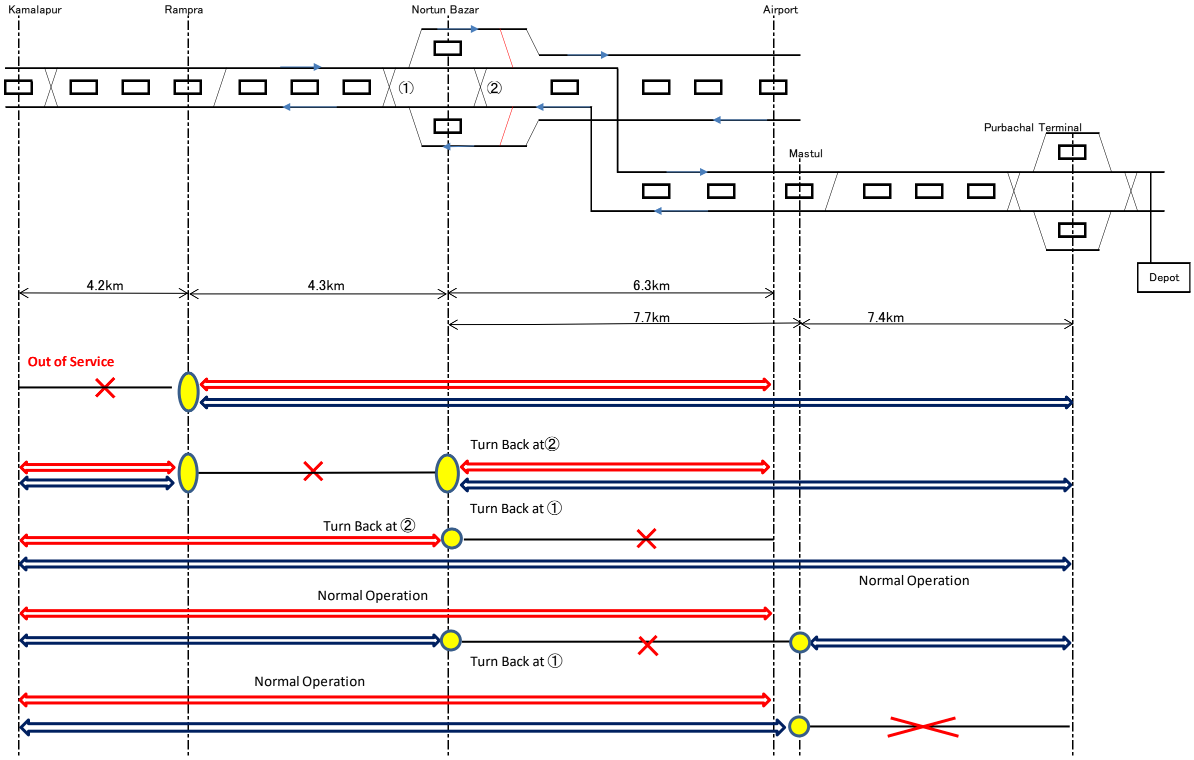


Source: JICA Study Team

Figure 4.8.4 Peak Hour Diagram 2035 (8 Cars)

4.8.7 Operation during an Emergency

As shown in Figure 4.8.5, it is possible to minimize train operation troubles by providing a crossover line for use during an emergency such as a train failure.



Source: JICA Study Team

Figure 4.8.5 Operation during an Emergency

4.8.8 Comparison of MRT Line 6 and MRT Line 1 Operation Plans

Table 4.8.12 shows the comparison of the operation plan of MRT Line 1 with the operation plan of MRT Line 6.

Table 4.8.12 Comparison with MRT Line 6

			Line 6		Line 1	
Gauge			1,435		1,435	
Train Operation						
1	Route Length (Km)		19.8		Kamalapur ～ Purbachal Terminal	Kamalapur ～ Airport
					23.5	14.8
2	Running		Left Side		same as on the left	
3	Operation hour		Summer（Mar.～Sep.）5：30～24：00		5:30～24：00	
			Winter（Oct.～Feb.）：6:00～23:30			
4	Headway		Peak 4'30"(2021)、3'45"(2026)		Peak 2'00"(2025 6Cars) 2'30"(2025 8Cars) 1'50"(2035 8Cars)	
			Off-peak 7'00"(2021)		Off-peak 4'00"(2025 6Cars) 5'00"(2025 8Cars) 4'00"(2035 8Cars)	
5	Congestion ratio		180%		same as on the left	
6	Speed		Design Max. Speed: 110km/h		- ditto -	
			Operation Max. Speed: 100km/h		- ditto -	
7	Depot		Located adjacent to Uttara North station		Located near Purbachal Terminal station	
	Emergency Route		Single Crossover: Pallabi Station, Kawran Bazaar Station, Agargaon Station		Single Crossover; Rampura, Mastul Crossover; Notun Bazar	
	Intersection Station		-		Notun Bazar Station	
	Terminal Station		Motiliheel: Island platform serving 2 Uttara North: 2 Sides platform serving 2		Kamalapur: Island platform serving 2 tracks Airport: Island platform serving 2 tracks Purbachal Terminal: 2 Sides platform serving 3 tracks	
Support Systems of Train Operation						
8	Block system of signaling		CBTC Moving Block		same as on the left	
9	Signal appearance type		Cab signal		- ditto -	
10	Automatic Train Protection		CBTC system		- ditto -	
11	Train Operation Control System		CTC from OCC		- ditto -	
Station and Facilities of Station						
12	Number of stations		Elevated; 16		Elevated; 7	Underground; 12
					Underground; 2	
13	Platform	Length	170m		same as on the left	
		type and width	Side; 7～10m		Side; 7～10m	
			Island;10m		Island; 11m	
14	PSD(Platform Screen Door)		Half Height PSD		Full Height PSD (Underground)	
					Half Height PSD (Elevated)	
Passengers Demand Forecast						
15	Design PHPDT		Year2021	22,372		
			Year2026	27,433		
			Year2051	60,979		
Rolling Stock						
16	Train formation		6 Cars (8 Cars)		same as on the left	
17	Train Composition		4M2T (6M2T)		- ditto -	
18	Carrying capacity		6 Cars Congestion ratio 180%		- ditto -	
			1,738pax. (2,332pax)			
19	Required number of trains		24 sets in 2026		25 sets	
20	Capacity of EMU					
	T	End Car	Seated	45	same as on the left	
			Standing	108		
			Total	153		
	M	Middle Car	Seated	54		
			Standing	111		
			Total	165		
		6 car formation	4M2T	966		
		8 car formation	6M2T	1,296		

Source: JICA Study Team

4.9 Rolling Stock Plan

As MRT is the high-speed public transportation system which transports many passengers, safety assurance is essential. The rolling stock equipment and facilities should have high reliability to prevent train derailment and collision accidents. Furthermore, the rolling stock should be safe and comfortable with long-life utilization to transport the passengers on the Dhaka MRT system throughout the specified design life.

4.9.1 Outline

The specifications of the rolling stock shall move existing systems to a common architecture with Dhaka Line 6 as much as possible. High capacity, high reliability trains shall be supplied to accommodate the passenger demand and the system availability requirements. A train configuration is to be employed to minimize components and weight and maximize redundancy, namely:

(a) The rolling stock shall be specified a proven design validated by statistical reliability data from revenue operation;

(b) As the trains run underground, it must satisfy the fire protection standards; and

(c) The rolling stock shall be specified to withstand the effects of high temperature and high humidity, with every consideration for the environmental conditions including the climate and pollution levels at Dhaka.

4.9.2 Design Criteria

1) Line Profile of Dhaka Line 1

The train operates following track and weather conditions.

Line profile of Dhaka Line1

Table 4.9.1 Line Profile of Dhaka Line1

No.	Item	Specification
1	Truck Gauge	1,435mm
2	Minimum curve radius on a main track	160 m
3	Steepest gradient in a running area of Rolling Stock	35/1000
4	Design speed	110km/h
5	Maximum train operating speed At the elevated section and At the underground section	 100km/h 90km/h
6	The train loading for civil structure	16 tons/Axle

Source: JICA Study Team

Weather Condition

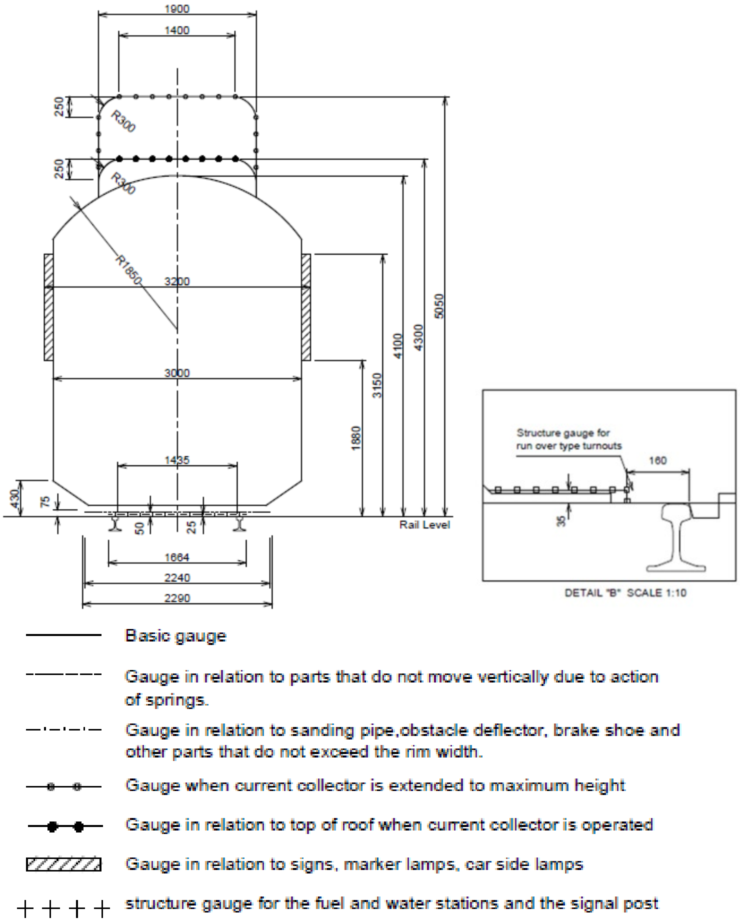
Table 4.9.2 Weather Condition

No.	Item	Specifications
1	Ambient Temperature	Maximum temperature record:41◦C
		Average maximum reading: 36 ◦C
		Minimum temperature record: 5◦C
		Maximum Variation during 24 hours: 22 ◦C
2	Relative Humidity:	During June to November: 100 %
		During December to May:75 %
3	Rainfall:	Varies, but normally 3050mm during the year, 80% of which usually occurs during the period from June to October (monsoon season).
		Maximum Rainfall during 24 hours: 630mm
4	Maximum wind velocity	140km/h

Source: JICA Study Team

2) Rolling Stock Gauge

The car body should comply with the Rolling Stock Gauge, and it should keep a sufficient gap with the Structure Gauge, shown in the following figure, so that even when in motion at maximum operational speed, the car body never infringes on the Structure Gauge.



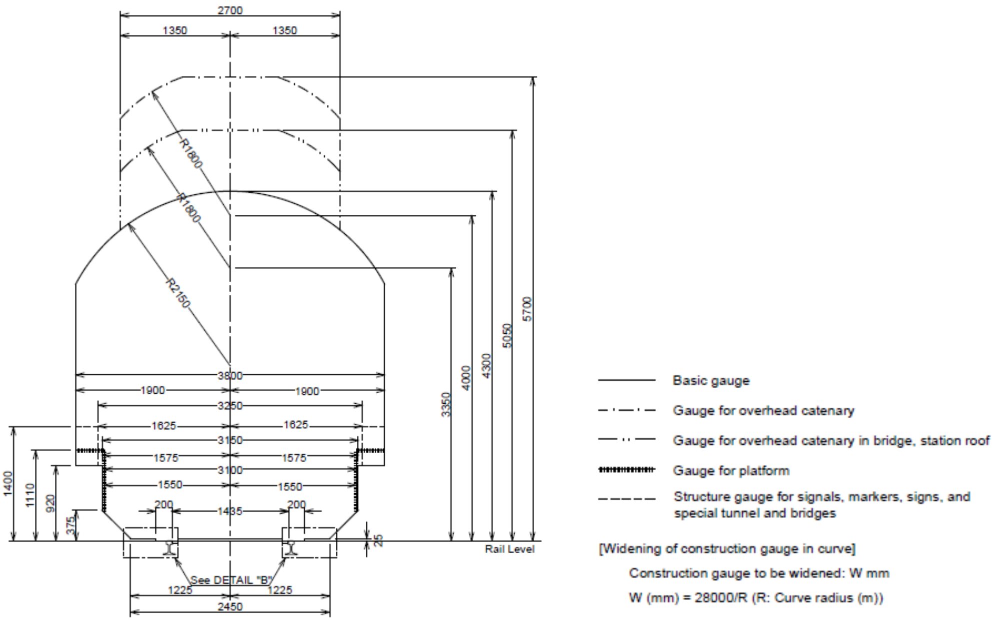
Source: Technical standards for the MRT in Bangladesh

Figure 4.9.1 Rolling Stock Gauge (On straight track in the stopped state)

3) Structure Gauge

Structure Gauge for the elevated section

Structure Gauge is the space the vehicles can pass safely any structures should be got rid of within the gauge. Due to daily train operation, track alignment may be changed. Adequate maintenance input is inevitable. Structure Gauge shown Fig 4.9.2 was provided by Technical Standards for the Metrorail in Bangladesh, December 2014, DTCA & JICA.

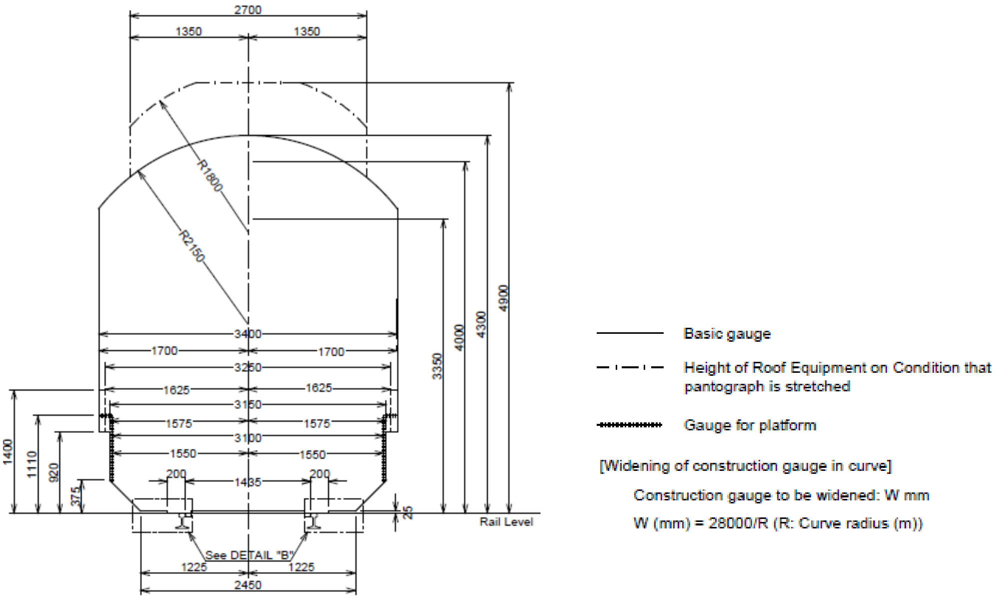


Source: Technical standards for the MRT in Bangladesh

Figure 4.9.2 Structure Gauge for straight lines at the elevated section

4) Structure Gauge for the underground section

The construction cost of the structure to be built at the underground section is roughly proportional to the section size of the structure. For this reason, the Structure Gauge for the underground section is reduced in size at the upper and lateral side compared to the Structure Gauge for the elevated section.



Source: JICA Study Team

Figure 4.9.3 Structure Gauge for straight lines at the underground section

5) System General Requirements

Reliability, Availability, Maintainability

A quality management system based on ISO 9001 shall be followed.

Reliability target

The Mean Distance between Failure (MDBF) shall be more than 120,000km per train for failures causing train service disruptions of 30 minutes or more and service withdrawal.

Availability target

Availability target shall not be less than 95%. The coaches in cleaning & scheduled maintenance will be excluded from availability calculation.

Maintainability:

The cars shall be maintenance friendly and shall require minimum maintenance.

Design Life

The train design life, during which the train is to provide continuing service under all operating conditions, is a minimum of 30 years.

Maximum Axle Load

The maximum axle load of a car is 15.2 tons with maximum passenger loading at (AW3) condition.

Fire safety and Emergency system

The rolling stock shall comply with the Technical Standard for the MRT in Bangladesh. The car body structure and the materials of the interior and exterior of rolling stock are prescribed for fire safety and emergency in this MRT technical standard. Emergency evacuation systems are also prescribed such as evacuation in case of fire.

Overhead Contact System(OCS) Power Supply

The rated voltage is DC 1,500V, and the contact wire height above the rail is within the pantograph working range of 4300mm to 5200mm at the elevated section.This is within the pantograph working range of 4300mm to 4900 mm at the underground section.

Train Protection system

The train is provided with Cab signalling under the control of an Automatic Train Protection (ATP) system. Additionally, an Automatic Train Operation (ATO) system under ATP control is provided. Manual operating capability is also required. In all ATO or manual operating modes, ATP is to remain operative.

Train information system

The train information system (TIS) has the multi-train control functions of Fault log, Data transmission of wayside and Passenger services. It should connect with the on-board subsystems.

On-board service facilities

On-board service facilities are provided for passengers including air-conditioning, public address, and information display.

Propulsion system

(a) Traction Motor

- AC 3 phase cage type induction motor mounted on bogie frame.
- The traction motor provides tractive effort and braking effort (regenerative braking).
- Rated voltage: 1,100V, Capacity: Around 220kW. This item shall be reviewed later depending on line profile of Dhaka Line 1 and operating condition i.e., running curve calculation.

(b) Traction inverter

- Variable Voltage Variable Frequency (VVVF) control traction inverter
- Input voltage: DC 1,500V (minimum 900V, maximum 1,800V)
- Output voltage: AC 3-phase from 0 to 1,100V (rms) at DC 1,500V input.

6) System Specific Requirements

Codes and Standards

Technical standards for the MRT in Bangladesh, Japanese standards and International standards shall provide the ‘base line’ for the minimum standards for design, manufacturing, installation, testing and commissioning and hand over. The main codes, standards and specifications applicable for the Rolling Stock are listed below:

Table 4.9.3 Codes and Standards

No.	Item	Codes and Standards
1	Design of Rolling Stock	UIC - 605-1 - International union of railways codes JIS E7103 - Rolling stock -- General requirements of car body for passenger car JIS E 7106:2006 Rolling stock -- General requirements of car body structures for passenger car JIS E4047 - Design methods for arc welded joints of steel for railway rolling stock
2	RAMS	IEC 62278 - Railway applications - Specification and demonstration of reliability, availability, maintainability and safety (RAMS)
3	Electromagnetic Compatibility	EN 50121, Railway Applications – Electromagnetic Compatibility JIS E4018- Railway rolling stock -- Measuring methods of leakage magnetic field
4	Electrical	IEC 60034-25 - Guide for the design and performance ofcage induction motors specifically designed for inverter supply (2007) EN 50155 – Railway applications – Electronic equipment used on Rolling Stock IEEE Std. 16-2004, Standard for Electrical and Electronic Control Apparatus on Rail Vehicles IEEE Std. 1476-2000, Passenger Train Auxiliary Power Systems Interfaces IEEEStd. 1478-2001, Environmental Conditions for Transit Rail Car Electronic Equipment JIS E6102- AC traction motors for rolling stock
5	Fire Safety	Technical Standards for the MRT in Bangladesh, Section 9.19 Ministerial Ordinance to Provide Technical Regulatory Standards on Railways of Japan
6	Lighting	JIS E4016 Illuminance for Railway Rolling Stock
7	Overhead Catenary System	EN 50163: railway applications supply voltages of traction systems
8	Ventilation and Air Conditioning System	JIS E4015- Measuring methods for air conditioning and heating temperature of railway rolling stock JIS E4024 - Railway rolling stock -- Test methods of ventilation
9	Wheels and Axles	JIS E4501 - Railway rolling stock -- Design methods for strength of axles JIS E5402-1 - Railway rolling stock -- Solid wheel -- Part 1: Quality requirements JIS E4504 - Wheel sets for railway rolling stock -- Quality requirements
10	Noise and Vibration	ANSI S1.4, Specification for Sound Level Meters IEC 61373, Railway Applications - Rolling Stock Equipment - Shock and Vibration Tests JIS E4021 - Railway rolling stock -- Test methods inside noise
11	Testing	IEC 61133 - Railway applications - Rolling stock - Testing of rolling stock on completion of construction and before entry into service JIS E4041 – Testing of Rolling on Completion of Construction and before entry into service

Source: JICA Study Team

7) Train performance

The following conditions shall be applicable to the 8-car train formation:

(a) The train is capable to achieve a speed of 100km/h on clean, dry, level, well maintained tangent track on the elevated section with half worn wheels and AW3 loading throughout the complete train.

(b) Propulsion and brake performance requirements are met using the following conditions: half worn wheels and AW3 loading throughout the complete train.

Table 4.9.4 Performance requirements of Propulsion and Brake System

No.	Item	Specification
1	Maximum acceleration	Greater than 0.92m/s^2
2	Degraded operation (Motor Cut out Operation)	Start and accelerate with AW3 load on a 35/1000 gradient by the two motor cars
3	Abnormal operation (Rescue Operation)	An AW0 loaded train shall be able to push another AW3 loaded train at least 1000 meters from stopped condition on a 35/1000 gradient
4	Maximum deceleration of Electrical braking	Greater than 0.97m/s^2
5	Minimum operating speed of Regenerative brake	Not fade at any speed above 8 km/h
6	Maximum Service brake deceleration	More than 0.97m/s^2
7	Maximum emergency brake deceleration	More than 1.25m/s^2
8	Jerk Control	Not exceed 0.7 m/s^{3}except emergency brake
9	Accuracy of Station Stopping	Stopping within 350 mm of the designated station stopping point with service braking in Automatic Train Operation (ATO) mode.

Source: JICA Study Team

8) Subsystem Part Configuration

Car body

The outline of Car body is shown in the following table:

Table 4.9.5 Outline of Car body

No.	Item	Specification
1	Body Length of Middle car	19,500mm
2	Body Length of End car	19,800mm
3	Body Width	2,950mm
4	Body roof Height above Rail Level	3,650mm
5	Air-condition height above Rail Level	4,100mm
6	Floor height (above rail level):	1,150mm
7	Maximum Gap between Platform edge and Car body entrance floor	70mm
8	Longitudinal compressive load at coupling point	490kN (50t)
9	Car body material	Stainless steel or aluminium alloy

Source: JICA Study Team

Body length

The body length of the intermediate car (M) is 19,500mm. The body length of the leading car (Tc) is 19,800mm. The maximum length of a 6-car train (coupler face to coupler face) shall be 121m. When the 8-car train is introduced, the maximum length, coupler face to coupler face, is 161m.

Source: JICA Study Team

Figure 4.9.4 Conceptual diagram of the leading car and the intermediate car

Passenger comfort

(a) Passenger entrance doors

Each car has four sets of power operated bi-parting, pocket type sliding entrance doors on each side. Door opening width of the entrance door is 1400mm and Door height is 1850 mm.

(b) Gangways

Gangways are to be provided on each car. Gangway doors are provided between cars. The gangway between coaches is approximately 900mm wide. The gangway at the end of the Tc cars is approximately 650mm (not less than 600mm) wide.

(c) Dropping window

Dropping windows of 400mm height have an opening area greater than 8% of the total floor area. This opening dimension will provide the expected passenger comfort in case of power failure. The fully opening area is placed at 1,350 mm above the body floor. The passenger must not be able to touch the platform screen door frame placed on the platform through this opening.

(d) Passenger seats

Longitudinal seats for three and seven persons are used; the seat space per person is 430mm wide and 550mm deep.

(e) Hand grips and Overhead racks

Hand grips, poles, hanging straps and overhead racks are provided.

(f) Train communication equipment

Table 4.9.6 Train Communication Equipment

No.	Item	Specification
1	PA system	Two exterior speakers on each side wall of car body
2	Passenger emergency communication system	Four call stations in each car at door bays
3	PID system	Display for End and Side Destination, Passenger Saloon
4	End destination display	Illuminated with three colours LED
5	Side destination display	Illuminated with three colours LED
6	Passenger saloon display	Each side door, multi colours with high resolution LCD
7	Door chime	Passenger Doors

Source: JICA Study Team

Lighting

The interior lighting is designed to give an even light distribution without glare. The lighting level is more than 200 lux over the whole saloon at height of 0.85m above floor.

Bogie

The principal data of bogies shown in the table below.

Table 4.9.7 Principal Bogie Data

No.	Item	Specification
1	Gauge	1,435mm
2	Distance between two bogies	13,800mm
3	Bogie wheel Base	2,100mm
4	Wheel Diameter	860mm (New), 780mm (Fully Worn)

Source: JICA Study Team

Driving cab

The cab environment is designed ergonomically and allows all drivers to operate the train comfortably and efficiently. The cab design maximizes outward visibility to provide the driver full observation of track area and station platform area.

Table 4.9.8 Main Equipment of the Driving Cab

No.	Item
1	Operating devices for control facilities
2	Operating devices for service brake devices
3	Transmitting devices and receiving devices for signal and communication.
4	Speedometer
5	Aspect facilities of onboard signal equipment
6	Operating device for raising and lowering the pantograph
7	Transmitting devices and receiving devices for security communication.
8	Warning generating devices and transmitting devices for alarm signal facilities
9	Horn activation device
10	Pressure gauge including pressure of main air tank piping
11	Receiving devices for emergency communication devices
12	Door closed and locked confirmation device for passenger doors

Source: JICA Study Team

Brake system

The brake system comprises regenerative and pneumatic friction braking. Motor bogie is Tread brake with composite brake blocks and Trailer bogie is Disc brake. The braking system is fail-safe.

(a) Brake control scheme and Service brake

The brake control scheme consists of electro-pneumatic service brake with blending control between electric and air braking. In case the train separates, the brake system detects the separation and operates the emergency brake.

(b) Parking brake

Parking brake is the spring applied parking brake. There is a spring applied air-release parking brake on trailer cars with driving cabs.

(c) Security brake

There is a security brake that operates automatically in case the service brake fails.

(d) Electric brake

The electric brake takes priority over the friction brake to use the regenerative energy and minimize friction brake wear.

Coupler Devices

(a) Front of leading cars (both ends of the train) is a semi-automatic tightlock coupler and draw-gear.

(b) Inter mediate portion between cars is semi-permanent couplers.

(c) There are electric couplings for train control and communication between cars and between trains for shunting and/or emergency operation.

Pantograph

(a) A single-Arm type pantograph is used. This type is widely used in the world as standard system.

(b) The pantograph has sufficient current capacity to supply the propulsion power for eight traction motors and the auxiliary power for four cars of an 8-car train.

Auxiliary power supply system

(a) Characteristics of Auxiliary Power Supply Unit (APU)

Table 4.9.9 APU Specifications

No.	Item	Specification
1	Control Method	Constant Voltage / Constant Frequency
2	Output Voltage	Three-phase AC 380V 50Hz
3	Basic design of APU	Approximately 260kVA x 2 sets/train(6 cars)

Source: JICA Study Team

(b) Redundancy system of auxiliary supply

In case one APU fails, the remaining APU provides power subject to reduced operating load requirements.

Table 4.9.10 Auxiliary Machine Load

No.	Item	Quantity/train	Specification
1	Air Conditioner	6 cars	Capacity 50,000kcal/h(58.1kW) x 2 sets/car, Input power:38kVA x 2 80kw/car
2	Motor driven air compressor	2 sets	Capacity 2000l/min/set, Input power: 2kW/set
3	Lighting	6 cars Train set	40Wlight x 16 sets = 0.64kW/car And other lights: 2 kW/train
4	Battery charging system	2sets	Around 15kW/set

Source: JICA Study Team

Air-Conditioning

(a) All saloon air conditioning units are of the self-contained package type.

(b) Their refrigerant shave zero ozone depletion potential indexes in compliance with the Montreal Protocol, for the life of the train. Coolant of non-pollution refrigerant, R407C, is preferable.

(c) Inside saloon temperature is 24ºC and 60% Relative Humidity (R.H) is maintained under the outside conditions of 41ºC, 98% R.H.

Data Recorder

The data recorder accurately records selected operation data of the train pertinent to investigation of an accident/incident. Two data recorders are installed in each driver's cab.

4.9.3 Passenger Capacity

1) Passenger capacity

The passenger capacity at AW1, AW2 and AW3 of 6- and 8-car train is as follows:

Table 4.9.11 Passenger Capacity of Each Train Formation

No.	Item	6-car train (Pax)	8-car train (Pax)
1	AW1	306	414
2	AW2	966	1,296
3	AW3	2,308	3,088

Source: JICA Study Team

4.9.4 Train formation

1) Train configuration

A 6-car train system consists of four-motor cars and two-trailer cars. The train configuration for six cars is as follows: Trailer car with driving cab (Tc) + Motor car (M) + Motor car (M) + Motor car (M) + Motor car (M) + Trailer car with driving cab (Tc).

i.e.: Tc – M – M – M – M – Tc

An 8-car train is introduced into operation at some time in the future. The additional two-trailer is inserted in the existing 6-car composition. The train configuration for eight cars is as follows: Trailer car with driving cab (Tc) + Motor car (M) + Motor car (M) + Trailer car (T) +Trailer Car (T) + Motor Car (M) + Motor Car (M) + Trailer Car with driving cab (Tc).

i.e.: Tc – M – M – T – T – M – M – Tc

4.9.5 Integrity with MRT Line 6

1) Comparison of Rolling Stock of Dhaka MRT Line 1 and Line 6

All facilities of Dhaka MRT Line 6 are planned at the elevated sections, and the facilities of Line 1 consist of the elevated sections and the underground sections. For these reasons, there is a difference between the fire safety standard and Structure gauge.

a. Fire safety standard at the underground sections

The technical standards for the rolling stock of the MRT in Bangladesh are the same as the fire protection standards in the underground section of Japan.

The fire protection standards for rolling stock cover requirements to provide safety from fire such as the use of non-combustible materials for the car body and installation of the gangway. The rolling stock for Line 1 is compliant with the technical standards for the MRT, same with the rolling stock of Line 6.

b. Structure Gauge for the underground section

Structure Gauge for the underground section is applicable to the underground stations and the tunnel sections. Depending on the Structure Gauge for the underground section, the items in the following table are affected:

Table 4.9.12 Countermeasures Against Structure Gauge for the Underground Section

Item	Rolling stock for Line 1	Rolling stock for Line 6
Working height of pantograph at the elevated sections	5,200mm	5,200mm
Working height of pantograph at the underground sections	4,650mm	Not applicable
Structure of the side windows	Not allowing passengers to extrude their bodies from windows.	Not allowing passengers to extrude their bodies from windows.
Maximum speed Elevated sections Underground sections	 100km/h 90km/h	 100km/h Not applicable

Source: JICA Study Team

The pantograph operates in a wide range at the elevated section, so it can be used at the underground section. The specification of the side window will not allow passengers to squeeze their bodies through the opening. The maximum operating speed is assumed to be 90 km/h because the underground section is an obstructed area.

4.10 Rolling Stock Depot Plan

4.10.1 Track Layout of the Rolling Stock

1) Basic Idea of the rolling stock depot

In general, the Rolling Stock Depot tracks are divided into three groups in accordance with the functions required from the depot, namely, storage track group, inspection and light repair track group and heavy repair track group.

It is important to properly arrange these three track groups according to their functions. The following are the basic considerations in designing the track layout in the Depot:

(a) Existing buildings and other facilities will not be affected in case of future expansion.

(b) The train movement remains efficient and smooth (”Entering the depot” →”Inspection and repair “→”Storage").

(c) There should be a track for pulling up Rolling Stock for shunting in order to avoid conflict with other trains to be worked on such as those for wheel surface grinding work, inspection and light repair work and heavy repair work.

(d) Arrange buildings and offices considering the character and the scale of the depot.

2) Number of Required Train Sets

The required number of train sets is discussed in Section 4.8.4, Operation Plan. In accordance with said operation plan, the following rolling stock is assigned to the Depot:

Table 4.10.1 Required Number of Trains and Train Sets According to the Operation Plan

Year	Number of cars per train	Required number of trains(Train set)	Total number of Cars
2025	8	25	200
2030	8	31	248
2035	8	36	288

Source: JICA Study Team

3) Number of Stabling Tracks

As discussed above, the required number of train sets is estimated at 25 sets for 2025, 31 sets for 2030, and 36 sets for 2035.

Two train sets will be at the depot for washing, inspection and/or repair work. Therefore, the number of train sets that should be kept at storage tracks is shown in Table 4.10.2.

In 2035, 32 train sets (40-(6 +2)=32) need to be kept at storage track at the maximum.

Table 4.10.2 Number of Train Sets Kept at Storage Track

Year	Total number of train sets	Number of train sets kept	
		At storage track	In other tracks
2025	25	23	2
2030	31	29	2
2035	36	34	2

Source: JICA Study Team

The space needed between storage tracks is 4m, but it is necessary to widen it to 4.5m every three or four tracks in order to install the pole for supporting the overhead wire.

4) Inspection and light repair track

On this track, daily, periodical and extraordinary inspections and light repair works are carried out. Daily inspection takes about one hour. The periodical inspection and light repair are called monthly inspection (in JR, these works are performed every three months),which covers the renewal of consumables; it takes about 8 hours. An example of monthly inspection track facility is shown in Photo Figure 4.10.1 below. For the monthly inspection work, two tracks are needed and more than one track is needed for the extraordinary inspection work. There should be a shed constructed for these 3 tracks. The distance between both tracks is 6m.

5) Cleaning Track

The cycle of the Rolling Stock washing work is about once a week, and it takes 2~3 hours each time. Assuming that the Rolling Stock washing work is once a week and the capacity of the Rolling Stock washing per track per day is four train sets, the following calculation can be made:36 train sets(total)/7days =5.1train sets/day. Thus, two washing tracks are needed.

The track space for the washing tracks is 6m in consideration of the washing work area. An example of rail car wash facility is shown in Figure 4.10.2 below.

6) Automatic washing track

Car washing by washing machine is carried out once every 2-3 days. In consideration of the maintenance of the automatic washing machine, a bypass track should be constructed. The train will use the bypass track when the washing machine is not operated.

An example of the automatic washing machine is shown in Figure 4.10.3 below. It would be effective to install the access track into the depot.

7) Wheel truing track

The cycle of the wheel truing depends on the train’s kilometreage, but the normal practice is every eight months or so. When a flat spot in the wheel is observed, wheel truing for the whole bogie wheels is carried out; one wheel truing takes about 30 minutes. This has an impact on the train operation schedule as the track requires one train set length. An example of the wheel truing machine is shown in Figure 4.10.4 below.

Source: JICA Study Team

Figure 4.10.1 Example of rail car repair track

Source: JICA Study Team

Figure 4.10.2 Example of rail car wash track

Source: JICA Study Team

Figure 4.10.3 Example of automatic rail car washing machine

Source: JICA Study Team

Figure 4.10.4 Example of Wheel surface grinding machine for wheel truing

8) Workshop

In the workshop, the examination for essential parts and the examination for whole Rolling Stock should be done. The examination for essential parts means the examination for the equipment which relates to car movement, and the examination for whole Rolling Stock means examinations for all parts of the Rolling Stock, i.e., an over haul. The examination of the bogie is performed at the stage of the examination for essential parts and the contents of its examination are overhauled. The respective number of days for both examinations is one month per train set.

The cycle of the examination for essential parts is every 2~4 years, but basically this examination is performed based on the train's kilometreage, while the cycle of the examination for whole Rolling Stock is every 6~8 years.

Assuming that the cycle of the examination for whole Rolling Stock is every eight years and the examination for essential parts is performed two times between examinations for whole Rolling Stock, one train set enters the workshop three times every eight years.

As an annual average, fifteen train sets(40train sets×3÷8years＝15 train sets/year) enter the workshop. Assuming that there is only one heavy repair track in the workshop, the utilization rate of this track becomes 125%(15train sets/year×1month÷12months/year×100＝125%).Therefore, two heavy repair tracks shall be provided because the utilization rate by only one heavy repair track is over 100%.

In the workshop, a track for full inspection of trains before leaving the workshop, a track for disassembling and assembling and a temporary repair track are needed. The full inspection track should have an overhead wire and a pit facility. The track for disassembling and assembling will facilitate the lifting of rolling stock bodies and also the pit facility.

In the latest workshop, like the picture shown in Figure 4.10.5, inspection and repair work are performed in the condition of lifting whole Rolling Stock bodies and turn table is used for pulling out old bogies and fixing new bogies or repaired bogies like Figure 4.10.6.

Source: JICA Study Team

Figure 4.10.5 An example of the device which can inspect and maintain the parts by lifting all the car bodies at the same time

Source: JICA Study Team

Figure 4.10.6 Turntable for the bogie

The temporary repair track has pit and two tracks are required as two Rolling Stocks separated from train set.

Therefore, in the workshop, one track for full train inspection, two tracks for disassembling and assembling, and two temporary repair tracks shall be installed.

9) Testing Track

Before leaving the workshop, the repaired train shall have an operational test on the testing track, which preferably should be as long as possible. If the track is not less than 500m, as minimum testing of a braking test, acceleration and deceleration test, shall be implemented.

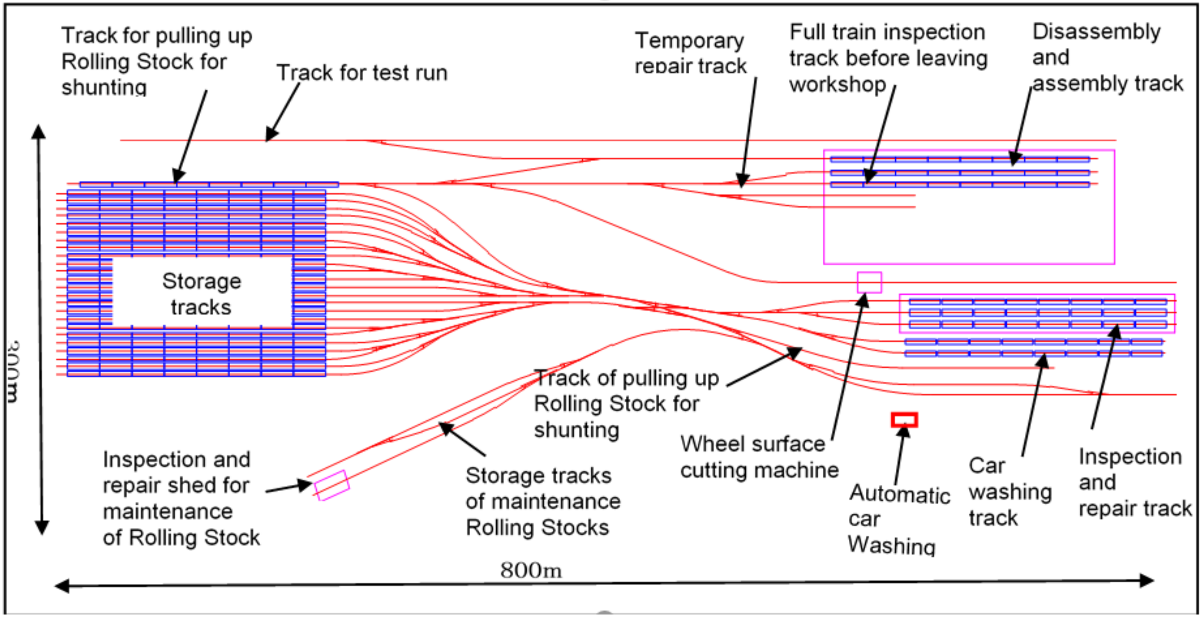
10) Facility Maintenance Vehicle

For the track maintenance, equipment such as track measuring machine, rail grinding wagon, multiple tie tamper and hopper wagon are needed, while for the electrical facility, several pieces of equipment such as an overhead wire measuring machine, a wagon for transporting the overhead wire roll, and a motor car for pulling trolleys are needed.

Storage tracks to keep these maintenance equipment shall be provided and a shed for inspecting these maintenance equipment is also required in the depot.

11) General layout of the depot

The basic track and facility layout in the depot is shown in Figure 4.10.7 below. According to site condition, area availability modification were made to the basic track and facility layout.



Source: JICA Study Team

Figure 4.10.7 General Layout of the Depot

12) The required area of the depot

The required area of the depot, computed as300m×800m=240,000 ㎡, is24 hectares.

4.10.2 Location of the Rolling Stock Depot

1) Basic idea for location of Rolling Stock depot

Technically, the basic idea for selecting the location of Rolling Stock depot is as follows.

(a) To look for an area that is near to the station as much as possible in order to reduce the loss of out-of-service operation;

(b) To design the approach which will allow direct entry to the depot from the departure and arrival track of the station and reduce to the utmost time loss such as longer turn back work.

(c) To select the route to the Rolling Stock depot which reduces the obstacle time of the train operation on commercial rack. Particularly, in case of the electric car operation, the obstacle time of crossing the main track is long and much time for changing the driver's cab at the turn back point and for the push operation will be needed. Therefore, it is important to select the track layout in which these problems are solved.

(d) To acquire the land of the Rolling Stock depot as easily as possible, because a considerably large area is necessary for the land of the Rolling Stock depot.

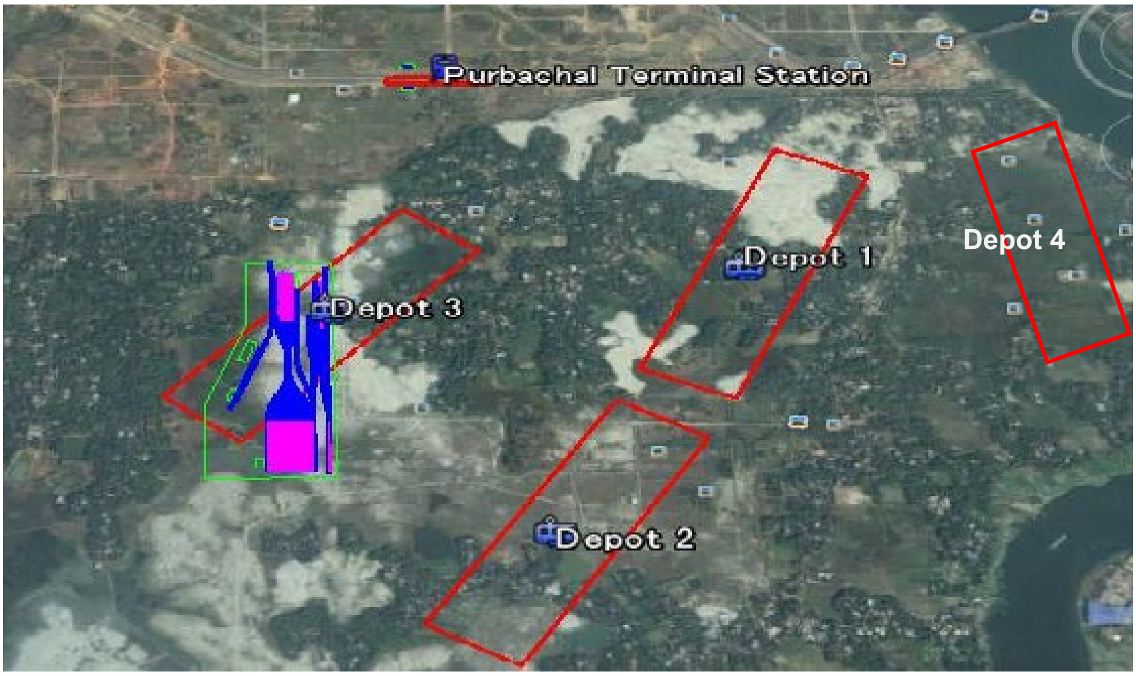
2) Consideration of alternative

Taking the above into consideration, JICA Study Team examined and proposed four candidates for Rolling Stock Depot for Dhaka MRT Line 1, as shown in Figure 4.10.8. The figure shows the relation of the positions among Depot 1 (Option1), Depot 2 (Option 2), Depot 3 (Option 3) and Depot 4 (Option 4).

From the viewpoint of train operation, in Options 1, 2 and 4, no turn back operation of the train and no change of driver's cab are expected. So, it may be said that these candidates are the most desirable ones. In the case of Option 3, the train approaches the depot from the front point of Purbachal Terminal Station. So, Option 3 has more time-loss than the other candidates.

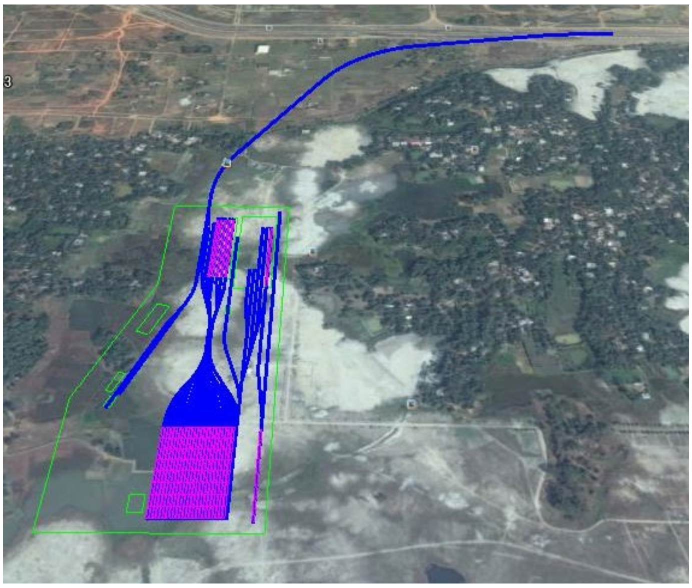
On the other hand, as a result of discussion with a local stakeholder, the environmental study group of the JICA Study Team informed the technical team that there are a lot of inhabitants in Option 1 and Option 2 areas, and it seems land issue will affect the project schedule. Thus, JST Environmental study group recommended the candidate site near Option 3 and Option 4 where inhabitants are fewer compared with the Option 1 and Option 2 areas, and land acquisition is relatively easy.

JST made several general layout drawings for option 3 and 4. Followings are as of results of the study. Figure 4.10.9 shows location connect line of Option 3. General layout is shown in Figure 4.10.10.



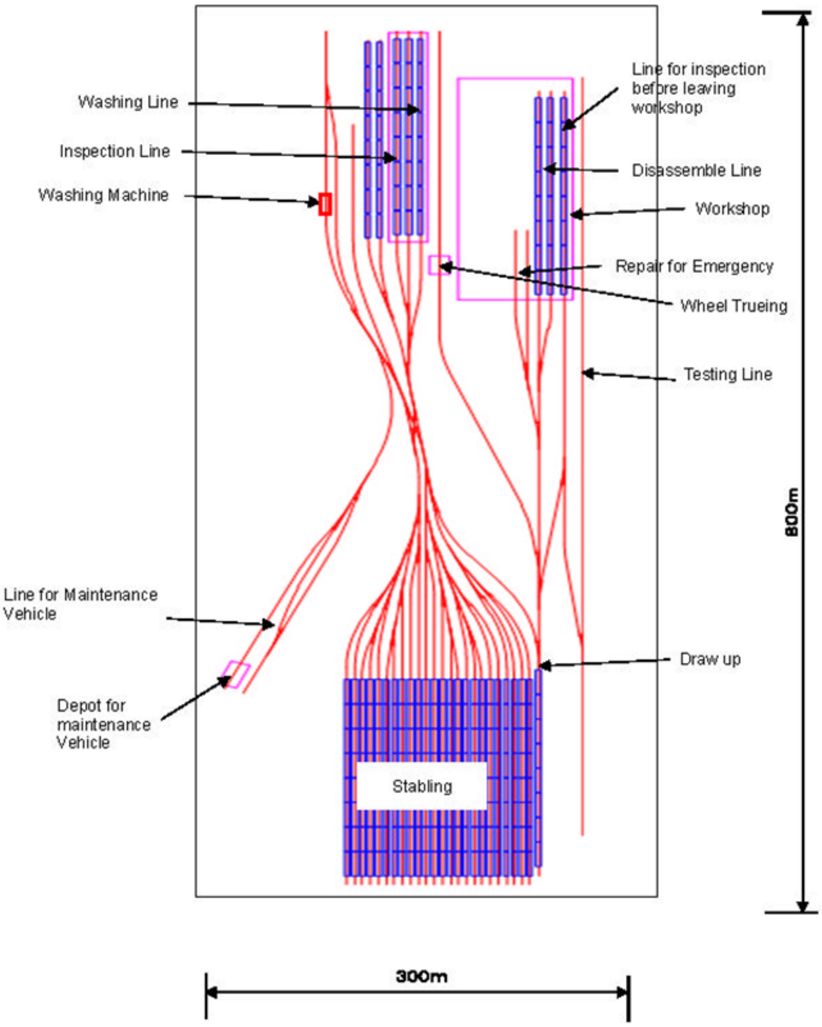
Source: JICA Study Team

Figure 4.10.8 Rolling Stock Depot Location Alternatives



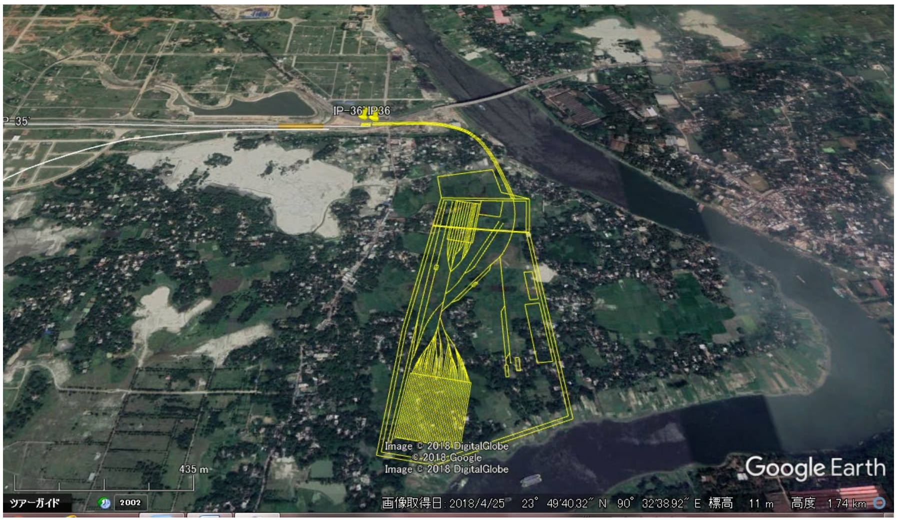
Source: JICA Study Team

Figure 4.10.9 Approach Track Connected between Terminal and Depot (Option 3)



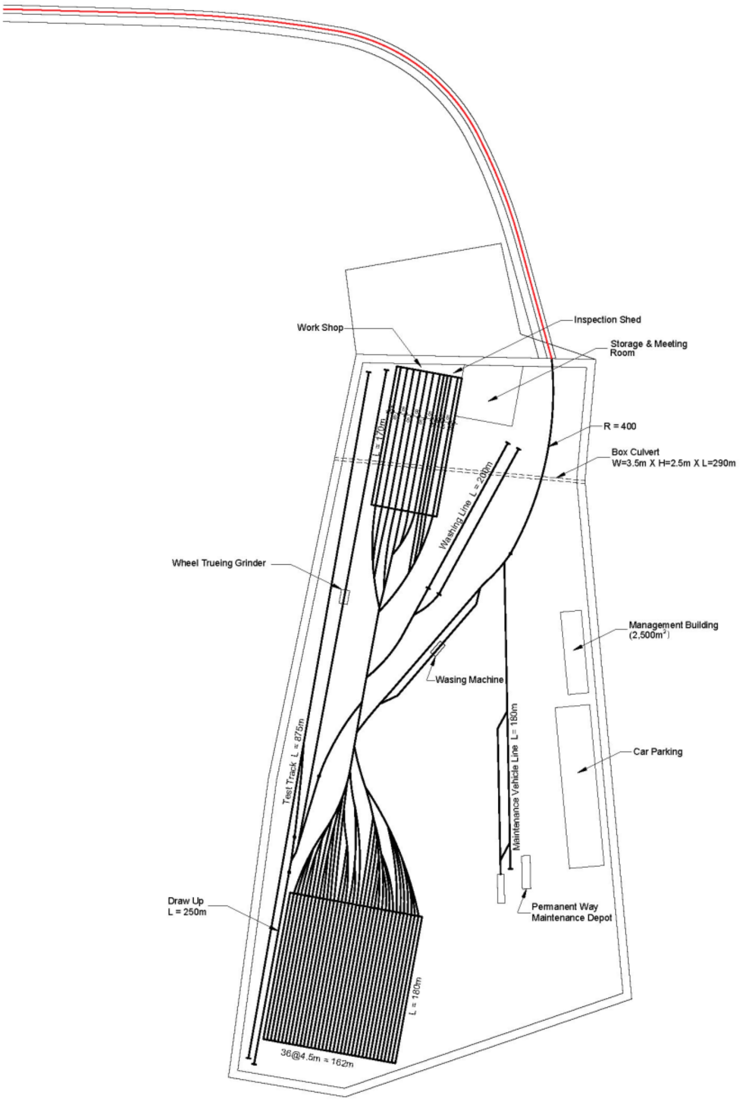
Source: JICA Study Team

Figure 4.10.10 General Layout of the Option 3



Source: JICA Study Team

Figure 4.10.11 Approach Track Connected between Terminal and Depot (Option 4)



Source: JICA Study Team

Figure 4.10.12 General Layout of the Option 4

At northern area there is the Padoma Oil Company's land. JST planned the approach track avoiding such private land.

As a result of the discussion with counterparts (DTCA), the JICA Study Team recommended that the Rolling Stock depot be established in Option 3 or 4. In the following Table 4.10.3 and Table 4.10.4, which compares the two options, the land area of Option 4 is 31.1 ha as given by DTCA.

Table 4.10.3 Comparison between Option 3 and Option 4 (1)

Subject		Depot for Line 1	
		Option 3	Option 4
Number of Car Assigned		Year 2025 200, Year 2035 288	Year 2025, 200, Year 2035, 288
Number of Stabling Lines		32	36 (Year 2025, 24)
Draw up line		1	1
Manual Washing Line		2 Platforms	2 Platforms
Painting		—	—
Inspection		3	3
Testing Line		1 (about 480m)	1 (875m)
Automatic Car Washing		1	1
Workshop	Inspection before leave workshop	2	2
	Disassemble and Assemble	1	1
	Repair for Emergency	2 (pit of 2 cars length)	2 (pit of 2 cars length)
Wide	Area	240,000m^2 (24ha.)	311,000m^2 (31.1ha.)
Possibility of future expansion		Capacity of Workshop further 8 trains. Space is sufficient	

Source: JICA Study Team

Table 4.10.4 Comparison between Option 3 and Option 4 (2)

Subject	Option 3	Option 4
Area (ha)	24.0	31.1 (Available)
Attraction to Commercial line	When enter the Commercial Line small restriction is expected	Free from commercial operation
Stabling Capacity	Depot Stabling Line 34 Lines, one Inspection line, one washing line Total 36 Trains	
Stabling at Station	Possible to Zero	
Approach Line	Western side of P. East Station crosses with Commercial Line. Grade separation structure shall be required	For future extension, draw-up line shall be lower level and approach line shall passes over them
Affection to Community (Refer to Chapter 5)	No	There is 3.5m wide partially paved road in depot area New box culvert width 3.5m shall be provided.
Construction Cost	Crossing commercial line viaducts shall be construct Long approach line is needed	Approach viaduct is shorter than Option 3. Box Culvert is required Box culvert is required
Other specific		Material for Embankment shall be transported by Sitalakhya River, refrain number of trucks for material transportation Imported Materials such as Rolling Stock shall be transported by ship cargo.
Others	Sufficient Land for Sub-station, Mosque, Car Parking, Environment Control Plan etc.	

Source: JICA Study Team

As a result of comparison study between Option 3 and 4, JST recommends option 4 due to easy approach to/from Depot. In addition to this large land may be used for future MRT line 1 expansion.

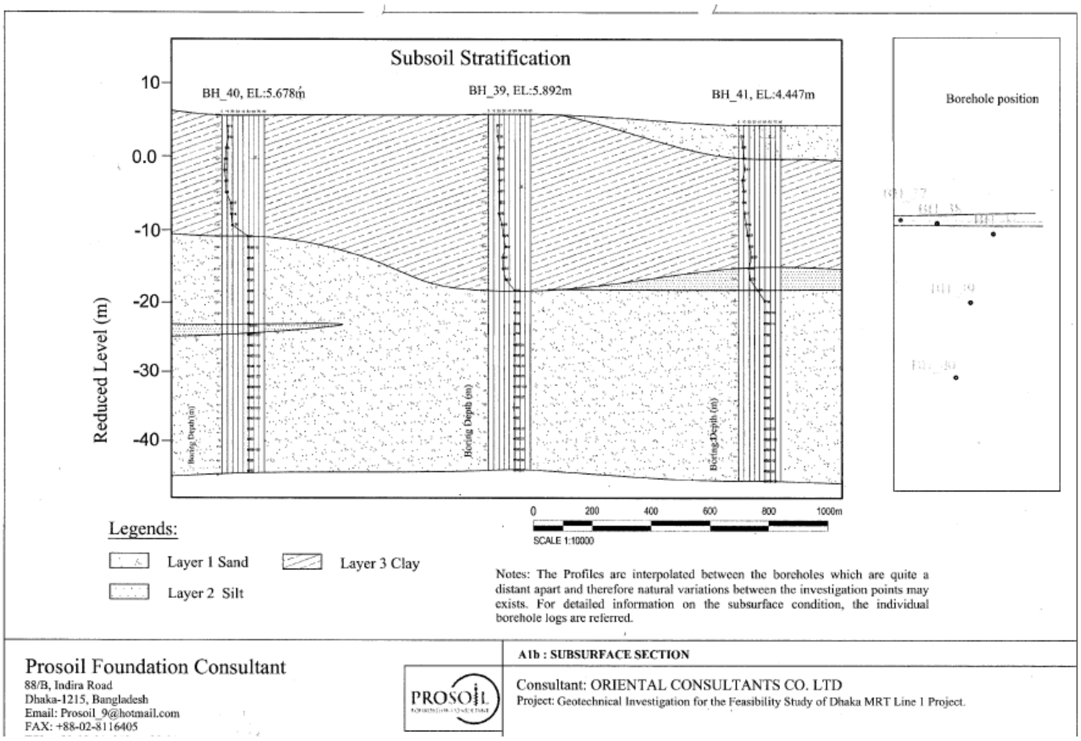
In order to keep existing road during/after MRT Line 1 depot, prior to embankment, new box culvert which inner size is width 3.5m and height 2.5m shall be built along the existing road.

4.10.3 Geological Feature and Ground Improvement

In general, at present, it is very difficult to acquire a large area of land such as that for the rolling stock depot near an urbanized area. This could lead to settling for an area where unstable soil condition is possible to construct the depot. As of the time of this report, the detailed geological survey for Option 4 is yet to be finished.

According to the data from a geological survey carried out near the recommended Rolling Stock depot location, there is a layer of soft sand from the ground level to around 5m below, and a layer of soft clay of around10m thickness under the soft sand layer. There is a relatively tight sand layer under the soft clay layer as shown Figure 4.10.13.

Therefore, a detailed geological survey should be carried out at the detailed design stage, and appropriate ground improvement plan should be examined. In addition, the drainage plan of the Rolling Stock depot in case of heavy rain should be examined.



Source: JICA Study Team

Figure 4.10.13 Geological Survey Data Near the Rolling Stock Depot

Embankment

JST proposes a 3m high embankment since the depot Option 4 is located near the river and soil condition is thought to be not tight enough to bear the Depot facility. About 720,000m^3 of soil is needed to build a 24ha depot. The following studies are requested in the detailed design stage:

- Embankment Material quality, quarry, transportation of material

- Method of embankment and ground improvement
- Mitigation impact to present Environment including at quarry

4.10.4 Environmental Consideration

There are four potential environmental impacts caused by the following:

1. Wastewater from car washing
2. Rubbish from cars
3. Noise from train
4. Settlement due to pumping water

Waste water from car washing shall be cleaned in a wastewater treatment facility provided at the depot and discharged into the river together with rain water. Prior to disposal, the water shall be regularly tested in accordance to the Laws Regulating the Environment in Bangladesh and the Environment Conservation Rules 1997. Detailed discussion with related agency shall be held.

With regards rubbish from rolling stock, this shall be handled together with the rubbish from the offices.

In the early morning, many trains shall leave the depot to the Terminal Station, and some noise is expected. But the depot is built on a 3m high embankment and approach track also runs 3m high. Thus, expected noise level is quite low. But in the design stage, countermeasures will be studied such as large curvature approach track, speed restriction, and noise barrier.

The Study Team thinks that ground settlement at outside the depot is very rare because the car washing tracks locate far from the residential area. But a more detailed study shall be carried out in the Detailed Design stage.

4.10.5 MRT Comparison between Line 1 & 6

Table 4.10.5 shows comparison between MRT Line 1 & 6.

Table 4.10.5 Comparison between Line 1 &6

Categories		Line 1	Line 6
Number of Assigned Trains and Cars		25 fleets, 200 cars in 2025, 36 fleets, 288 cars in 2035	36 fleets, 288 cars
Stabling Line		36 lines	18 lines (1 line stables 2 fleets)
Draw-up for shunting		1 lines	1 line
Washing Line		2 lines and 1 washing machine line	1 line
Painting Line		–	1 line
Inspection Line		3 lines	5 lines
Testing Line		1 line (900m)	1 line (1,000m)
Automated Train Washing Line		1 line	1 line
Workshop	Inspection and Repair	2 lines	2 lines (For 8 cars x 2 lines) 4 lines (For 4 cars x 4 lines)
	Inspection before dispatch	1 line	
	Dismantle	2 lines	
	Temporally/Emergency	2 lines with 40m (pit length 2 cars)	

Categories		Line 1	Line 6
Required Area	Depot Area	311.000m² (31.1ha)	220,000m² (22ha)
Possibility of expansion		Work shop capacity to handle is about 8 fleets 8 stabling lines will be laid between Testing Line and stabling lines	

4.11 Electrification System and Utilities Plan

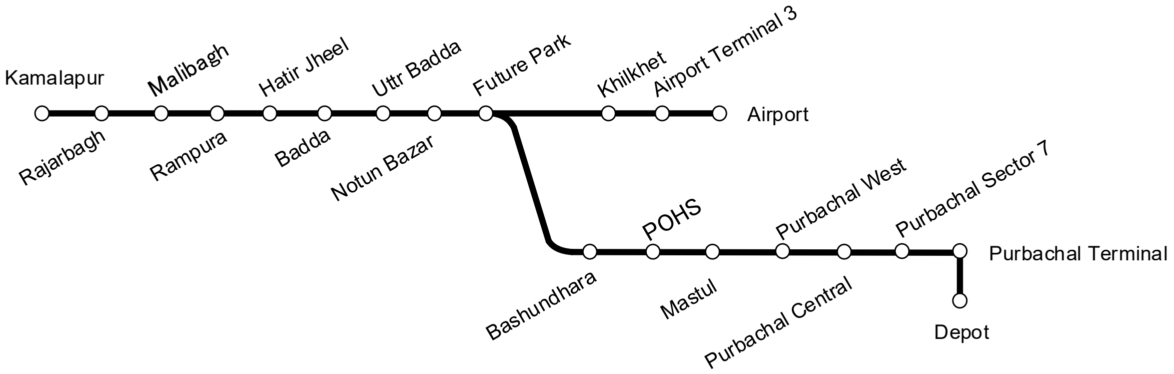
4.11.1 Substation System Plan

1) Prerequisites

The power supply system for MRT Line 1 will comply with the technical specifications for MRT Line 6. The primary specifications are shown below:

- Track gauge 1435 mm
- Traction system 1500VDC (lower limit 900V, upper limit 1800V)
- Design speed 110 km
- Train configuration Six cars 4M2T, Eight cars 4M4T in the future
- Propulsion system VVVF three-phase AC induction motor
- Power supply AC 132kV 50Hz
- Loop distribution voltage AC 33kV
- Station/depot power distribution voltage AC 415V

The route map for Line 1 is shown in Figure 4.11.1 The line consists of two routes: one travelling from the Kamalapur Station to the Airport Station (hereafter the "Airport Line"), and the other from the Notun Bazar Station to the Purbachal Terminal Station (hereafter the "Purbachal Line"). The Airport Line will run through an underground tunnel, and the Purbachal Line will run through an underground tunnel from Notun Bazar to the section before Bashundhara Station, after which it will run on an elevated structure.



Source: JICA Study Team

Figure 4.11.1 Route Map of Line 1

2) Power Receiving System

(1) 132kV Power Supply System

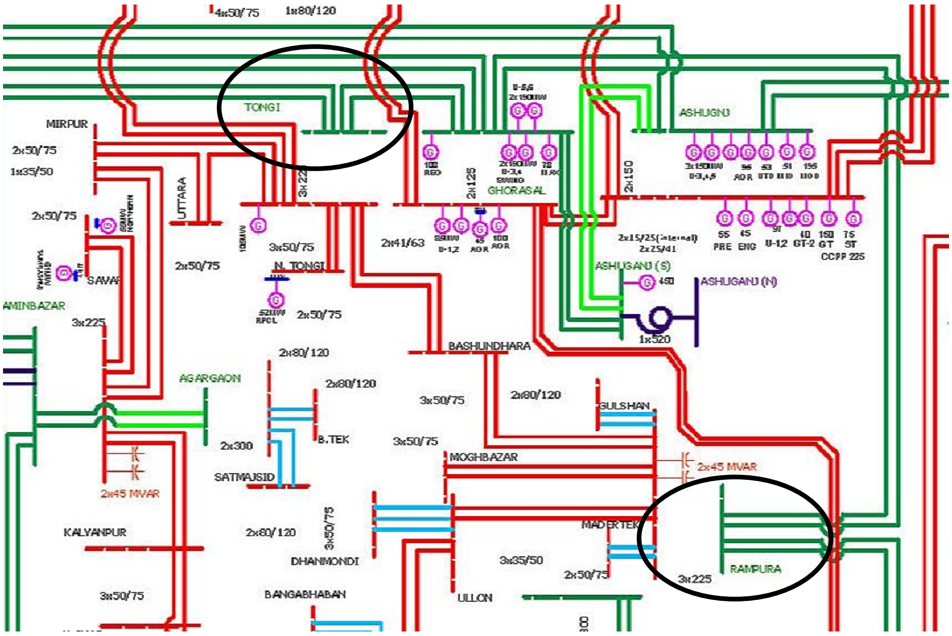
The railway requires a stable source of large amounts of power, and therefore substations (RSS) will be built to receive 132kV power from grid substations (GSS). Two RSSs will be built to ensure the reliability and redundancy of the power supply system. The received power is stepped down to 33kV which is then distributed to the rectifier traction substation (TSS), substations for stations (ASS), and a substation for the depot.

Regarding power supply, since it is necessary to secure railway power preferentially, a power supply contract with electric power company must be concluded. In addition, by installing a power station, the electric power necessary for each station to drive in the event of an emergency is secured. Furthermore, at the time of a power outage, a storage system will be introduced as a vehicle emergency power supply at each station in order to secure the safety of passengers by moving to the nearest station.

(2) Selecting a Grid Substation (GSS)

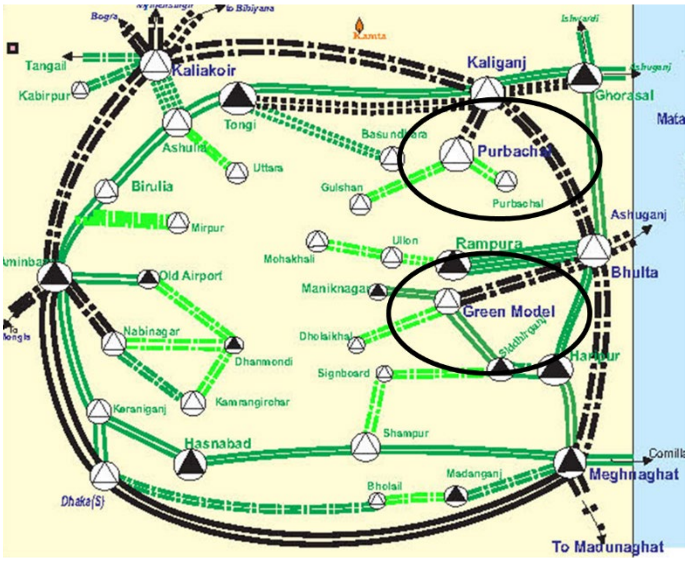
GSSs that are near Line 1 will be identified, and GSSs with short transmission distances will be considered as the power supply for Line 1. Figure 4.11.2 shows the existing power grid and GSSs near the Dhaka area. Figure 4.11.3 shows the grid and GSSs that are slated for future construction in the area.

The encircled GSSs are those that currently exist or are already scheduled to be built near Line 1. Existing GSSs are Tongi (approx. 6.4km) and Rampura (approx. 1.1km). The distances in brackets indicate their distances to Line 1. Meanwhile, GSSs slated for future construction are Purbachal (approx. 1.8km) and Green Model (approx. 3.2km).



Source: Web Site

Figure 4.11.2 Existing Power Grid and GSSs near the Dhaka Area



Source: Web Site

Figure 4.11.3 Grid and GSSs for Future Construction in the Area

The identified GSSs are shown in Table 4.11.1.

Table 4.11.1 Candidate GSSs

No	Route	GSS	Location	Nearest station	Transmission distance	Remarks
1	Airport Line	Rampura 230/132kV GSS	Aftab Nagar	HatirJheel	1.1 km	Existing
2	Airport Line	Tongi 132kV GSS	Tongi BSCIC	Airport	6.4 km	Existing
3	Airport Line	Green Model	Green Model Town	Kamalapur	3.2 km	Construction scheduled
4	Purbachal Line	Purbachal 132kV GSS	RAJUK Sector-4	Purbachal Terminal	1.8 km	Construction scheduled

Source: JICA Study Team

With regard to the Airport Line, the Rampura GSS provides the shortest transmission distance. As for the Purbachal Line, the Purbachal GSS is the only candidate. While the Study Team concludes that these two GSSs are suitable as the power supply for Line 1, the existing GSSs do not have sufficient power, and therefore power for Line 1 should preferably be supplied from a power grid based on the Bangladesh National Master Plan on Electric Power. In this study, these two GSSs are positioned as provisional options.

(3) 132kV Power Transmission

As power transmission from the GSS to RSS will pass through urban areas, the Study Team proposes the use of an underground lead-in using underground power cables. Taking into consideration the possibility of transmission accidents, two transmission circuits will be employed to improve the reliability of train operations. As the 132kV transmission lines will be designed and built according to local electric power standards, discussions with local power companies are a must.

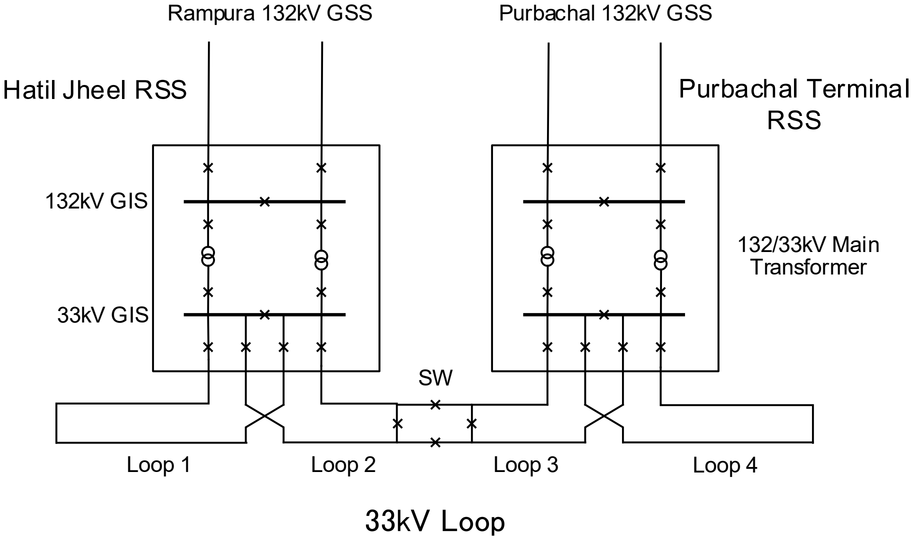
(4) Receiving Substations (RSS)

The RSSs will be built above ground near the Hatir Jheel and Purbachal Terminal stations. The locations of the sites and land size will have to be determined based on local electric power standards.

Primary equipment that the RSSs will require are 132kV gas-insulated switch gears (GIS), main 132/33kV transformers (two sets), and 33kV GIS.

(5) 33kV Loop Distribution

The loop distribution used for Line 6 constantly receives power from a double line and is advantageous in that train operations can be maintained without power outages even in the event that there is a transmission problem in one line. Figure 4.11.4 is a system diagram of the 132kV power supply system and 33kV loop distribution for Line 1.



Source: JICA Study Team

Figure 4.11.4 132kV Power Supply System and 33kV Loop Distribution System Diagram

The 33kV loops, Loops 1 thru 4, will be allocated to the distribution areas shown in Table 4.11.2.

Table 4.11.2 33kV Loop Distribution Areas

	Distribution areas
Loop1	Kamalapur ~ UttrBadda
Loop2	Notun Bazar ~ Airport
Loop3	Notun Bazar ~ Mastul
Loop4	Purbachal West ~ Purbachal Terminal, Depot

Source: JICA Study Team.

A circuit breaker switch will be installed at Notun Bazar so that this can be switched to extend the loop distribution if one of the RSSs has a power outage.

(6) Rectifier Traction Substation (TSS)

Since high-density train operation is presumed, a guideline of the interval for TSS installations will be 5 kilometres. As an extension of Line 1 is being envisioned, a TSS will be installed at the terminal station. Table 4.11.3 shows the results of installing TSSs near Line 1 stations based on these conditions.

Table 4.11.3 TSS Locations and their Intervals

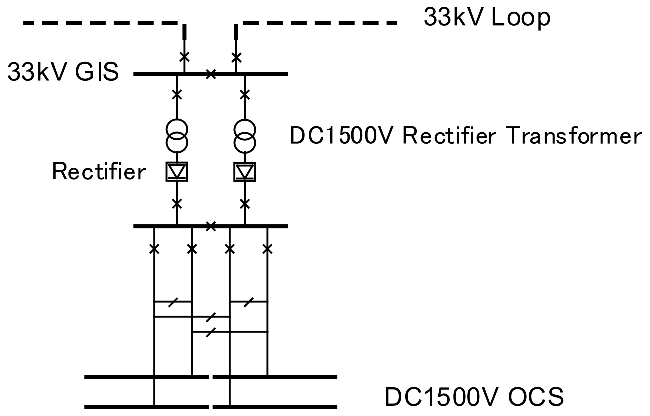
Airport Line	Purbachal Line
Kamalapur	Notun Bazar
(5.4 km)	(4.3 km)
HatirJheel	Bashundhara
(4.7 km)	(5.0 km)
Future Park	Purbachal West
(4.7 km)	(5.7 km)
Airport	Purbachal Terminal

Source: JICA Study Team.

As a general rule, at underground stations, the TSSs will be built in or beside the underground station yard. At elevated stations, they will be built on the ground under viaducts.

The 33kV line that is loop-distributed from the RSS is stepped down to 1500VDC and rectified at the TSS. The 1500VDC traction power is sent via an overhead contact system (OCS) above the rails to the electric multiple-units (EMU) where they are consumed, and then returned to the TSS via rails, etc.

Primary components are the 33kV GIS, rectifier transformers and rectifiers (two sets), DC circuit breaker, and disconnecting switch. The implementation of power storage type regenerated power absorber has been held off for future consideration. Figure 4.11.5 shows a single-line system diagram of the components that make up a TSS.

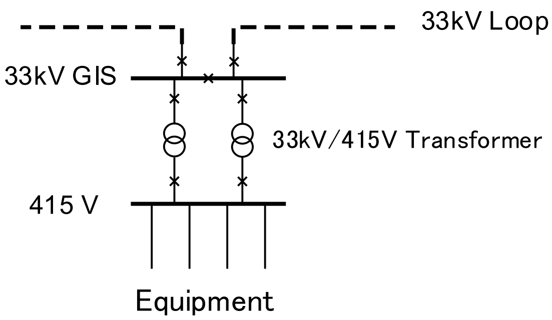


Source: JICA Study Team

Figure 4.11.5 TSS Single-Line System Diagram

(7) Station Substations (ASS)

Substations will be installed in all station yards to supply the power needed for station services, station facilities, and underground facilities. The loop-distributed 33kV power will be stepped down to 415V at the ASSs. Primary components are the 33kV GIS, dry type 33kV/415V transformers (two sets), and a switchboard. Figure 4.11.6 shows a single-line system diagram of the components that make up an ASS.



Source: JICA Study Team

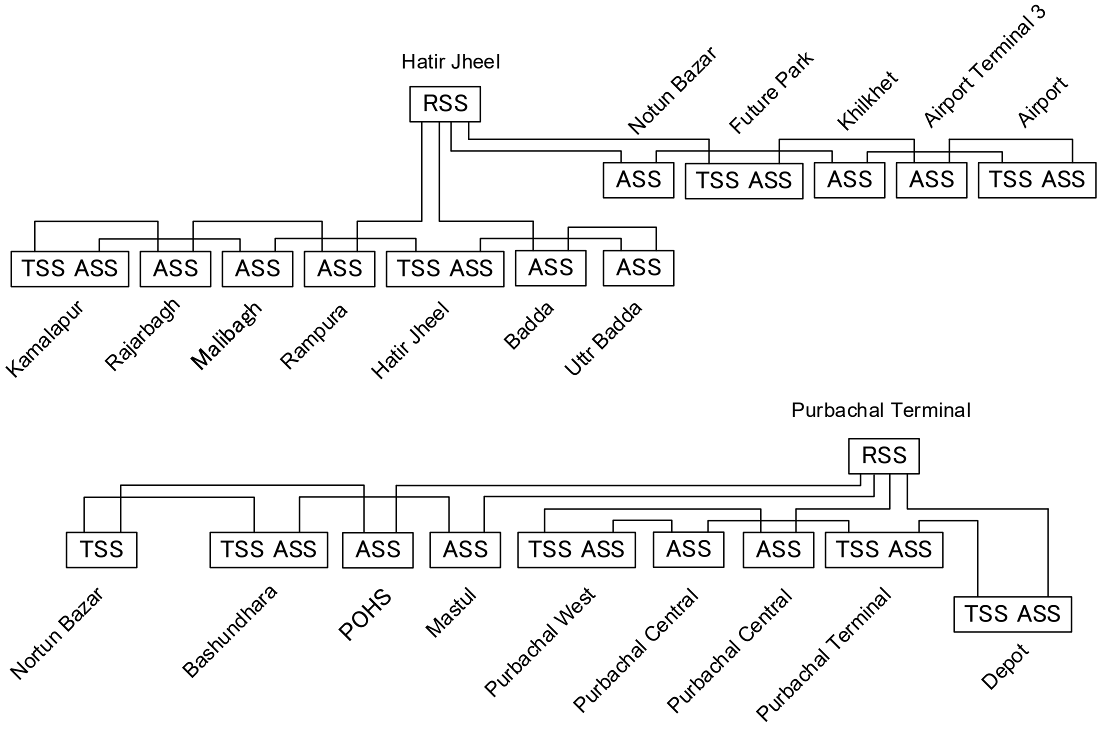
Figure 4.11.6 ASS Single-Line System Diagram

(8) Depot Substations

At the depot near the Purbachal Terminal station, a TSS will be built for running trains in the depot, and an ASS for the workshop and maintenance work. Specifications of primary components are the same as for the TSS and ASS described above.

33kV Loop Distribution System Diagram

The 33kV distribution loop, which the RSSs will be responsible for, and the relationship between the different substations are shown in Figure 4.11.7, which shows a diagram of a 33kV loop distribution system.



Source: JICA Study Team

Figure 4.11.7 33kV Loop Distribution System Diagram

Table 4.11.4 Receiving Substation, Traction Substation and Station Substation

Receiving Substation (2)			
(Airport Line)			
1)	Hatir Jheel RSS	Hatir Jheel (5k490m)	Underground
(PurbachalLine)			
2)	Purbachal Terminal RSS	Purbachal Terminal (In Depot) (23k590m)	Elevated
Rectifier Traction Substation (9)			
(Airport Line)			
1)	Kamalapur TSS	Kamalapur Station (0k130m）	Underground
2)	Hatir Jheel TSS	Hatir Jheel Station (5k490m)	
3)	Future Park TSS	Future Park Station (10k150m)	
4)	Airport TSS	AirportStation (14k890m)	
(Purbachal Line)			
5)	Notun Bazar TSS	Notun Bazar Station (8k570m）	Underground
6)	Bashundhara TSS	BashundharaStation (12k880m)	Elevated
7)	Purbachal West TSS	Purbachal West Station (17k920m)	
8)	Purbachal Terminal TSS	Purbachal Terminal Station (23k590m)	
9)	Depot TSS	In Depot	
Station Substation (20)			
1)	Station ASS	MRT Line 1 19stations	
2)	Depot ASS	Depot	

Source: JICA Study Team

3) Required Electrical Energy

In this section, the capacities of the TSS rectifier and RSS transformer are calculated. The Study Team also considered the matter of voltage drops from extensions of the feeder range when a TSS is down.

(1) Prerequisites

Traction power

Table 4.11.5 shows the operational plan for trains.

Table 4.11.5 Train Operational Plan

Year	2025	2035	Remarks
Train configuration	8-car train	8-car train	
	4M4T	4M4T	
Train headway	4 min	2 min. 30 sec	Peak hours
Scheduled speed	36.5 km/h	36.5 km/h	Airport Line
	39.0 km/h	39.0 km/h	Purbachal Line
Train weight	441 tons	441 tons	AW3

Source: JICA Study Team

The values shown in Table 4.11.6 are used in the power consumption specifications of the trains.

Table 4.11.6 Train Power Consumption Specifications

Item	Contents
Control type	Inverter control car
Power consumption rate	47.6 kWh/1000 ton.km
Maximum current on pantograph	2667 A
Auxiliary power	260kWh/train

Source: Japan Rail Electrical Engineering Associations

(2) Station power

Taking into consideration future power consumption such as by signal units, telecommunications, lighting, elevators, escalators, station services, fire fighting, and underground facilities, the power consumption for elevated and underground stations are presupposed to be 500kW and 1600kW, respectively.

(3) Depot power

Taking into consideration future power consumption such as for traction in the depot, workshop operations, maintenance, and maintenance infrastructure facilities, the facility power is presupposed to be 2700kW.

(4) TSS maximum power

The maximum power demand for each of the TSSs was calculated for when trains are operated based on the operating plan and the power consumption of EMUs described above. The maximum power per hour was calculated based on train weight, energy consumption rate, etc., and the instant maximum power was calculated from traction power, auxiliary outputs, etc.

Table 4.11.7 shows the calculated maximum power values.

Table 4.11.7 TSS Maximum Power

(Unit: kW)

TSS	2025		2035	
	1 hour	Instant	1 hour	Instant
Kamalapur	2,291	10,006	3,665	13,299
HatirJheel	4,284	13,566	6,855	17,479
Future Park	3,987	14,837	6,380	21,965
Airport	1,994	11,821	3,190	11,933
Notun Bazar	1,794	7,780	2,870	10,882
Bashundhara	3,380	12,175	6,208	18,603
Purbachal West	4,464	9,422	7,143	25,452
Purbachal Terminal	2,378	9,569	3,805	11,328

Source: JICA Study Team

4) TSS rectifier capacity

The demand overload ratios for rectifiers are defined as 120% for maximum power per hour, and 300% for instant maximum power. Table 4.11.8 shows the results arrived at by calculating the capacity of rectifiers for each of the maximum power values. Two sets of rectifiers will be installed and operated in accordance with chronological fluctuations in power consumption.

Table 4.11.8 TSS Rectifier Capacity

(Unit: kW)

TSS	Rectifier capacity	Maximum power		Overload ratios		Rectifier size	Sets
		1 hour	Instant	120%	300%		
Kamalapur	5,000	3,665	13,299	73%	266%	5,000	1
HatirJheel	10,000	6,855	17,479	69%	175%	5,000	2
Future Park	10,000	6,380	21,965	64%	220%	5,000	2
Airport	5,000	3,190	11,933	64%	239%	5,000	1
Notun Bazar	5,000	2,870	10,882	57%	218%	5,000	1
Bashundhara	10,000	6,208	18,603	62%	186%	5,000	2
Purbachal West	10,000	7,143	25,452	71%	255%	5,000	2
Purbachal Terminal	5,000	3,805	11,328	76%	227%	5,000	1

Source: JICA Study Team

The transmission range for Terminal TSSs—the TSSs at the Kamalapur, Airport, Notun Bazar, and Purbachal Terminal stations—will be approximately half of that of intermediate TSSs, and therefore the capacities of their rectifiers will be smaller.

The Kamalapur, Airport, and Purbachal Terminal TSSs will have two sets of 4,000kW size rectifiers to accommodate potential future extensions. The depot TSS will have one set with a of 4,000kW rectifier.

5) RSS transformer capacity

The capacities for RSS transformers at Hatir Jheel and Purbachal Terminal were calculated.

The electrical energy required at the ASSs, based on station power and depot power prerequisites, is shown in Table 4.11.9. The electrical energy required at the TSSs are the rectifier capacities calculated above.

Table 4.11.9 Electrical Energy Required at ASSs and TSSs

(Unit: kW)

Route		Kilometrage	Location	ASS	TSS
Airport Line	Loop 1	0.13	Kamalapur	1,600	10,000
		1.25	Rajarbagh	1,600	
		3.36	Malibagh	1,600	
		4.31	Rampura	1,600	
		5.49	HatirJheel	1,600	10,000
		6.55	Badda	1,600	
		7.58	Uttra Badda	1,600	
	Loop 2	8.57	Notun Bazar	1,600	
		10.15	Future Park	1,600	10,000
		12.62	Khilkhet	1,600	
		14.04	Airport Terminal 3	1,600	
		14.89	Airport	1,600	10,000
Purbachal Line	Loop 3	8.57	Notun Bazar		5,000
		10.15	Future Park		
		12.88	Bashundhara	500	10,000
		14.57	POHS	500	
		16.25	Mastul	500	
	Loop 4	17.92	Purbachal West	500	10,000
		19.46	Purbachal Central	500	
		21.42	Purbachal Sector 7	500	
		23.59	Purbachal Terminal	500	10,000
			Depot	2,700	4,000

Source: JICA Study Team

By aggregating the values in the table above, the results shown in Table 4.11.10 are arrived at.

Table 4.11.10 RSS Transformer Capacity

RSS	ASS	TSS	Total
Hatir Jheel Airport Line	19.2 MVA	40.0 MVA	59.2 MVA
Purbachal Terminal Purbachal Line	6.2 MVA	39.0 MVA	45.2 MVA

Source: JICA Study Team

Therefore, the RSSs at Hatir Jheel and Purbachal Terminal will require transformer capacities in the 55MVA class and 40MVA class, respectively.

6) Study of voltage drop due to extension of feeder range

If a TSS suffers a power outage, the adjacent TSS will supply power by extending its feeder range. At longer feeder ranges, the voltage in the feeder will drop and reduce the trains' propulsion power. In this section, scenarios are reviewed wherein the Hatir Jheel TSS and Purbachal West TSS are down—scenarios which require the longest feeder range extensions—and whether this will cause the traction voltage to breach the lower limit of 900V.

Calculations for voltage drops are typically performed under a scenario where the train with the largest load is placed at the centre of the feeding range, and trains with normal loads are placed at equal intervals, wherein the voltage drop is calculated from the trains' current consumption and the resistance of the OCS.

Table 4.11.11 shows the results of these voltage drop calculations.

Table 4.11.11 Results of Voltage Drop Calculations

	Airport Line HatirJheel	Purbachal Line Purbachal West
Extension of feeder range	10.1 km	10.7 km
Train intervals	1. 52km	1.63 km
Number of trains placed at equal intervals	6	6
Current at the centre train	2667A	
Current at trains placed at equal intervals	1,006A	1,006A
OCS resistance	0.040 s/km	
Voltage drop	550V	532 V
Feeder voltage	995V	968 V
Lower limit	900 V	

Source: JICA Study Team

In either scenario, the feeder voltage remains above the lower limit, posing no problems.

7) Supervisory Control and Data Acquisition (SCADA)

SCADA systems for the electrical power are installed at the operation control centre (OCC) and RSS to monitor the entire power supply system of Line 1. Remote terminal units (RTU) are installed at the RSS, ASS, and TSS, and via these, remote control is performed, including disconnecting switch operations during failures and periodic data collection.

Listed here are the primary supervisory control items:

- Status of high, medium and low voltage, and the DC power supply
- Status display of all electrically operated switching devices in AC132kV, 33kV, and 1500VDC systems
- Protection device with alarm
- Main circuit breaker and connection breaker of the main LV switchboards at TSS and ASS
- Bus voltages and currents of all 132kV AC, 33kV, 415V, and 1500VDC systems
- Status of circuit breakers and disconnecting switches
- Rectifier current

8) Emergency Trip System (ETS)

Line 1 will be equipped with an emergency trip system that will immediately cut off the traction power. Cut-off devices will be placed at the ends of platforms, station control centres, TSSs, and the depot. The ETS is monitored by SCADA, and if tripped, this status is reported to the OCC and RSS.

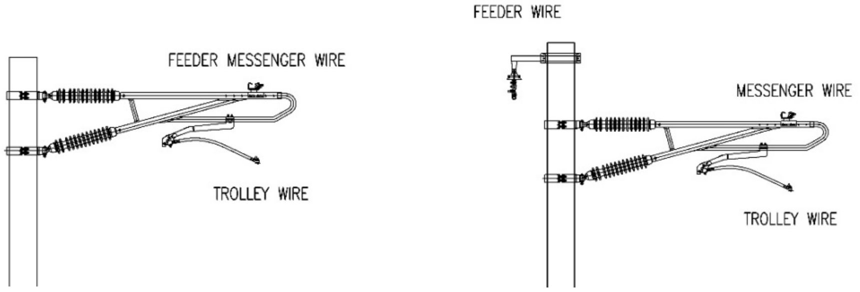
9) Uninterruptable Power Supply (UPS)

The SCADA units at the OCC and RSS will be equipped with their dedicated UPS. Basic specifications call for a power supply guarantee time of 10 hours. RTUs at the RSS, ASS, and TSS will be equipped with UPS that uses maintenance-free, nickel-cadmium 110V batteries. Even if the charger fails, it must provide a supply time of at least 10 hours at the rated load.

4.11.2 Overhead Contact System (OCS)

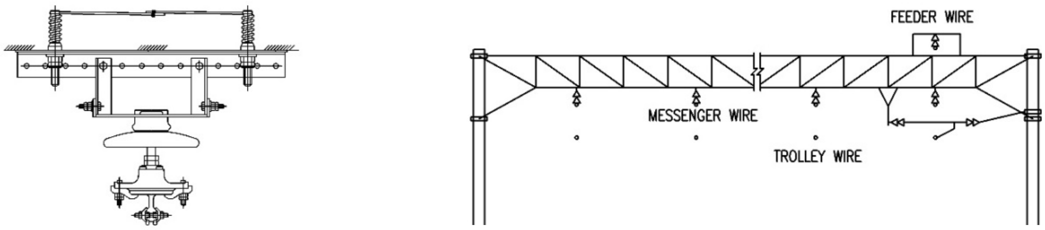
1) Proposed OCSs

The OCSs shown in Figure 4.11.8 are recommended for a design speed of 110km/h.



Feeder messenger system
(Elevated sections)

Simple catenary system
(Elevated sections)



Overhead conductor rail system
(Underground sections)

Simple catenary system
(Depot)

Source: JICA Study Team

Figure 4.11.8 Proposed OCSs

The feeder messenger system has a messenger wire whereby the feeder wire and messenger wire are integrated. Its lack of a feeder wire offers better aesthetics compared to simple catenary systems. It also poses less workload for catenary maintenance. JST recommends the feeder messenger system for the elevated sections on Line 1.

Underground tunnels have height restrictions, and therefore, an overhead conductor rail system will be employed which uses support units that are positioned lower than in the simple catenary system.

The depot will be equipped with a simple catenary system which is economical and whose feeder wires are each capable of supplying power to multiple trolley wires.

Trolley wire height

The height to the trolley wire from the top of the rail is prescribed in Table 4.11.12.

Table 4.11.12 Trolley Wire Height

	Main lines	Depot
Standard height	4,800 mm	5,100 mm
Upper limit	5,100 mm	5,200 mm
Lower limit	4,500 mm	4,600 mm

Source: JICA Study Team

However, where level crossings are to be built, the trolley wire must be installed at 4800mm or higher.

Poles

Single poles will be made of either concrete or steel. Portal type supports with truss beams will be used for track sections with more than three tracks.

OCS support structures

In elevated sections, support structures will consist of hinged cantilevers, and in underground sections, a supported hardware for the overhead conductor rail. The overhead conductor rails consist of a grooved trolley bar, T-shaped rigid aluminium alloy conductor rail, mounting for overhead conductor rail, insulator, supporting bracket, and anchor bolt.

Automatic tensioner

Catenary tension is balanced by a tensioner that is attached to the ends of the OCS. Tensioners come in different types including pulley type, spring type, hydraulic, and pneumatic. It would be preferable to use a type of tensioner with a proven track record. JST recommends automatic tensioners for the main line, and pulley type tensioners in the depot.

If a feeder messenger system is used, the cross section of the messenger wire will be thicker than that of a simple catenary system, and therefore, the catenary tension will be larger.

Trolley wire bias

In order to avoid uneven wear of the pantograph strip, the trolley wire will be installed in a zigzag manner with a range of bias of no larger than 200mm.

Trolley wire gradient

In order to prevent the pantograph from losing contact with the wire and to ensure good contact with the trolley wire, limits must be placed on variations in rail and trolley wire gradients. These limits are shown in Table 4.11.13.

Table 4.11.13 Variations in Rail and Trolley Wire Gradients

	Limit value
Elevated sections	No greater than 5/1000
Underground sections with overhead conductor rail system	No greater than 1/1000 Height difference must be no greater than 5mm for 5m of rigid rail.
Depot or service lines	No greater than 15/1000

Source: JICA Study Team

4.12 Signal and Telecommunication Facility Plan

4.12.1 Brief summary

It is indispensable for MRT Line 1 to be whole maintained with Line 6.Therefore, to examine the technical specification of Line 6 and to inherit a necessary specification from it accordingly the Signal and Telecommunication system should be congruent between Line

1 and Line 6. Considering both Lines are connected in the future, to adjust the same specification is large advantage in terms of spare parts and utilizing all machines in depot together. The specification of the Signal and Telecommunication Facility system is as follows:

Table 4.12.1 Technical specification of MRT Line 6

Item	Sub-Item	Main specification
Signal system	Frame of system	CBTC, Signal
	Security equipment	ATP by CBTC
	Central control of train	CTC,PRC
Telecommunication system	Frame summary of system	Radiocommunication, passenger information, Broadcast system

Source: JICA Study Team

The objective of a signal system is to secure the operation of train. Therefore the signal system highly requires the reliability and it is indispensable to activate the system safety side if the system is malfunction.

Telecommunication Facility is also indispensable to secure the train operation control, on a railroad and working in a station. It is required the services of communication among the personnel and information to passengers.

Table 4.12.1, Technical specification of MRT Line 6, satisfies the above preconditions of Signal and Telecommunication Facility. Therefore the specification of Line 1 follows the same system plan.

4.12.2 Signalling Facility Plan

1) Prerequisites

The main prerequisites for the signalling facilities planning are as follows.

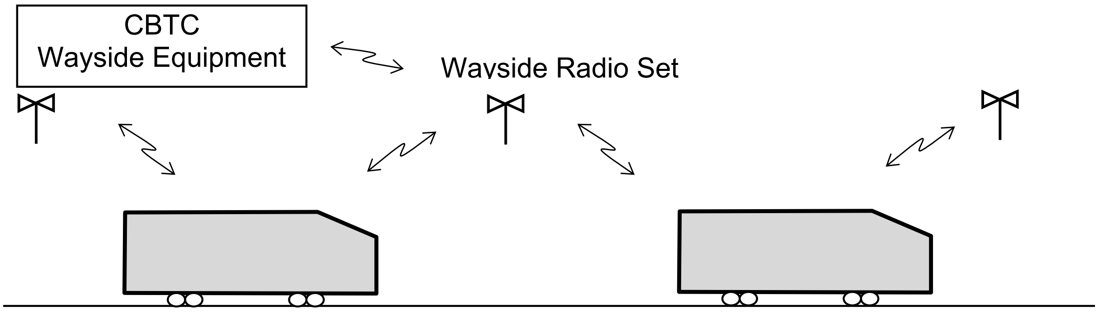
- The signal facilities are equipment to support safe and efficient train operation.
- The signal safety system functions to ensure backup to counteract driver errors.
- Signalling systems ensure the efficient movement of train operation.
- Signalling systems must be designed so as to ensure a high level of safety for train operation.

2) Summary of Signalling Facilities

An overview of the facilities is as follows.

(1) Train control system

- The train control system installs a Communication Based Train Control (CBTC).



Source: JICA Study Team

Figure 4.12.1 Conceptual Diagram of CBTC

- CBTC is the latest signalling technology that enables the continuous and bidirectional transmission of train control information between the ground and the train by radio communication.
- In this system, each train calculates location continuously by itself and provides the information to the ground.
- Ground CBTC equipment collects the location of all trains and distributes that information to all trains.
- Safe separation between trains is maintained based on this information (Moving Block System).
- This function enhances short headway operation compared with traditional signalling systems (Fixed Block system).
- CBTC does not require much equipment compared with a traditional system because the signal transmission between the train and the ground is accomplished by radio communication.
- CBTC is a total system that combines a train control system and an operation management system.

The comparison between CBTC and a conventional system (Track Circuit) is shown in the table below.

Table 4.12.2 Comparison between CBTC and Conventional System (Track Circuit)

Item	CBTC	Conventional System (Track Circuit)
Block system	Moving Block System	Fixed Block System
Train position detection	Transponder, Axle rotation	Track Circuit
AATP / ATO function	Yes.	Yes. However, the number of devices is large.
Train headway	Train operation headway shortens by adopting moving Block	Due to fixed Block, train operation headway is fixed.
Equipment	Less equipment and cables	There is a lot of equipment and cables.

Source: JICA Study Team

Conventional Track Detection is performed using track circuits, while CBTC train location is found by the device mounted on the train and transmits the data to all trains. Therefore, track circuits, which need much maintenance input, is not required.

Adoption of the Moving Block system means that theoretically train operation frequency increases because the distance to the front train can be reduced. In addition to this, at present, many MRT operators are adopting the CBTC System. The Study Team recommends adopting the same CBTC system as the one used in MRT Line 6.

(2) Signal Safety System

CBTC is composed of several major subsystems as follows:

a. Automatic Train Protection (ATP)

- ATP is a system to prevent accidents caused by driver error and almost corresponds to Automatic Train Stop (ATS) and Automatic Train Control (ATC).
- ATP is a vital function of CBTC because ATP must ensure safe train movement.
- CBTC controls the brakes so that the train stops within the Limit of Movement Authority (LMA) and prevents a collision.
- If monitored train speed exceeds the permitted speed profile, CBTC applies the brake so that the train stops within the limits of the train movement authority or the train speed is reduced to less than the permitted speed profile.

b. Automatic Train Operation (ATO)

- ATO is necessary for Platform Screen Door (PSD) operation because PSD requires a precise stopping position for the train in a station.
- ATO controls acceleration and deceleration of the train so that train runs in accordance with the given run-curve, namely, the train operating Profile.
- CBTC controls a train to stop at a target position (TASC: Train Automatic Stop-position Controller) in the station.
- Transponders shall be arranged properly to determine and ensure the train location.

(3) Interlocking system

- This interlocking device is for train route control and has proved to be safe in the station yard by inter-relating the signal and electric point machine. The interlocking device refers to an electrical device.
- The interlocking system adopts a computerized interlocking system (CIL), which has high compatibility with CBTC.
- CIL is applied in the Main Line and Depot because the interlocking system must have high compatibility with CBTC. As stated earlier, CIL has high compatibility with CBTC.

(4) Train Operation Control System

- As the operation Control System, the Operation Control Centre (OCC) installs a Centralized Traffic Control (CTC) and a Programmed Route Control (PRC).

- CTC is a remote control system for the point machines and signals. It is also an organized and integrated system for monitoring train positions and operating trains efficiently.
- CTC collects local information regarding the main line and transmits that information to the OCC. The OCC dispatcher can then grasp the condition in Main Line.
- PRC is a system that automatically manipulates signals and point machines, and is used in connection with CTC.
- PRC works so that the operation is in compliance with the train diagram. In normal cases, PRC commands CIL according to the diagram. PRC has a delay recovery function allowing operations to keep to the diagram.

(5) Depot signalling

- The Depot Control Centre (DCC) controls all train movements in the depot including maintenance cars.
- Safe movement of CBTC trains is ensured by CIL and ATP in the Depot. Safe movement of non-CBTC trains, such as maintenance cars, is ensured by CIL and operational regulations.

4.12.3 Telecommunication Facilities Planning

1) Prerequisites

Main prerequisites for the telecommunication facilities are as follows.

The required services consist of telecommunication service for safety and security, telecommunication service for passenger service, and telecommunication service for common and administrative use. These are described below.

- Telecommunication facilities for security include the dispatcher telephone, train radio system, wayside telephones, etc. to ensure safe train operations. These are used by dispatchers, train crew, station staff, workers and others.
- Telecommunication facilities for passenger services include the passenger information display system, public address facility, clock system, CCTV, etc.
- Transmission facilities are transmission paths and other devices.
- Information collection facilities are facilities for collecting information installed at stations and areas around the railway line, including rain gauge, anemometer, seismometer, smoke alarm, etc.

2) Summary of Telecommunication Facilities

An overview of each facility is given below.

(1) Telecommunication Facility for Security

a. Telephone System

- The telephone system should be a dedicated private automatic exchange and direct line telephone system network. The telephone system is composed of the following:
  - Private Automatic Branch Exchange (PABX) system
  - Direct Line Telephone (DLT) system
  - Digital Voice Recorder
  - Interface and integration with Public Switched Telephone Network (PSTN), public address (PA) system and RC system.
- The grade of service between the internal users with PSTN connectivity should be better than 95% non-blocking.
- The DLT system should provide 100% non-blocking and not be shared with the PABX system.
- The DLT system should have a function to record all the DLT telephone and dispatcher’s telephone conversations.
- The recorder should be shared with the radio communication recording system.

b. Radio Communication (RC) System

- The RC system provides fully dedicated wireless voice communication channels to support the operational and maintenance requirements of the railway.
- The communication channels will be allocated at least as follows:
  - Traffic Controller in OCC and Train Driver
  - Station Master and Train Driver
  - Engineering Controller and Railway Staff
  - Depot Controller and Train Driver
  - Depot Controller and Railway Staff, and Operating and Maintenance Staff at station, trackside and depot areas.
- Long Term Evolution (LTE) Technology will be applied as the RC system.
- Compared to previous standards, LTE incorporates technology that reduces delay and speeds up connection and transmission.

(2) Telecommunication Facility for Passenger Services

a. Passenger Information Display (PID) System

- For the passenger information display system, a display panel is installed on the platform of each station to indicate the departure time of trains, operational status, and other information.
- PID system provides visual display of operational, safety and other information to the public in the station.

- The PID system should be integrated with the Programmed Route Control (PRC), which will be provided as signalling equipment, and a PA system.
- The PID system will apply liquid crystal display (LCD) in consideration of visibility and maintainability. The LCD should be installed at the concourse (near AFC gates, platforms, and paid areas).

Concourse	
	
Platform	
	

Source: JICA Study Team

Figure 4.12.2 Photos of Passenger Information Display System

b. Public Address (PA) System

- The public address facility is used to broadcast information on train operations and emergencies to passengers and operation staff at the station. Usually, an automatic broadcast is made to all stations or to specified stations by centralized control. Furthermore, an independent broadcast is enabled at each station.
- The PA system should be integrated with the PRC and PID systems to disseminate train information to passengers.
- The PA also should be interfaced with radio communication (RC) and PABX system for the dispatcher to be able to make announcements to pre-defined zones with pre-selected telephones and hand held radios.
- The announcement zones of the PA system should be decided in consideration of broadcasting an emergency announcement to passengers and station/railway staff.

(3) Master Clock (MC) System

- For the clock system, a main clock shall be installed in the OCC. The distribution panel for clocks (repeaters) and secondary clocks are installed for each station.
- The MC system provides synchronized time information and date signals to all clocks and rail systems.
- The MC system should be driven by a Global Positioning System (GPS) reference source.
- The MC system should be composed of a GPS antenna, an MC unit sub-master clock unit and Slave Clocks.

(4) Closed Circuit television (CCTV) System

- The CCTV monitor system is installed to observe and check the status (flow of passengers at the station concourse and platforms) in the station yard for each station.
- The CCTV system provides video surveillance and a recording function for the railway operators to monitor strategic areas to secure the safety and security of the passengers, public and railway staff.
- CCTV's image will be recorded at each station, the depot, OCC and substations.
- The proposed locations to install CCTV cameras are given in the table below.

Table 4.12.3 Installation Locations of CCTV Cameras

Main Uses	Installation Location
Monitoring Train Operation	- Station (at Platform) - Depot (at Access track to main line/Depot)
Security	- Station (at AFC Gates, at Ticket Office, at Ticket Vending Machine, at Entrance of toilets) - Depot (at Boundary Fence Lines, at Security Gates, at Substation, Generator) - OCC (at Entrance of OCC Building, at Each Security Door) - Substation (at Boundary Fence Lines, at Entrance of Substation Building, at Each Security Door)

Emergency Measures	- Station (at Staircase, at Escalator, at entrance of toilet, at Shutter, at Electrical/Mechanical Equipment Room)

Source: JICA Study Team

Source: JICA Study Team

Figure 4.12.3 Photos of CCTV Monitoring System

(5) Transmission Facilities

a. Backbone Transmission Network (BTN) System

- The BTN system provides sufficient capacity to transmit voice and data circuit of the various systems such as the signalling system, AFC system, SCADA and PSD between sites as a common network service
- The BTN system should be formed by ring protection using two independent optical fiber cables.
- Multi-Protocol Label Switching (MPLS) Technology (bandwidth: 10 Gbps), which is defined by ITU-T and IEEE, will be applied as the BTN system.

(6) Information Collection Facility

a. Disaster Warning System

- The Disaster Warning System will collect environmental information such as wind speed and direction, rainfall, seismic intensity and rail temperature, and provide the information to the displaced in order to secure a safe train operation.
- The disaster warning system should consist of anemometers, seismographs, rain gauges and rail thermometers.

- The disaster warning system enables dispatchers at OCC to monitor real time measurement information of environmental conditions, analyse it and issue alarms or warnings.

(7) Other Facilities

a. Uninterruptible Power Supply (UPS) System

- The UPS system provides a stable power supply to the next system.
- (BTN system, RC system, CCTV system, PID system, PA system, Telephone system, MS system, Disaster Warning System, and SCADA system)
- The UPS system should be installed at the signal and telecom equipment room in stations and OCC.

b. SCADA System

- The SCADA usually refers to centralized systems which monitors and controls the status of facilities located far from the OCC.
- The facility SCADA system supports an operational staff in OCC and maintenance staff in the Maintenance Base in monitoring various subsystems such as Building Automation systems, the fire prevention system, signalling systems, telecommunication system and PSD system to provide undisturbed transportation services.

4.13 Platform Screen Doors Plan

4.13.1 Prerequisites

In modern urban railway systems, Platform Screen Doors (PSD) have been used in consideration of safety, efficiency, and convenience including barrier-free movement for passengers with disabilities. In Dhaka MRT Line 6, which is now under construction, PSD are introduced considering adoption of modern urban railway system. As for MRT Line 1, which is similar to MRT Line 6, the Study Team proposes introducing PSD considering adopting a modern urban railway system with high safety, efficiency and convenience.

Characteristics of PSD

The advantages and disadvantages of PSD are presented in the following table:

Table 4.13.1 Advantages and Disadvantage of Platform Screen Doors

Advantage	Disadvantage
Not only do PSD prevent passengers on the platform from falling on the track, but they also prevent train delays due to falling and contact accidents.	They increase initial cost (including augmentation of relevant signals and communication facilities, etc.).
Since the safety on the platform improves by installing PSD, staff for safety confirmation is reduced, and safety management of the station is possible with a minimum number of staff.	When PSD are installed, the number and position of the doors of the rolling stock are limited by the opening position of the PSD. (It will be difficult to change the number and position of the doors of the rolling stock after installing the PSD.) *For MRT Line 1, PSD are installed for 8-car train formation (1 train car has 4 doors) considering the future increase in the number of vehicles.
Advantage	**Disadvantage**

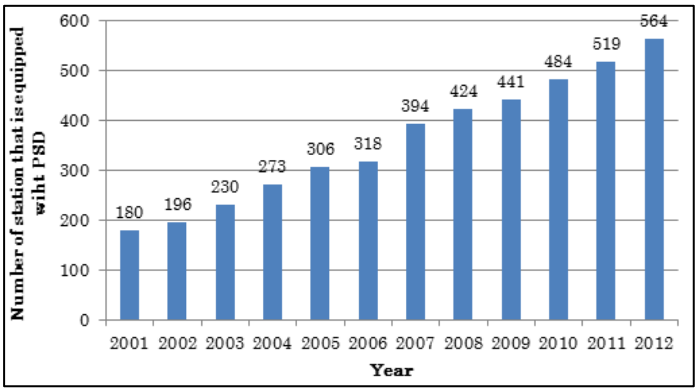
When full-height (home door type) PSD are installed in an underground station, the air cooled at the underground station remains in the platform, enabling efficient and economical cooling with reduced cooling energy consumption. (Installing full-height PSD in an underground station can reduce energy consumption by about 40%).	Because stop time of train is increased by about 5 to 10 seconds per station due to opening and closing of PSD, transport capacity at the peak is decreased.

Source: JICA Study Team

Although there are some disadvantages mentioned in the above table, PSD are introduced as a modern urban railway system as the advantages outweigh the disadvantages. Introduction of PSD prevents delays of train due to accidents on the platform and improves safety, efficiency, and convenience. Use of PSD in major cities in Japan and Asia is shown in the following.

1) PSD in Japanese Railway

In Japan, in 2006, the Act on Promotion of Smooth Transportation, etc. of Elderly Persons, Disabled Persons (Barrier-Free Act) was enacted. And installation of PSD has been considered as one of the safety measures for the elderly people and persons with disabilities at the station platform. As of end of March 2016, PSD had been installed in 65 lines (665 stations) including Shinkansen, conventional line, subway, monorail, new transport system, etc.



Source: Ministry of Land、Infrastructure and Transport (Japan)

Figure 4.13.1 Number of PSD-Installed Stations in Japan

2) PSD in Urban Railways in Asian Cities

Status of PSD installation in urban railways in Asian cities is shown in the following table.

Table 4.13.2 Status of PSD in Asian Cities

Line	Length	Date of commencement	PSD	
Delhi Metro Line 1, 2,3, 4, 5, 6	190km	2002	E	None
			U	None
Singapore North South Line	45km	1987	E	Half
			U	Full
Singapore East West Line	57km	1987	E	Half
			U	Full
Bangkok MRT	21km	2004	U	Full
Beijing Metro Line4	28km	2009	E	Half
			U	Full
Hong Kong MRT West Rail Line	31km	2003	E	Full
			U	Full
Ho Chi Minh MRT Line1	20km	2018	E	Half

		(Under Construction)	U	Full
Jakarta MRT Line 1	16km	2018 (Under Construction)	E	Half
			U	Full

Note: E: Elevated, U: Underground
Source: JICA Study Team

Under the guidance of the Land Transport Authority LTA), the Singapore Mass Rapid Transit (SMRT) had completed installation of half-height PSDs at all elevated stations by 2012.

Delhi METRO Transport Corporation (DMTC) installed PSD at the six stations of Kashmiri Gate Station, Chowri Bazar Station, Chandni Chowk Station, New Delhi Station, Rajeev Chowk Station and Central Secretariat Station on Line 2. Also, for Line 7 and Line 8, PSD will be installed at all stations.

3) Type of PSD

There are 2 types of PSD: 1) Half Height PSD and 2) Full Height PSD system. The half-height PSD system is generally applied for elevated and/or at-grade stations for the purpose of obtaining benefits of passenger safety and reduction of the number of station staff and crew. In contrast, the full-height PSD system is generally introduced at underground stations in order to reduce energy cost for air-conditioning in addition to the benefits of half-height PSD.

Of the nineteen stations in MRT Line 1, twelve stations are planned as underground and seven stations are planned as elevated. Since air-conditioning is installed for the platform in the underground stations, the full height PSD are adopted at the underground stations and the half height PSD is adopted at the elevated stations.

Main features of full-height PSD and half-height PSD are as follows.

Table 4.13.3 Features of Full Height PSD and Half Height PSD

	Full Height Type	Half Height Type
Appearance		
Summary	It is a wall-like structure provided on the platform, and it is a structure which prevents anybody portions to be let out to the railway side. Although it is excellent in safety, installation cost is high. However, in the closed platform, the running cost can be reduced by improving the air-conditioning efficiency.	It is a pane-like structure with a height of about 1.3m provided on the platform. Some users may feel uneasy because the fence height is lower than full height, but on the other hand, there is no sense of confinement. Initial cost is cheaper than full height type.
Initial Cost	High (about twice expensive than half height)	Medium
Safety	Very High	High (There is no contact with the rolling stock unless intentionally overcomes the fence.)
Air-conditioning Efficiency	Effective (About 40% energy consumption can be reduced)	—
Suitable Station type	Underground Station	Elevated Station

Source: JICA Study Team

4) Cooperation with other railway systems and system configuration of PSD

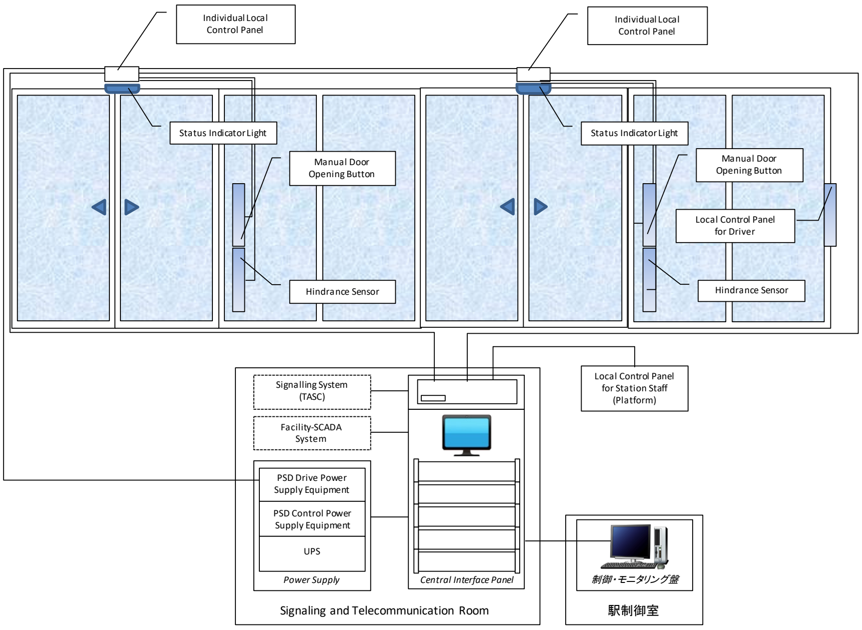
(1) Cooperation with other railway systems

- Introduction of PSD requires coordination with signals, communication and rolling stock. Since it is required to accurately stop the vehicle at the sliding door part of the PSD, safe and accurate train control by the signalling system must be realized.
- Train control by signalling system is executed by the following path: ground signalling equipment (including TASC: Train Automatic Stopping Controller) - Communication path (CTC) - ground antenna (CBTC) - Radio communication (train control by CBTC) – on-board antenna - Radio communication (train control by CBTC) – on-board signalling equipment (CBTC including ATP, ATO).
- When the train stops at station, the stop control of the train is carried out by the above-mentioned path. The TASC ground unit and the TASC on-board unit grasp the position of entering train in platform, and train stops at the accurate position of the sliding door of the PSD with an accuracy of ± 350 mm.
- The PSD system receives a signal that the train has stopped at the correct position from the signalling device, then opens and closes the door.
- The operation status of the PSD is monitored by the central facility monitoring system (SCADA facility).

(2) System Configuration of PSD

The system configuration of the PSD, in conjunction with the other systems, is as follows:

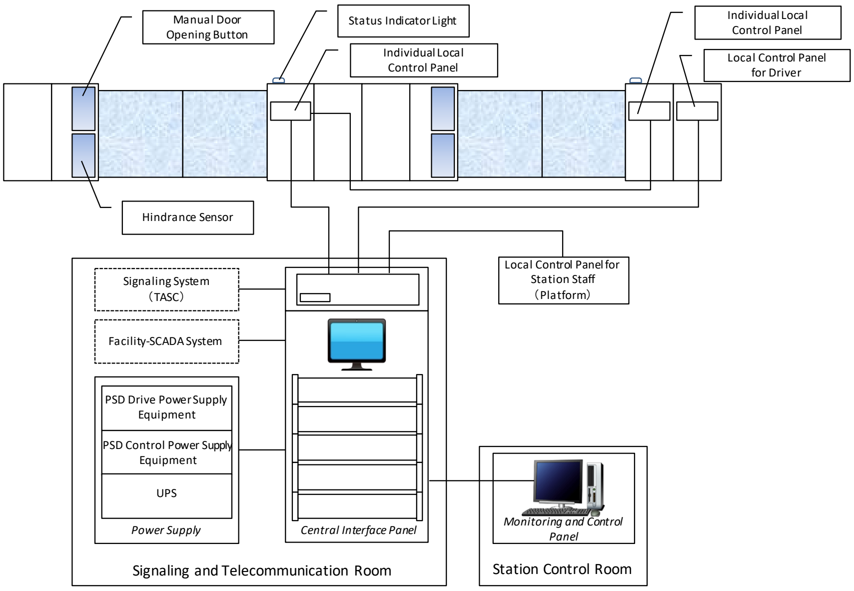
a. Full Height PSD



Source: JICA Study Team

Figure 4.13.2 System Configuration of Full Height PSD

b. Half Height PSD



Source: JICA Study Team

Figure 4.13.3 System Configuration of Half Height PSD

5) Requirement of PSD Installation

(1) Provision of Number and exact location of Doors of PSD

Prior to design of the PSD, the number of doors per train and the train configuration must be decided. The number of doors for each train on MRT Line 1 was stipulated as four doors on each side. The exact location of the doors and size of the doors shall be decided as soon as possible.

(2) Implementation of Periodic Maintenance with high ratio accuracy

As PSD introduction requires high accuracy such as stop position of train within ± 350mm, periodic maintenance of signal system (train control system by CBTC including ATO), train (brake performance) and PSD system are required. Regarding the braking performance of the train, it is necessary to follow the regular maintenance schedule of the train. For the signalling system and the PSD system, maintenance is required at the following frequency:

a. Maintenance of Signalling System (TASC)

Table 4.13.4 Maintenance of Signalling System (TASC Track Antenna)

Maintenance Item	Frequency (Time/Month)	Inspection Time (Time/Unit)	No. of Units/Station
1. Function Inspection			
1) Repeater	2	0.5	2
2) Controller	2	1.0	1
3) TASC Track Antenna	2	0.2	8
2. Visual Inspection			
1) Repeater	4	0.1	2
2) Controller	4	0.1	1
3) TASC Track Antenna	4	0.1	8

Source: JICA Study Team

b. Maintenance of PSD System

Table 4.13.5 Maintenance of PSD System

Maintenance Item	Frequency	Inspection Time	No. of Units/ Station
1. Operation Inspection	Everyday	5 Minutes/Station	―
2. Function Inspection			
1) Insulation resistance and wire fixing	1time/Year	1 Minute/Unit	64
2) Controller	1 time/6 months	15 Minutes/Unit	64
3. Visual Inspection	1 time/3 months	1 Hour/Station	―

Source: JICA Study Team

(3) Reliability provision

There is no international standard on the reliability of PSD yet. However, PSD are a system linked with the operation of trains and safe passengers boarding and alighting as well as signalling systems. Therefore, the Study Team can estimate the reliability of PSD on Line 1, based on reliability of PSD procured in recent years, as follows:

- Design Life:20 years
- Mean Cycle Between Failures (MCBF):more than 2,000,000
- Mean Time to Repair (MTTR): less than 60 minutes

4.14 Automatic Fare Collection System

4.14.1 Features of Automatic Fare Collection System

The main function of the Automatic Fare Collection System (AFC) is to collect ride fare automatically, correctly and efficiently. Moreover, AFC can also collect information on origin and destination (OD) of railway customers, number of boarding and alighting passengers at peak hours, number of passengers per station, etc., In addition, by analysing the collected information, it is possible to provide effective railway services according to the current situation of railway users and future railway users.

DMTC, which operates MRT Line 6, will also operate MRT Line 1, and it is planned that users of both MRT Line 1 and MRT Line 6 will transfer between lines at Kamalapur Station. Also, AFC will be introduced for MRT Line 1. Based on this background, it is desirable to introduce the same system of MRT Line 6 for MRT Line 1, from the viewpoints of convenience and operation efficiency of DMTC and user's convenience. Therefore, for AFC, the same system as that of MRT Line 6 will be introduced.

The Study Team studied each item of AFC proposed to be introduced at MRT Line 6 according to the situation of MRT Line 1.

1) AFC System Composition

The items of consideration are as follows:

Considering the AFC system planned for MRT Line 6, the Study Team proposes the following main system configuration of AFC in MRT Line1:

(1) IC ticket

- Stored Value Ticket: Tickets for which the monetary value for one ride or more is recorded as digital data in the ticket media.
- Single Journey Ticket: Tickets for which the monetary value for one ride is recorded as digital data in the ticket media.

(2) Station FC Equipment

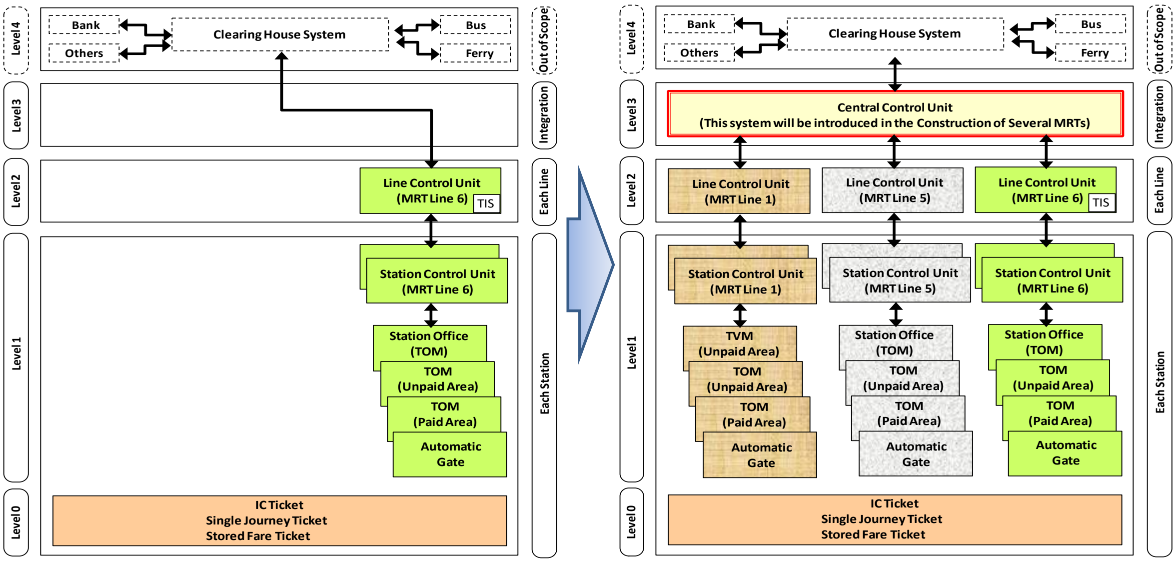
- Ticket Vending Machine (TVM)
- Ticket Office Machine (TOM)
- Automatic Gate (AG)
- Station Control Unit (SCU): A computer that manages AFC equipment installed at the station.

(3) Line AFC Equipment

- Line Control Unit (LCU): A computer that manages data collected by the AFC system for each line.
- Ticket Initializing Machine (TIC)

(4) Future AFC System Configuration

- MRT Line 6 is scheduled to be operated in 2021, and the AFC system is to be developed for each line section, so that it can be expanded according to the construction plan of the route. With reference to MRT Line 6, the AFC system configuration accompanying the construction of MRT Line 1 is carried out in stages as follows:



Source: JICA Study Team

Figure 4.14.1 Future AFC System (Multiple Lines)

- Level 0: Ticket Media

  Following the same system of MRT Line 6, a non-contact type IC card is to be used as a ticket media. Distance based fare system will be introduced. The fare table will be finalized at the construction stage. The contactless IC card proposed as a ticket media needs to be initialized before operation starts.

- Level 1: Station AFC Equipment

  Automatic ticket vending machines installed at the station, ticket sales counter equipment, automatic ticket gates, and station AFC management equipment correspond to Level 1 AFC equipment. The main roles of station AFC management equipment are as follows:

  (a) Download of operational and technical parameters from LCU
  (b) Download of new software of the equipment
  (c) Monitoring and control of station equipment
  (d) Upload sales and transaction data to LCU
  (e) Upload alarms and events to LCU received from equipment

- Level 2: LCU

  This level manages the AFC system for each Line. The main roles of the line control system are as follows:

  (a) Control and monitoring of Level 1 facilities of each line
  (b) Monitoring and Control of the station equipment of each line
  (c) Traffic and transaction management of each line
  (d) Processing and reporting of both financial and traffic statistics of each line
  (e) Communication with Central Control Unit (CCU)
  (f) Communication with clearing house system before CCU installation (optional)

- Level 3: CCU

  Level 3 manages multiple line segment control systems. The main functions of the central control system are as follows:

  (a) Control and monitoring of Level 2 and Level 1 facilities in Dhaka MRT lines
  (b) Traffic and transaction management of Dhaka MRT lines
  (c) Processing and reporting of both financial and traffic statistics of Dhaka MRT line
  (d) Communication with upper layer system such as a clearing house system.

- Level 4: Clearing house system

  This level distributes freight revenues obtained from a common IC ticket appropriately according to the number of users among different carriers (buses, ferries, etc.).

2) Ticket System

(1) Ticket Media (IC Card)

MRT Line 6 does not use magnetic tickets as a ticket media but adopts a contactless IC card. The advantages of IC ticket introduction are 1) high security, 2) expandability (data and programmes can be installed), 3) rapid processing performance when passing through the ticket gate, and 4) reusability due to high durability of the medium.

On the MRT Line 1, IC tickets will be used as the ticket media similar to MRT Line 6, and thus ensures maximum convenience of passengers and ease of operation.

Table 4.14.1 Comparison of Magnetic Ticket and IC Ticket

Item	Magnetic Media	IC Media (Contactless IC)
Capacity	72 bytes	500 – 2,000 bytes
Contents	Data only	Data & Programme
Security	Low No access control of R/W (Read/Write) data	High Access control of data using encryption
Ease of Falsifying	Comparatively easy	Difficult
Maintainability	Mechanical function is required (Ticket handling function, magnetic head, etc.)	No mechanical function (Basically, no maintenance for mechanical function is required.)
Expandability	Limited	High
Durability	Weak under magnetic influence	No influence by magnetic field
Process time	Approx. 0.7 sec	Approx. 0.2 sec
Cost	Depends on the condition (Number of order, etc.)	Depends on the condition (Number of order, etc.)
Evaluation	Not recommended	Recommended

Source: JICA Study Team

(2) Ticket Type

Ticket types considered for MRT Line 6 are categorized as follows: 1) for passengers and 2) other (for staff, for test). Also on MRT Line1, from the viewpoint of mutual use with MRT Line 6, the same ticket type as that in MRT Line 6 is considered.

Each passenger ticket type is described below.

Table 4.14.2 Features of Passenger Ticket Type

Normal Ticket (Single Journey Ticket, Stored ValueTicket)	• The ticket can be of a Single Journey Ticket (a one-time ticket) and a Stored Value Ticket (a reloadable ticket that can store an amount in the card up to a predetermined upper limit). • The Single Journey Ticket is purchased at an amount corresponding to one distance for one ride and collected when exiting the ticket gate. • The Stored Value Ticket is a mechanism in which an amount in the preloaded ticket medium is collected as a fare when exiting the ticket gate. • Passengers can reload stored values to their Stored Value Tickets at the automatic ticket vending machine or station office. • A deposit is provided on the IC card and reflected in the selling price. • The deposit for the IC card shall be returned to passengers when returning the IC card at the ticket vending machine and station office.
Day Ticket (1 day ticket / 3-day ticket)	• Valid tickets that give a passenger unlimited rides for a day or a number of days depending on the Day Ticket bought. On MRT Line 6, two types of tickets, a one day ticket and a three-day ticket have been proposed. • The Study Team proposes introducing two kinds of day tickets: a one day ticket and a three-day ticket similar to MRT Line 6. • A deposit is provided on the IC card and reflected in the selling price. • Deposit of IC card shall be returned to passengers when returning the IC card at the ticket vending machine and station office
Commuter Pass (30 days)	• In MRT Line 6, a commuter pass effective for 30 days has been proposed. • A deposit is provided on the IC card and reflected in the selling price. • Deposit of IC card shall be returned to passengers when returning the IC card at the ticket vending machine and station office

Source: JICA Study Team

3) Fare System

For MRT Line 6, the Institutional Development Consultant (IDC) has proposed fares according to distance. Based on the proposal, DMTC, the project implementation entity, will decide the fare system. The fare structure of MRT Line 1 will be determined taking into consideration the final fare structure for MRT Line 6.

4) Ticketing Condition

In general, before IC ticket operation, it is necessary to decide the fare, ticket validity period, issuance/withdrawal conditions including deposit and handling fee, and penalties. In MRT Line 6, since these IC ticket operating conditions have not been finalized yet, the following conditions can be proposed:

- Charge a deposit when issuing a ticket.
- Do not charge a deposit when issuing Single Journey tickets.
- Refund the deposit upon return of the IC ticket.
- Charge a handling fee when refunding the deposit for the IC ticket.
- Set the expiration date of the ticket for each ticket type.

In MRT Line1, the operation conditions of the IC ticket are decided in consideration of the operation condition of the IC ticket to be finalized for the MRT Line 6.

5) Function required from IC Ticket

There are international standards relating to IC chips used for contactless IC tickets like ISO / IEC 14443 (type A, type B) and ISO / IEC 18092 (NFC, commonly known as type C). Types A and C are mainly used for railway automatic fare collection systems. In an actual IC ticket, an IC chip created based on the international standard mentioned above is embedded. When an IC card is selected as a ticket media, it is assumed that an amount up to a predetermined upper limit is stored in the card. It is assumed that high security is required for an IC ticket. In the JICA Clearinghouse Establishment Project, its recommendation is to use IC tickets of type C for both Single Journey and Stored Value. Considering the performance and characteristics of the IC chip and the above security requirements in MRT Line 6, it is proposed to apply type C conforming to ISO / IEC 18092 for the IC card.

Similarly, for MRT Line1, ISO / IEC 18092 shall be applied to Single Journey tickets / Stored Fare tickets taking into consideration the proposal for MRT Line 6 and the ease of mutual use with MRT Line 6.

It is proposed that the reader / writer of the AFC gate should be of multi-type so that it can read any type of IC chip loaded media.

A comparison of each IC chip is shown in Table 4.14.3.

Table 4.14.3 Comparison Table of IC Chips

Item	ISO/IEC 14443 Type A	ISO/IEC 14443 Type B	ISO/IEC 18092 Type C
Shape	Card	Card	Free (Card, Token, Watch, Cellular Phone)
Wireless Spec	Manchester/Modified Mirror	NRZ	Manchester
Anti-collision	Bit collision	Slot-Marker	Time Slot
Carrier	Fc=13.56MHz		
Communication Speed	From 106kbps		From 212kbps

Source: JICA Study Team

6) Automatic Gate

The automatic ticket gates at the train stations are classified into three types: 1) flap door type, 2) retractable type, and 3) turn style type.

In MRT Line 6, the flap door type is proposed because its processing speed is fast, the installation space at the station can be minimized, and highest safety can be ensured when a user such as a pregnant woman, a child, or an elderly person is trapped at the door.

In consideration of safety to users as well as mutual and smooth use by MRT Line 6, the flap door type is proposed for MRT Line 1.

The features of the three types of automatic ticket gates are as follows:

Table 4.14.4 Comparison Table of Automatic Gate

	Flap-door	Retractable-door	Turnstile
Appearance			
Processing Speed	60 passengers/minute	40 passengers/minute	30 passengers/minute
Width of machine	200mm	300mm	300mm
Protection performance	Comparatively weak compared with retractable door	Strong	Excellent
Passenger safety	High	There is a possibility that the passenger gets stuck in the doors	Good

Source: JICA Study Team

7) Ticket Vending Machine and Fare Adjustment Machine

In Bangladesh, the state of paper currency is rather poor due to dirt and tears, so it would be difficult for the vending machines with identification function to identify the value of the bill / money. In MRT Line 6, taking this situation into consideration, the ticket is to be sold at the station office mainly by the staff, and it is suggested that one ticket vending machine is installed for each ticket gate and two at each station.

However, fare adjustment machines have not been introduced in MRT Line 6.

According to the JICA Clearinghouse Establishment Project that designed the IC tickets, “Negative Value” is proposed as a settlement method for shortage of amount. Since the method of subtracting the insufficient fare from the deposit of the IC ticket is adopted, it is not necessary to settle the fare difference by the automatic fare adjustment machine.

MRT Line 1 opening is expected after the opening of MRT Line 6 (2021), in earliest case, end of 2025, and the state of the banknotes is expected to improve. Thus the establishment of the automatic ticket vending machine is not restricted, and an appropriate number will be decided based on the result of the demand forecast. No fare adjustment machine is proposed, because similar to MRT Line 6 specifications, the "Negative Value" method will be adopted in MRT Line 1 to adjust shortage of fare.

8) Interface with Back Office System

Since data collected/managed by the AFC system will be handled by railway operators as sales/operation information, cooperation with the railway operator's core system is required. Since MRT Line 6 has not decided the procurement of the core systems of railway operators, the Study Team cannot confirm the interfaces necessary for system cooperation. But before the opening of MRT Line 6, the details of the core system will be clarified.

For MRT Line 1, when the details of the core system procured by railway operators are clarified, the interface is to be confirmed and reflected in the design.

9) Interface with Clearing House

The clearinghouse system was founded by DTCA, and its operation is scheduled to begin in 2017. Since the AFC system provides fare collection data and OD data for each line section to the clearinghouse, an interface with the clearinghouse system arises. The required interfaces are shown in Table 4.14.5.

Table 4.14.5 Interface for Clearing house System

Interface	In case of MRT Line 6
Number of Secure Access Modules (SAM)	4 or more
Provision of SAM	It is planned to be offered through a clearinghouse business from the service businesses (buses, ferries, etc.) using clearinghouse systems.
Interface relating to transmission path with clearinghouse system	Install VPN in the depot where LCU is installed and transfer AFC information for each line section to the clearing house. (The transmission path to the VPN modem / line control system and the clearing house system is provided by the Clearinghouse System Establishment Project).
Data structure of IC ticket	Complies with specifications of IC tickets created in the Clearinghouse System Establishment Project.
Logical interface of IC ticket	Complies with specifications of IC tickets created in the Clearinghouse System Establishment Project.
Data processing /communication interface including security policy	Complies with specifications of IC tickets created in the Clearinghouse System Establishment Project.

Source: JICA Study Team

Considering the case of MRT Line 6, the interface with the clearinghouse system in MRT Line1 will be finalized.

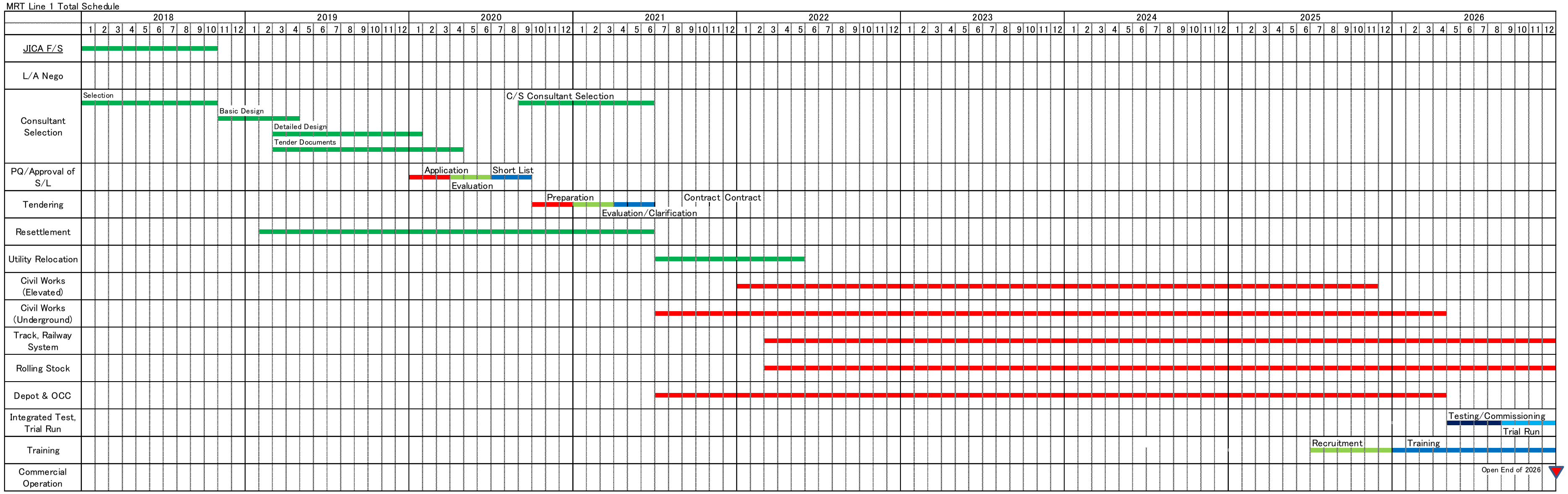
4.15 Project Implementation Plan

4.15.1 Project implementation schedule plan

The target date of inauguration is end of 2025 due to q strong requirement from the Project counterpart.

The schedule is shown in Figure 4.15.1. It shows that the critical works of substructure and tunnel are at least 48 months and continuously finishing works and M&E work will be implemented. There is a possibility for tight schedule against civil works and another possibility of overlapping railway work and civil works.

Details of the schedule will be described later.



Key Date		
Selection of Consultant	ES January 2018 - October 2018	CS September 2020 - June 2021
Consultant Contract	October 2018	June 2021
Preparation of DD & TD	November 2018 - April 2020	
Tender Assistance	January 2020 - February 2022	
Construction Supervision	July 2021- December 2026	
Preparation for Land Acquisition	February 2019 - October 2020	
Land Acquisition		
Procurement of Contractors	October 2022 - February 2022	
Civil Works	July 2021 - April 2026	
Railway E/M	March 2022 - December 2026	
Defects Liability Period (Civil)	December 2025 - November 2026	
Defects Liability Period (E/M)	January 2027 - December 2028	
Commercial Open	December 2028	
Project Completion	September 2027	

Source: JICA Study Team

Figure 4.15.1   Schedule of Inauguration at End of 2025

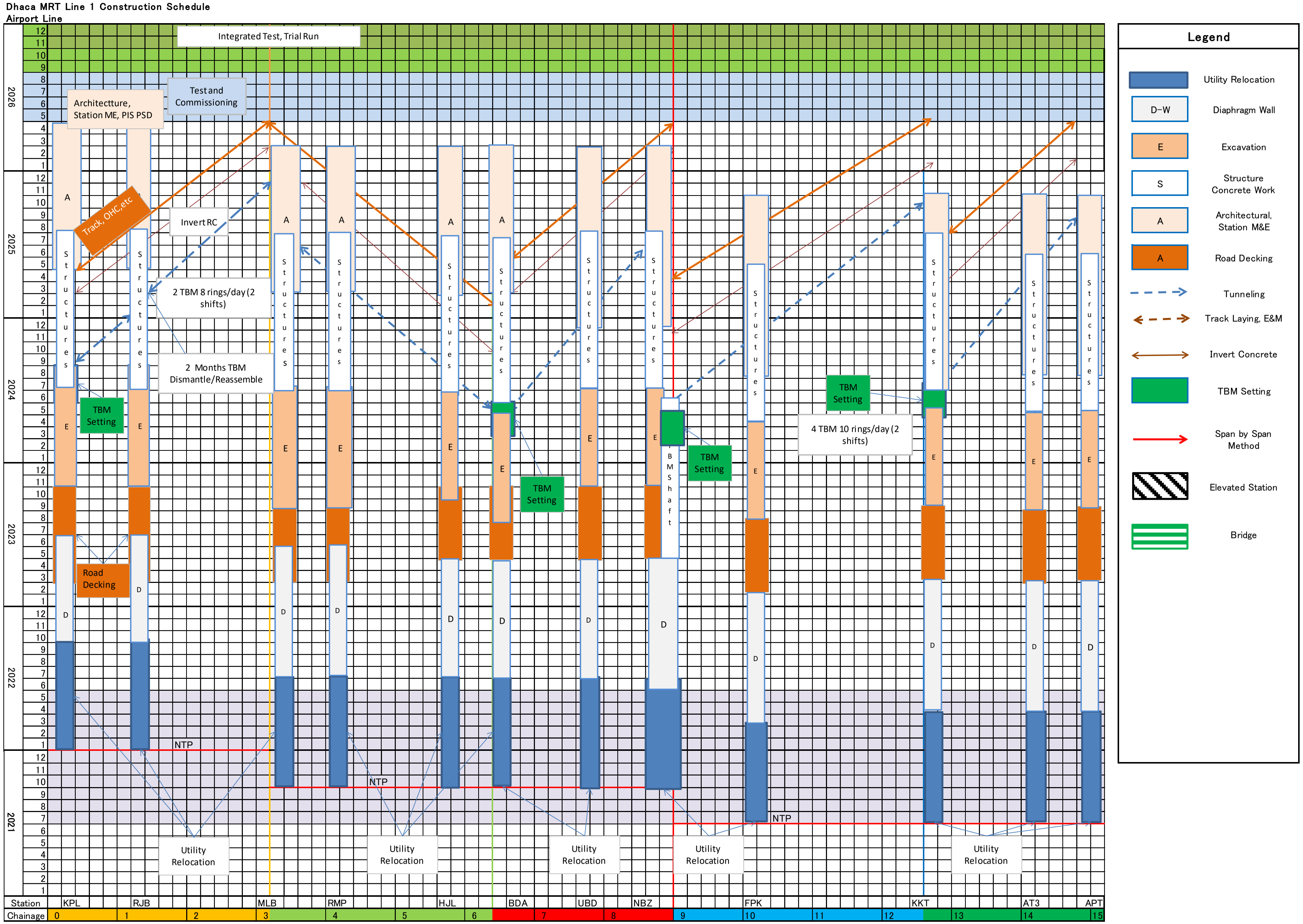
To compare construction of tunnel work with elevated section work, the latter is rather easy since it enables control over scheduling with manpower flexibility (number of workers to hire).

Moreover the elevated section is located in the suburbs, so there is not so much traffic. Therefore, tunnel work is assumed as the critical pass all over the construction.

When drawing up the overall schedule, the following items should be considered critical:

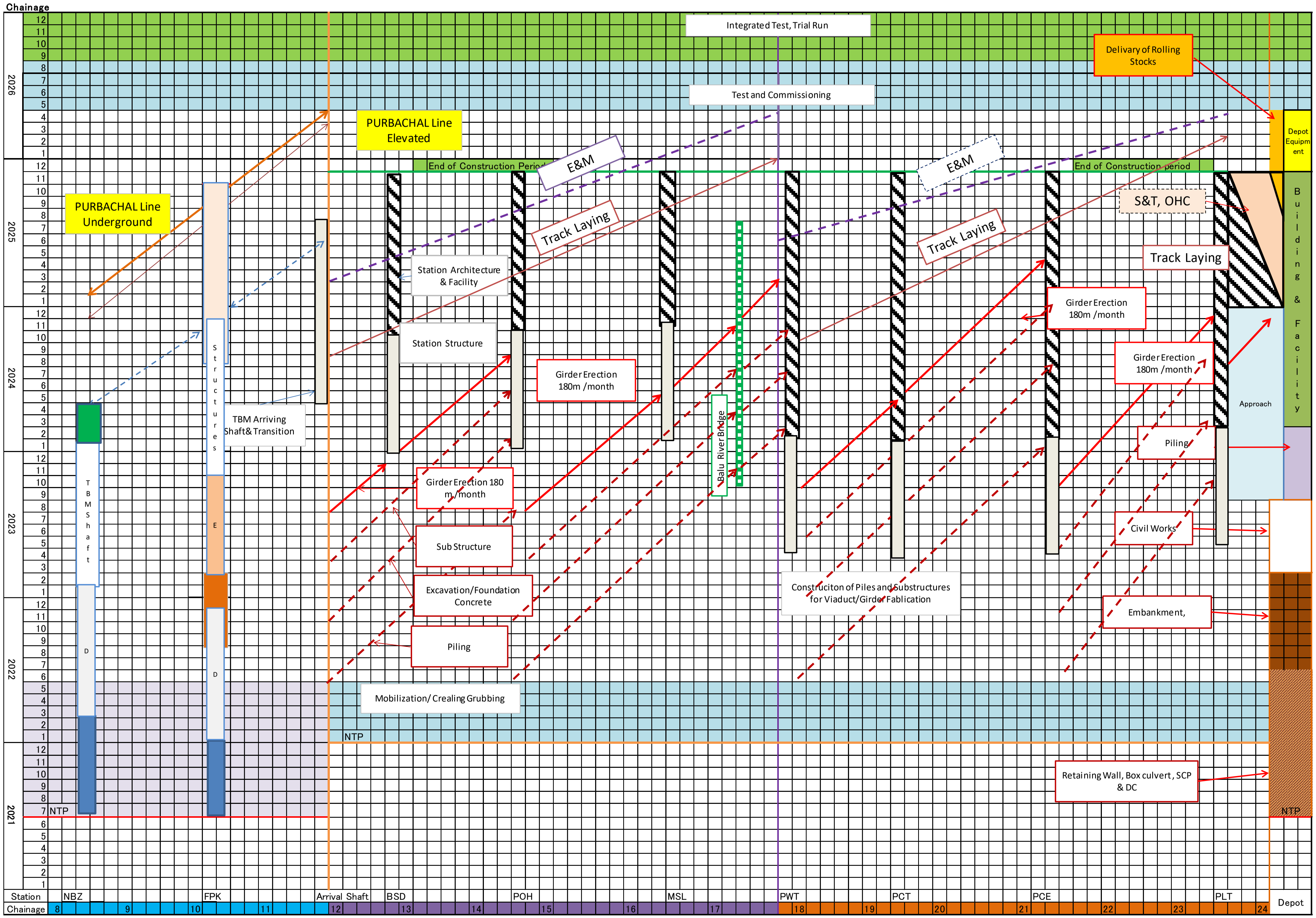
- It will probably take eight months to remove an obstruction underground. But If the proprietor of an obstruction underground agrees to have it removed before the start of construction, the eight months is deducted.
- Construction schedule of station, launching and arrival shaft with open cut method is assumed at eleven months, and at the time, the road will be covered up by road deck panels to keep traffic flowing.
- TBM drilling work performs ten rings forward per day, but eight rings are adapted in this planning. Length of one segment ring is 1.2m.
- TBM drilling work commences from launching shaft and reaches arrival shaft adjacent to next station, The TBM machine is lifted up to the ground and transported to the opposite side of the station. After that, the TBM machine is re-fabricated there. This cycle presumes two months.
- When TBM reaches the arrival shaft, casting inverted concrete is implemented within one month.
- Inverted concrete is casted by civil contractor, but the track bed concrete is casted by the railway system contractor (package 9).
- After casting the inverted concrete, the track laying work will be commenced two months later.
- The following track laying work and overhead catenary wiring work will then commence.

JST recommend to adopt an SMW method to construction of launching shaft because about one month earlier TBM can start excavation work. Details are discussed in 5.2 of Chapter4. Details shall be referred 4.5.2, Cut and Cover Method for Station Box, and discussion in 15.2 of Chapter 4.



Source: JICA Study Team

Figure 4.15.2 Underground Section Construction Schedule (1)



Source: JICA Study Team

Figure 4.15.2 Underground Section Construction Schedule (2)

Assumed key dates are as shown in the table below.

Table 4.15.1 Key Dates

Key Event	Date
Preparation of DD & TD	November 2018- April 2020
Tender Assistance	January 2020 - February 2022
Construction Supervision	July 2021- December 2026
Land Acquisition	February 2019- October 2020
Procurement of Contractors	October 2022 – February 2022
Civil Works	July 2021- April 2026
Railway E/M	March 2022 – December 2026
Defects Liability Period (E/M)	January 2027- December 2028
Commercial Open	31 December 2026
Project Completion	31 December 2028

Source: JICA Study Team

4.15.2 Facilitating Japanese Technical Method Adaptation Possibility

1) Screw Steel Pipe Pile

This is a method of construction for steel pipes with a blade at the lower end that penetrates the ground, and it is applied in railway track construction in close proximity to buildings in Japan. This method is applied in MRT Line 6 at the station section close to buildings. In MRT Line 1, the elevated section where a pile foundation is required is in the suburbs, and there are no nearby buildings at the moment. However, if the situation around the station and the elevated section will change in the future, there is the possibility of applying the same construction method in case of proximity construction.

Source: http://uedakikou.adsmart.jp/method_ok04.html

Figure 4.15.3 Screw Steel Pipe Piles

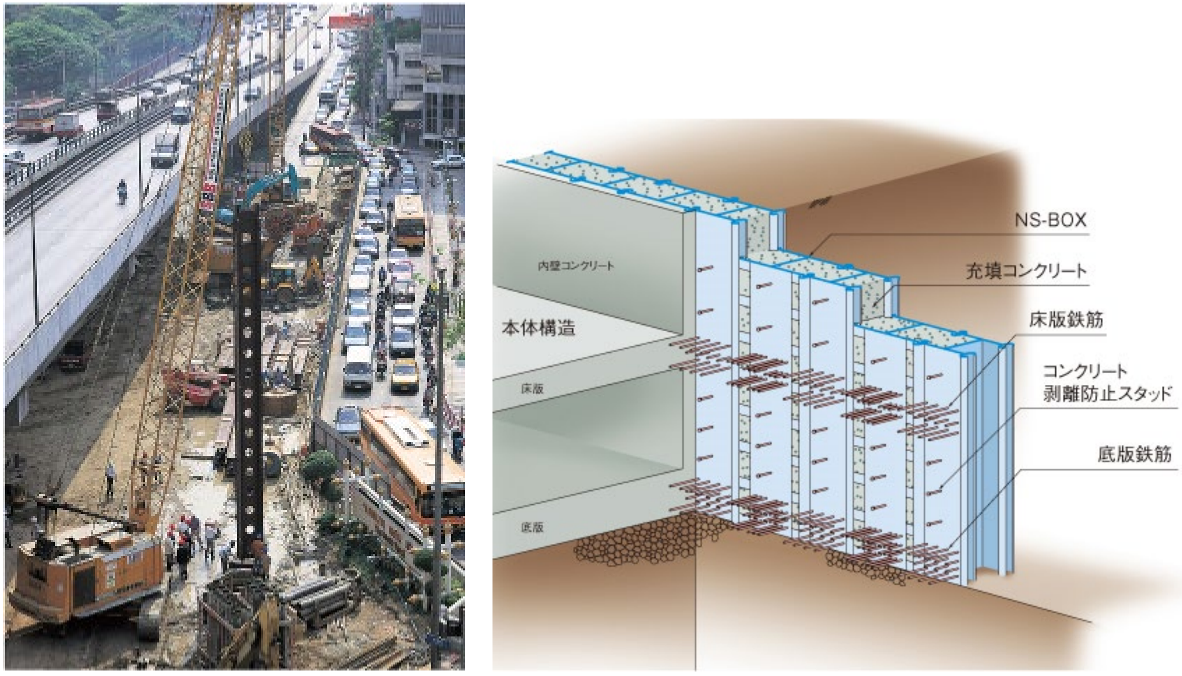
2) Steel Diaphragm Wall

A steel diaphragm wall is a construction method in which an earth retaining wall is constructed with connected steel diaphragm wall members. Compared with the conventional underground diaphragm wall method, it is possible to thin the wall body, and construction time and space can be minimized. It has been applied in MRT underground station construction in Japan and Thailand. Since the underground station of MRT Line 1 is located near existing buildings, there is a possibility of adoption if this construction method has an advantage over the conventional method.

Diaphragm wall joints are connected by steel interlocking one another. Pre-cast concrete is placed supported by a bentonite solution.

All the underground stations in MRT Line 1 are assumed to have a diaphragm wall in which the excavation and installation is until the bottom of the station box. Minimizing the width of the open cut area keeps the traffic lane as much as possible. Another advantage of this method is that the only additional finishing wall requires a thickness of about 20cm; therefore, 20cm is reduced compared to conventional diaphragm walls.

As a result 40cm of width of construction area on the road can be reduced. Thus, if the cost of using this method is reasonable and falls within acceptable scheduling, adoption of this method is possible.



Source: http://www1a.biglobe.ne.jp/ns-box/ns-box01.html

Figure 4.15.4 Steel Diaphragm Wall

3) Soil Improvement

The ongoing MRT Line 6 construction is adopting soil improvement work in its depot area in order to shorten the time of construction. The Sand Compaction Method is an excellent technology for ground stabilization and preventing liquefaction that is used in Japan; therefore, the method has been adopted at the project.

The MRT Line 1 project will also adopt this method because of the same conditions such as limited time and soft ground.

4) Earth Supporting System by SMW

This method is adopted for the station area at Oedo subway line in Tokyo, and most of the underground station construction sites adopted this method as earth supporting system for temporary walls in Japan.

On the other hand, the diaphragm wall is adopted as a shoring wall in overseas underground railway construction projects, and this wall finally forms permanent walls. In overseas countries except Japan, the diaphragm wall is designed as a permanent wall eventually.

Meanwhile, the SMW method is mainly considered as a temporary wall in Japan; therefore, another permanent finishing wall is applied normally. Alternatively, an additional thin wall is combined on SMW wall and it becomes a permanent structure.

Comparing diaphragm walls with the SMW method, the SMW method has advantages in terms of cost and time-savings. Since the occupied space of construction yard is 1m to 2m larger than the diaphragm wall, the planning of construction is adjusted on site condition.

The current construction project at subway phase 3 in New Delhi adopts diaphragm walls as permanent walls, and reportedly, a great deal of water leakage is observed. It is assumed that employing skilful workers in Bangladesh is not easy, so it is not recommended to adopt the diaphragm wall as permanent wall. The joint of diaphragm walls require high-level technical construction.

Less accurately built diaphragm walls may cause water leakage not only under construction but even after they are completed. This will require pumping up the leaking water resulting in increased maintenance and repair costs. There is also the aesthetic aspect to consider.

As a result, JST proposes combining the diaphragm wall with an additional wall. But SMW method is proposed in the area where no passengers are expected as follows:

- Transition area;
- Open cut area at backward and forward Notun Bazar Station, Kamalapur Station; and
- Section between Airport Terminal 3 Station and Airport Station.

Recently in Japan as the earth supporting system SMW method is commonly adopted due to advantage to D-Wall, because it is 1) shorter construction duration, 2) cheaper. Construction of D-wall requires taut and stable ground to bear heavy equipment. Further guide trenches made of concrete is applied prior to digging, about one month is required for such preparation of D-wall construction, while the SMW method doesn't require such preparation work. But equipment for the SMW method is not available in Bangladesh, only in Japan. This results in a little higher construction cost. JST proposes to adopt the SMW method to TBM launching shaft which requires some 20m in length.

5) Rolling Stock (EMU)

EMUs made in Japan are utilized worldwide because of excellent energy savings, safety and liability. Also, the West and China have been developing the technology as same as Japan. Since EMUs introduced for MRT Line 6 is manufactured based on SYTRASYA specifications, which had been established based on Japanese Technology, MTR Line 1 shall also follow the same specification.

6) Head Hardened Rail

Head-hardened rail has high quality and durable; therefore, it is possible to cut the life-cycle cost of a high-density railway.

UIC 60 rail is available to be manufactured in Japan. JST recommends adopting this rail for MRT Line1 as well as MRT Line 6.

7) Railway system

There is a high possibility to utilize Japanese technology for such aspects as signalling, power, communication, AFC and PSD. Since it is preferable to integrate specifications such as maintenance and procurement as much as possible, Japanese technology is also available to adopt in MRT Line 1.

Especially proposed Japanese standard type C (ISO/IEC18092) of AFC is suggested to be adopted in MRT Line 6, and MRT Line 1 shall adopt the same.

4.15.3 Consulting service

JICA Standard Bidding Documents, Conditions of Contract for Construction For Building and Engineering Works designed by the Client (Multilateral Development Bank Harmonised Edition（June 2010）should be adopted. Meanwhile, Standard Bidding Documents Under Japanese ODA Loans Procurement of Electrical and Mechanical Plant, and for Building and Engineering Works designed by the Contractor (July 2015) (Trial Version) should be adopted for Railway System (signal, communication, train line, facility of station, AFC, machines in depot area and train car)

Hence, the Consultant has to establish bid documents as his Engineering service including Pre-qualification Documents and Evaluation Criteria. The Consultant shall also estimate the project cost in accordance with BOQ sheet which shall be incorporated in the bid documents.

Main services are denoted as follows:

1) Basic Design and Detailed Design, Bid Documents Preparation

- Review previous accomplishment
- Design work (Formulating specification, Linearizing railway, Location of station, civil structure, design of station, railway system, rolling stock, etc.)
- Assist the Client in land acquisition and monitoring
- Respective investigation (surveying, soil condition, hydraulic geology, social and natural environment, etc.)
- Assist the Client in coordination with related organization/s
- Estimate construction cost
- Prepare bid documents (bidding, document of contract, technical specification, drawings, etc.)
- Prepare bid evaluation criteria
- PR activity

2) Tender Management Services

- Invitation of tender (included PQ, conduct pre-bid conference)
- Make Q/A and Addendum, if required
- Evaluate bid documents
- Make reports of bid evaluation for finance organization

- Attend clarification meeting
- Make contract documents for signing

3) Construction Management Services

- Manage the Contractors in quality, schedule, safety management
- Examine civil, building and architectural works on site
- Examine a facility, delivery of materials, system and EMU
- Coordinate interface of respective packages
- Check and approve submitted drawings from contractor
- Establish and manage testing and commissioning plan for pre-opening
- Conduct completion inspection and issue completion certificate
- PR activity

4) Assist the Client in maintenance and operation

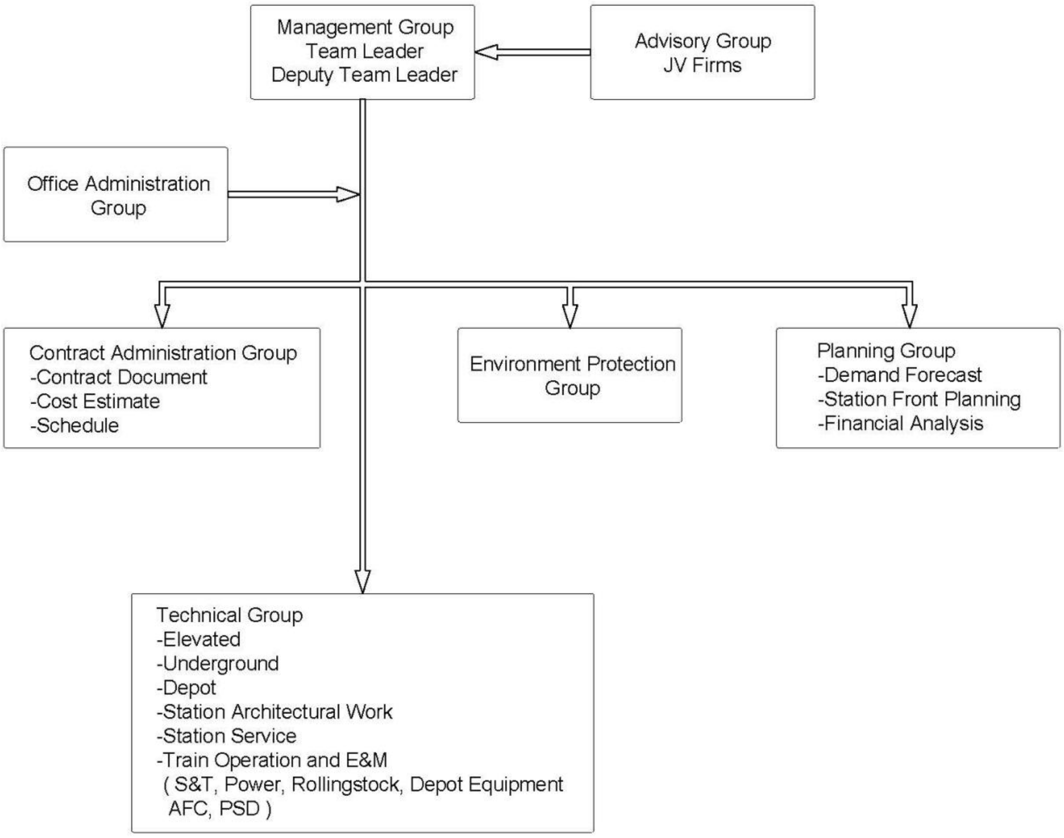
- Support human resource development for relevant organizations
- Draw up a manual of management of maintenance and operation

Appendix 3 and consultant service TOR are included in order to support a bid.

Consultant organization chart is shown below. Form a team composed of Resident Engineer, Quantity Surveyor and Inspector to be assigned to two or three packages based on this chart.

Assigned teams on site mainly enforce monitoring of quality and safety control conducted by contractor and approval of volume in terms of construction progress. Meanwhile, approval of submittals by the design and build contractors are enforced in HQ.

MRT Line 1 Consultant organization chart is shown below.



Source: JICA Study Team

Figure 4.15.5 Consultant Organization Chart

4.15.4 Construction Contract Packaging

1) Framework of construction Contract packaging

Matters considered in deciding the construction sections are shown as follows.

(1) The opening target of Line 1 shall be the end of 2026, with the section length possible to meet the target.

(2) The limit of drilling distance of the TBM shall be 3 km based on the normal Japanese practice. However, the distance differs depending on the soil condition, thus examination is necessary when designing.

(3) The velocity of drilling by TBM is planned at eight rings per day (1.2 m length per ring) regardless of it being possible to install 10 rings by work on a two-shift system.

(4) The railway system (electric power, signal, communication, track) will be in one package for the whole of Line 1 considering maintenance and operation since one system is better for management. There is also the idea to divide the railway system into power supply, electricity for signal and telecommunication and the Automatic Fare Collection System (AFC) which has relatively few interfaces. This shall be described later.

(5) Considering the maintenance of the cars, car maintenance equipment will be included in the car procurement package.

(6) There is the idea to separate the land reclamation from the civil works of the depot, but this is be discussed later.

(7) The installation of escalators and elevators in the station need close coordination with the civil works, thus are included in the civil package.

(8) Regarding the track circuit, the tracks will be installed after the civil works, followed by the construction of overhead contact lines using the track circuit. These will be included in one package to prevent conflict between these works.

(9) The appropriate scale of works was investigated to encourage Japanese companies to participate in the project. Construction of two to three stations and the tunnelling in between per one package of the underground section had most demand.

(10) The cost of civil works per package shall be within JPY 40 billion.

(11) Around half a year shall be secured for invert concreting, track circuit installation and overhead contact lines after the TMB drilling has been completed.

Length of the construction of underground section

In addition to the above mentioned conditions, the position of the launching shaft of the TBM was critical to consider the length of construction of the underground sections.

1. As it is not possible to construct a launching shaft at Malibagh, to include Kamalapur to Malibagh in one package means that CP101 will be from Kamalapur to Rampula, which is 4 km in distance. There is also the possibility that it will take half a year for commissioning after the drilling has finished. Therefore, CP101 was set from Kamalapur until before Malibagh. There will only be two underground stations, but a box for the draw out track is necessary 600m meters from the end of the platform of Kamalapur Station, so the work load will be more than that of one station.
2. In CP201, the launching shaft will be constructed at the southern end of Badda Station, and the TBM shall be launched towards Malibagh. As it is difficult to ensure space to construct launching/arriving shaft, drilling will start from Badda and the TBM shall be left in place at Malibagh. There will be three underground stations.
3. The launching shaft shall be constructed at the north of Badda Station for CP103. It was considered to include Future Park Station, but as the work volume of Notun Bazar Station with two platforms and 4 tracks is larger compared to other stations, although the TBM drilling is only 1.5 km, considering the work volume, the northern end of Notun Bazar Station was set as the border of the construction section.
4. CP104 has the longest distance for TBM drilling, but there is only one station, and the work volume can be considered balanced with other sections.
5. CP105 is from Khilket to Airport Station, with a short tunnel of 1.8 km, but a draw out track will be installed on the northern side of Airport Station like Kamalapur, so it can be considered that the work volume is balanced.
6. The elevated section is difficult for Japanese companies to participate, so it was divided in to sections with expectations on the local contractors.

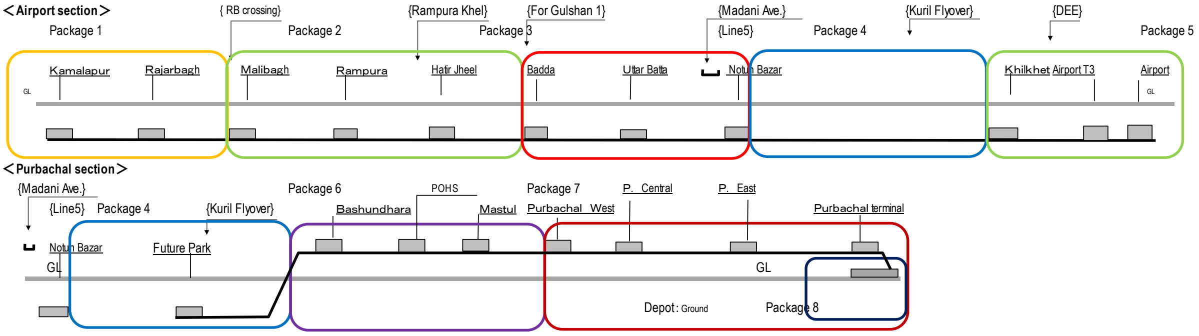
2) Contract Packaging Study

In consideration of above conditions, the consequence of packaging is as follows:

Table 4.15.2 Proposed Contract Package

No	Name	Contents	Note	Remarks
Package 1	Underground Civil 1	Kamalapur Sta. to Malibagh Sta. 2.73kmx2 tunnel construction, 2 sta. boxes, Station & Tunnel Safety Management System	Excluding Malibagh Sta.	Escalator & Elevator are included
Package 2	Underground Civil 2	Malibagh Sta. to BADDA Sta. 2.45km x 2 tunneling, 3 Sta. boxes, Station & Tunnel Safety Management System	Including Malibagh Sta. Excluding BADDA Sta.	Escalator & Elevator are included
Package 3	Underground Civil 3	BADDA Sta. to N. Bazar Sta. 1.27 kmx2 tunneling and 2 Sta. boxes, Station & Tunnel Safety Management System	Including BADDA including N. Bazar sta.	Escalator & Elevator are included
Package 4	Underground Civil 4	Nortun Bazar Shaft. to Khilikhet Sta. and N. Bazar to Transition, Station & Tunnel Safety Management System	Including FP and Trasition excluding Khiliket Station	Escalator & Elevator are included
Package 5	Underground Civil 5	Khiliket Station to Airport Station 1.77km tunneling and 3 stations, Tunnel Safety Management System	Including Khiliket Station	Included Lift and Escalators, People Movers at Airport Terminal Sta.
Package 6	Elevated Civil 1	Transition – Purbachal West station Viaduct 5.00km, 3 elevated stations	Including Balu River Bridge	Escalator & Elevator are included
Package 7	Elevated Civil 2	Purbachal West and P. Terminal station viaduct 4.68km, 4 elevated stations	Including 400m viaduct Terminal East end	Escalator & Elevator are included
Package 8	Depot Civil	Soil Improvement, Embankment, Approach Structure, Shed & Building, Track Maintenance Equipment		Sig. Power, Sub-station for depot are excluded. Power for Car Maintenance is excluded
Package 9	Signal, Telecom. Power Supply, AFC, PSD and Track	Depot Signal, OHC island Power Supply for Car Maintenance Equipment are included		CBTC, Cab signal, DC 1500V Rigid Catenary
Package 10	Rolling Stock & Car Maintenance Equipment	200 EMU		Rolling Stock Maintenance Equipment is included

Source: JICA Study Team



Source: JICA Study Team

Figure 4.15.6 Proposed Contract Package

As an alternative, a case with the railway system is divided into three packages and the land reclamation is separated from the depot is described as follows.

Table 4.15.3 Contract Package Alternative

Contract Package Alternative

No	Name	Contents	Note	Remarks
Package 1	Underground Civil 1	Kamalapur Sta. to Malibagh Sta. 2.73kmx2 tunnel construction, 2 sta. boxes, Station & Tunnel Safety Management System	Excluding Malibagh Sta.	Escalator & Elevator are included
Package 2	Underground Civil 2	Malibagh Sta. to BADDA Sta. 2.45km x 2 tunneling, 3 Sta. boxes, Station & Tunnel Safety Management System	Including Malibagh Sta. Excluding BADDA Sta.	Escalator & Elevator are included
Package 3	Underground Civil 3	BADDA Sta. to N. Bazar Sta. 1.27 kmx2 tunneling and 2 Sta. boxes, Station & Tunnel Safety Management System	Including BADDA including N. Bazar sta.	Escalator & Elevator are included
Package 4	Underground Civil 4	Nortun Bazar Shaft. to Khilikhet Sta. and N. Bazar to Transition, Station & Tunnel Safety Management System	Including FP and Trasition excluding Khiliket Station	Escalator & Elevator are included
Package 5	Underground Civil 5	Khiliket Station to Airport Station 1.77km tunneling and 3 stations, Tunnel Safety Management System	Including Khiliket Station	Included Lift and Escalators, People Movers at Airport Terminal Sta.
Package 6	Elevated Civil 1	Transition – Purbachal West station Viaduct 5.00km, 3 elevated stations	Including Balu River Bridge	Escalator & Elevator are included
Package 7	Elevated Civil 2	Purbachal West and P. Terminal station viaduct 4.68km, 4 elevated stations	Including 400m viaduct Terminal East end	Escalator & Elevator are included
Package 8	Depot Civil	Soil Improvement, Embankment, Box Culvert, Retaining Wall,		
Package 9	Depot System	Approach Viaduct、Inspection Shed、Adminisatration Building、Permanentway Maintenance Equipment		Sig. Telecom. Power, Sub-station for depot are excluded.
Package 10	Signal, Telecom. and PSD	Signalling and Telecommunication, Depot Signal and Communication, Platform Screen Door		CBTC, Cab signal,
Package 11	Power Supply and Track	Sub-station, OHC, and Track Laying		Power Supply for Car Maintenance Equipment are included
Package 12	AFC	Automated Fare Collection System		Incliding Contactless IC Cards
Package 13	Rolling Stock & Car Maintenance Equipment	200 EMU		Rolling Stock Maintenance Equipment is included

Source: JICA Study Team

Study result of Contract Packaging is summarized below.

Table 4.15.4 Comparison Contract Packaging

	Advantage	Disadvantage	Japanese Entities
Case 1, Contract according to Work Field			
	The Contract Amount may be lower than Case 2. The Contractor can concentrate onto special field	It is difficult to integrate several special field. Employer's administration cost may increase. It is difficult to mange the schedule. Duplicate Works in OCC is expected. Delay of one contract effects to all. Responsibility of System Integration is not clear.	It is difficult to success the competition due to low price. Some manufactures have no experience of International Standard. SIL 4 is not common for Japanese manufacture.
Case 2, Integrated the Works			
	Contractor is responsible for Interface Management results in less claim. Administrative works of Employer is lee than Case 1. Schedule Management is flexible. Delay of one work may be absorbed in other works.	Contract amount may be higher than Case 1. Contractor needs System Integrator.	As System Integrator Mitsubishi Heavy Industry, Hitachi, Kawasaki are expected.

Source: JICA Study Team

It should be considered that staff of PIU shall be arranged for integration between packages and man-month of consultant shall be added for dealing with interface problems by subdividing packages while preventing the high contract cost.

4.15.5 Cost Estimation of Project

1) Introduction

Generally, the project cost is composed of the following:

(a) Direct construction cost (Material, worker, plant and equipment, indirect charge)
(b) Consulting service fee
(c) The cost of land acquisition and compensation of transferring
(d) The administration cost of project
(e) Contingency against physical factors and escalation
(f) Tax (import duties and VAT) and interest of bank credit

Estimating project cost is vital for financial evaluation, budgeting of project by government and DMTC. The direct construction cost, which consists of the major project cost, is examined by estimating unit price, which reflects local condition.

This estimate is based on other practical constructions since this feasibility report has yet to conduct practical design. The main practical constructions are MRT Line 6 and the unit price followed its contract price.

2) Construction Cost Estimate

Quantity of the respective major works was based on the presumed design done prior to calculation of each major work volume.

The presumed standard span of column in elevated construction area is 30m and estimating the quantity of concrete, rebars and form work is based on this presumption.

Moreover, all columns and portals were estimated as same as this presumption. On the other hand, underground major work volumes were determined by each station and between stations. The following table shows major work volumes.

(1) Major Work Quantities

Table 4.15.8 shows major work quantities.

(2) Setup of Unit Price

The unit price of respective works and procurement in this estimation are summarized below.

a. Construction Cost

Construction cost estimate is separately made by the two types of construction works;

- Civil, Track and Architectural works, and
- Equipment, Plant and Mechanical works.

a) Contractor's Direct Cost

- **Civil, Track and Architectural Works**

This work item of civil, track and architectural works are mainly made with the following:

i)Elevated Civil Structures
ii) Underground Civil Structures,
iii) Architectural Works,
iv) Track Works,
v) Depot Facilities Works,
vi) Electric and Mechanical Facilities,
vii) Signal and Telecommunication Facility and Equipment, and
viii) Procurement of Rolling Stock.

The direct cost consists of a direct labour cost, a direct material cost and a direct operation and transportation cost. Mobilization and demobilization cost is usually estimated by about one percent (1.0%) of the estimated at other estimated construction direct cost.

In this project, those costs for mobilization and demobilization was considered in direct cost and indirect cost respectively.

(a) Direct Labour Cost

The pure labour rates were applied from actual market prices such as wage and site allowances in Bangladesh on 2015 to 2017.

(b) Direct Material Cost

The pure construction materials costs were set based on information obtained from construction companies and interview with Bangladesh suppliers on 2015 to

2016.

(c) Direct Operation Cost

The pure operation cost basically consists of royalty and utilities (water and electric tariff) expenses and procurement, rental and maintenance cost of construction equipment were set based on information obtained from the international / local contractors, manufacturer and suppliers.

- **Equipment, Plant and Mechanical Works**

Item of equipment, plant and mechanical works are mainly made with the following:

i)Installation and Mechanical Works of Plant and Equipment on Depots

ii) Power Distribution Station (Generator, Transformer and Transmission Lines)

The direct cost consists of material/ equipment/ plant cost, accessories cost (for material/ equipment/ plant), transportation and insurance cost, and erection cost. In this project, mobilization and demobilization cost was included in “Preparatory Works Expenses” as mentioned in a clause later.

(a) Direct Materials, Equipment and Plant Cost

These pure materials and production rates were applied from actual market selling prices in the countries of supply on 2015 and 2017.

(b) Direct Accessories Cost (Materials, Equipment and Plant)

The pure costs of accessories will be estimated by ten percent (10.0%) of a) Materials, Equipment and Plant cost.

(c) Direct Transportation and Insurance Cost

The following pure costs of transportation and insurance are included into the direct cost estimate by the following rates (percentages) of production cost a) +b), which are adopted considering of the rate of the recent international projects.

Table 4.15.5 Cost Estimate of Transportation and Insurance

No.	Work Item	Ocean Freight and Insurance: Percentage (%) of a)+b)	Inland transportation and Insurance: Percentage (%) of a)+b)
(a)	Installation of Plant and Equipment on Depots	5.0 %	3.0 %
(b)	Installation of Generator, Transformer and Transmission Lines	3.0 %	2.0 %

Source: JICA Study Team

(d) Direct Erection and Commissioning Cos

The pure costs of Erection and Commissioning will be estimated by twenty percent (20%) and ten percent (10%) of a) Materials, Equipment and Plant cost for (i) Installation of Plant and Equipment on Depots, and (ii) Installation of Generator, Transformer and Transmission Lines for Power Distribution Station respectively as summarized in Table 4.15.6 These rates are determined to be applied based on recent international project.

Table 4.15.6 Cost Estimate of Erection and Commissioning

No.	Work Item	Erection and Commissioning Cost: Percentage (%) of a)+b)
(a)	Installation of Plant and Equipment on Depots	20.0 %
(b)	Installation of Generator, Transformer and Transmission Lines for Power Distribution Station	10.0 %

Source: JICA Study Team

b) Contractor's Indirect Cost

The indirect cost generally consists of the following expenses: a) Office operation, insurance and field expense, b) Temporary construction expense, c) Contractor's engineering management expense, d) Contractor's profit margin, e) Preparatory works expense, f) Miscellaneous and contingencies expense, g) Test and Training, and h) Taxes component. However, in this project, taxes are excluded from this category and separately estimated.

These the contractors' indirect costs are estimated for (1) Civil, Track and Architectural works and (2) Equipment, Plant and Mechanical works with applying the following percentage (%) of the sum of construction direct cost or material / production cost referring to similar international projects in Asian countries as shown in Table 4.15.7.

Table 4.15.7 Indirect Cost Item and Rate for the Construction Work

Item of Contractor's Indirect Cost on Construction Works	Rate for the Contractor's Indirect Cost (%) *	
	(1) Civil, Track and Architectural works	(2) Equipment, Plant and Mechanical works
a) Office Operation, Insurance and Field Expense The office expenses are for office running, transportation of staff, telecommunications, operation of repair shop and storehouse of construction equipment and materials, administrative expense such as a premium on contractor's all risk insurance cost for labor accident, sick and health, and financing costs for bid security/bond and so on. The field expense include cost for meetings, coordination with other stakeholders, billboards, stages during ground breaking and inauguration ceremonies and other unforeseen events.The rate (percentage) to the estimated direct cost normally is applied when the project cost will be far more than US$ 3.0 million in Asian countries.	**5.0%**	**5.0%**
b) Temporary Construction Expense The temporary construction cost is required for construction, repair and operation for temporary buildings and plant/facilities such as site office, staff dormitory and clinic, laboratory, concrete batching plant, aggregate and ballast production plant, power supply and water supply equipment, generator and pump. In addition, construction and repair cost for temporary construction of access roads and crane-way during construction works.	**1.0%**	**1.0%**
c) Contractor's Engineering Management Expense These expenses are required for contractor's engineering management under EPC contract package; Engineering/ Design, Procurement and Construction including costs on site topographic and geological survey & investigation works laboratory & quality & progress control activities, plant operation and factory inspection.	**1.0%**	**1.0%**
d) Contractor's Profit Margin The contractor's profit margin will be at eight percent (8.0%) of the estimated direct cost.	**8.0%**	**8.0%**
e) Preparatory Works Expenses Before the main construction works, there are several works or issues shall be done or considered such as clearing and grubbing, mobilization and demobilization of construction equipment and facilities, installation of construction safety signs and precaution measures, setting out survey works installing of bench marks and pegs, and so on are categorized as "Preparatory Works".	**3.0%**	**3.0%**
f) Miscellaneous and Contingencies Expenses Some works will be required in a construction stage are categorized as "Miscellaneous and Contingencies" such as removal or demolition of existing structures, relocation of utilities, weak foundation measures for plant equipment / facilities, and the physical contingency against unforeseen conditions (noise of construction works, land subsidence & groundwater level change and pollution geology, topography, weather and burglary of equipment and materials etc.).	**5.0%**	**5.0%**
g) Test and Training Installation of Plant and Equipment on Depots and Installation of Generator, Transformer and Transmission Lines for Power Distribution Station: Estimation based on remuneration of assigned expert for test and training in the site. Costs of test and training are calculated by 2.0% of the materials and production cost.	**-**	**2.0%**
h) Taxes Import tax at five percent (5.0 %) and Value Added Tax (VAT) component at ten percent (10.0 %) will be excluded from the indirect cost and calculated separately.	**-**	**-**
Total	**23.0%**	**25.0%**

Note: * Indirect Cost is calculated by a rate (%) to total estimated Construction Direct Cost at each works item.

Source: JICA Study Team

As a result, the total ratio of the contractor's indirect cost excluding import taxes becomes 23.0 % for (1) Civil, Track and Architectural works, and 25.0 % for (2) Equipment, Plant and Mechanical works of the sum of construction direct cost or material / production cost.

The construction cost estimate was made based on unit price of each work item which includes direct and indirect costs of construction civil and building works, and the purchase costs of material, machinery, equipment and facilities

Table 4.15.8 Summary of Quantities

Summary of Quantities

SQ	Subject			Main Works
1	**Elevated Civil Structures**			
	1-1	**Viaduct Structure**		
		1-1-1	**Substructures - standard type (Main Line)**	Foundation Piles (Bored Pile, Dia.: 1,200mm) 56,640m, Concrete 55,578m3, Reinforcing Bar 3,890ton, Excavation 45,312m3
		1-1-2	**Substructures - portal type (Main Line)**	Foundation Piles (Bored Pile, Dia.: 1,200mm) 8,320m, Concrete 11,700m3, Reinforcing Bar 819ton, Excavation 6,656m3
		1-1-3	**Superstructures (Main Line)**	PC Box Simple 30m span (Double Track) 362nos, for Double Track 18
		1-1-4	**Special Long Span Bridge_90**	Bored Pile Dia 1.8m 480m, Span L=90m 1nos
		1-1-5	**Substructures (Depot Access Line)**	Foundation Piles (Bored Pile, Dia.: 1,000mm) 6,400m, Concrete 3,480m3, Reinforcing Bar 244ton, Excavation 3,400m3
		1-1-6	**Superstructures (Depot Access Line)**	PC Box Simple 30m span (Double Track) 40nos
	1-2	**Elevated Station Structure**		
		1-2-1	**Bashundhara St.**	Foundation Piles (Bored Pile, Dia.: 1,500mm) 2,220m, Concrete 1,390m3, Reinforcing Bar 97ton, Excavation 169m3
		1-2-2	**POHS St.**	Foundation Piles (Bored Pile, Dia.: 1,500mm) 2,220m, Concrete 1,390m3, Reinforcing Bar 97ton, Excavation 169m3
		1-2-3	**Mastul St.**	Foundation Piles (Bored Pile, Dia.: 1,500mm) 2,220m, Concrete 1,390m3, Reinforcing Bar 97ton, Excavation 169m3
		1-2-4	**Purbachal West St.**	Foundation Piles (Bored Pile, Dia.: 1,500mm) 2,220m, Concrete 1,390m3, Reinforcing Bar 97ton, Excavation 169m3
		1-2-5	**Purbachal Central St.**	Foundation Piles (Bored Pile, Dia.: 1,500mm) 2,220m, Concrete 1,390m3, Reinforcing Bar 97ton, Excavation 169m3
		1-2-6	**Purbachal East St.**	Foundation Piles (Bored Pile, Dia.: 1,500mm) 2,220m, Concrete 1,390m3, Reinforcing Bar 97ton, Excavation 169m3
		1-2-7	**Purbachal Terminal St.**	Foundation Piles (Bored Pile, Dia.: 1,500mm) 3,330m, Concrete 2,086m3, Reinforcing Bar 146ton, Excavation 3,253m3
	1-3	**Transition Section Structues**		
		1-3-1	**Box Culvert**	Bored Pile, Dia.: 1,000mm) 2,400m, Concrete 11,662m3, Reinforcing Bar 1,166ton, Excavation 44,717m3
		1-3-2	**U Shape Retaining Wall**	Bored Pile, Dia.: 1,000mm) 2,850m, Concrete 2,237m3, Reinforcing Bar 157ton, Excavation 5,585m3
		1-3-3	**Half Underground Section**	Bored Pile, Dia.: 1,000mm) 2,220m, Concrete 2,977m3, Reinforcing Bar 298ton, Excavation 1,749m3

SQ	Subject			Main Works
2	**Underground Civil Structures**			
	2-1	**Underground Stations and Launching Shaft**		
		2-1-1	**Kamalapur St.**	D. Wall 586m, Soil Improvement 11,664m3, Temporary Decking 4,640m2, Excavation 97,862m3, Backfil 36,600m3, Concrete 19,630m3, Re-bar 1,963ton, Water Proof 74,594m2, Entrance 4 nos
		2-1-2	**Rajarbagh St.**	D. Wall 586m, Soil Improvement 11,664m3, Temporary Decking 4,640m2, Excavation 97,862m3, Backfil 36,600m3, Concrete 19,630m3, Re-bar 1,963ton, Water Proof 75,170m2, Entrance 4 nos
		2-1-3	**Malibagh St.**	D. Wall 531m, Soil Improvement 25,560m3, Temporary Decking 13,420m2, Excavation 85,765m3, Backfil 36,600m3, Concrete 19,630m3, Re-bar 1,963ton, Water Proof 24,417m2, Entrance 4 nos
		2-1-4	**Rampura St.**	D. Wall 586m, Soil Improvement 11,664m3, Temporary Decking 4,640m2, Excavation 97,862m3, Backfil 36,600m3, Concrete 19,630m3, Re-bar 1,963ton, Water Proof 75,170m2, Entrance 4 nos
		2-1-5	**Hatir Jheel St.**	D. Wall 566m, Soil Improvement 11,664m3,Temporary Decking 4,640m2, Excavation 97,861m3, Backfil 12,654m3, Concrete 19,630m3, Re-bar 1,963ton, Water Proof 16,590m2, Entrance 4 nos
		2-1-6	**Badda St.**	D. Wall 566m, Soil Improvement 10,214m3,Temporary Decking 4,026m2, Excavation 97,862m3, Backfil 10,980m3, Concrete 19,630m3, Re-bar 1,963ton, Water Proof 17,070m2, Entrance 4 nos
		2-1-7	**Uttr Badda St.**	D. Wall 566m, Soil Improvement 11,654m3,Temporary Decking 4,640m2, Excavation 97,862m3, Backfil 12,654m3, Concrete 19,630m3, Re-bar 1,963ton, Water Proof 16,590m2, Entrance 4 nos
		2-1-8	**Notun Bazar St.**	D. Wall 586m, Soil Improvement 23,309m3,Temporary Decking 9,280m2, Excavation 195,724m3, Backfil 25,308m3, Concrete 39,260m3, Re-bar 3,926ton, Water Proof 33,180m2, Entrance 4 nos
		2-1-9	**Future Park St.**	D. Wall 586m, Soil Improvement 10,080m3,Temporary Decking 4,640m2, Excavation 97,862m3, Backfil 10,002m3, Concrete 33,390m3, Re-bar 3,339ton, Water Proof 20,820m2, Entrance 4 nos, Ventilation shaft 2 nos, Connection corridor 1 no
		2-1-10	**Khilhet St.**	D. Wall 566m, Soil Improvement 10,440m3,Temporary Decking 4,026m2, Excavation 97,862m3, Backfil 10,980m3, Concrete 19,630m3, Re-bar 1,963ton, Water Proof 17,280m2, Entrance 4 nos, Ventilation shaft 4 nos
		2-1-11	**Airport Terminal 3St.**	D. Wall 566m, Soil Improvement 10,440m3,Temporary Decking 4,026m2, Excavation 97,861m3, Backfil 10,980m3, Concrete 19,630m3, Re-bar 1,963ton, Water Proof 18,800m2, Entrance 4 nos
		2-1-12	**Airport St.**	D. Wall 566m, Soil Improvement 10,440m3,Temporary Decking 4,026m2, Excavation 97,861m3, Backfil 10,980m3, Concrete 19,630m3, Re-bar 1,963ton, Water Proof 18,800m2, Entrance 4 nos
		2-1-13	**Launching shaft (6 nos)**	D. Wall 68m, Soil Improvement 230m3,Temporary Deck 0m2, Excavation 5,600m3, Backfil 560m3, Concrete 1,080m3, Re-bar 108ton, Water Proof 680m2, Cut & Cover Tunnel 1 no, CP-01 1 no, CP-02 1 no, CP-03 1 no, CP-04 2 nos, CP-05 1 no
		2-1-14	**Transportation costs for Equipment**	2 Machines for each contractors Except Contract # 4 which needs 4 machines
	2-2	**Tunneling Works (Track Section)**		
		2-2-1	**CP-01 Kamalapur St. to Malibagh St.**	TBM 2 nos, Surplus Soil 183,093m3, Steel Girder 4,200ton, Soil Improvement 460 m3, Segment 4,760m, Invert Concrete 2,618m3, Construction Facility 2 set, Back Anchor facilities 4sets, Passing Station 2 times, Abondon of TBM 2 sets, Entrace concrete and Face Breaking 6 sets, Soil improvvement for protect existing structure 1 set
		2-2-2	**CP-02 Malibagh St. to Badda St.**	TBM 2 nos, Surplus Soil 197,633m3, Steel Girder 6,300ton, Soil Improvement 690m3, Segment 5,138m, Invert Concrete 2,826 m3, Construction Facility 2 set, Back Anchor facilities 6sets, Passing Station 4 times, Abondon of TBM 2 sets, Entrace concrete and Face Breaking 12 sets
		2-2-3	**CP-03 Badda St. to Notun Bazar St.**	TBM 2 nos, Surplus Soil 88,239m3, Steel Girder 6,300ton, Soil Improvement 460m3, Segment 2,294m, Invert Concrete 1,262 m3, Construction Facility 2 set, Back Anchor facilities 4 sets, Passing Station 2 times, Removal of TBM 2 sets, Entrace concrete and Face Breaking 6 sets
		2-2-4	**CP-04 Notun Bazar St. to Khilkhet St. and Nortun Bazar St. to Launching shaft**	TBM 4 nos, Surplus Soil 461,272m3, Steel Girder 6,300ton, Soil Improvement 1,840m3, Segment 11,992m, Invert Concrete 6,596 m3, Construction Facility 2 set, Back Anchor facilities 8 sets, Passing Station 2 times, Removal of TBM 4 sets, Entrace concrete and Face Breaking 16 sets, Soil improvvement for protect existing structure 1 set
		2-2-5	**CP-05 Khilket St. to Airport St.**	TBM 2 nos, Surplus Soil 87,469m3, Steel Girder 2,100ton, Soil Improvement 460m3, Segment 2,274m, Invert Concrete 1,251 m3, Construction Facility 2 set, Back Anchor facilities 2 sets, Passing Station 2 times, Removal of TBM 2 sets, Entrace concrete and Face Breaking 6 sets

SQ	Subject			Main Works
	2-3		**Cut and Cover Tunneling Works Track Section)**	
		2-3-1	**CP-01 Kamalapur St. to Malibagh St.**	Cut & Cover Tunnel D Wall 1,858 m, Cut & Cover Tunnel Excavation 230,160 m3, Cut & Cover Tunnel Concrete 52,738 m3, Cut & Cover Tunnel Road Deck 16,460 m2, Cut & Cover Tunnel Rebar 5,273.8 ton
		2-3-2	**CP-02 Malibagh St. to Badda St.**	Cut & Cover Tunnel D Wall 200 m, Cut & Cover Tunnel Excavation 41,760 m3, Cut & Cover Tunnel Concrete 7,291 m3, Cut & Cover Tunnel Road Deck 2,22 m2, Cut & Cover Tunnel Rebar 729.1 ton
		2-3-3	**CP-03 Badda St. to Notun Bazar St.**	Cut & Cover Tunnel D Wall 686 m, Cut & Cover Tunnel Excavation 226,060 m3, Cut & Cover Tunnel Concrete 48,394 m3, Cut & Cover Tunnel Road Deck 12,870 m2, Cut & Cover Tunnel Rebar 4,839 ton
		2-3-4	**CP-04 Notun Bazar St. to Khilkhet St. and Nortun Bazar St. to Launching shaft**	Cut & Cover Tunnel D Wall 467 m, Cut & Cover Tunnel Excavation 159,100 m3, Cut & Cover Tunnel Concrete 31,530 m3, Cut & Cover Tunnel Road Deck 8,385 m2, Cut & Cover Tunnel Rebar 3,153 ton
		2-3-5	**CP-05 Khilket St. to Airport St.**	Cut & Cover Tunnel D Wall 2,430 m, Cut & Cover Tunnel Excavation 367,440 m3, Cut & Cover Tunnel Concrete 7,705 m3, Cut & Cover Tunnel Road Deck 15,496 m2, Cut & Cover Tunnel Rebar 7,671 ton
	2-4		**Underpass beneath the Kamalapur Road with Box Culvert**	LS 1
3			**Architectural Works**	
	3-1		**Elevated Station**	Bashundhara, POHS, Matsul, PURBACHAL West, PURBACHAL Central, PURBACHAL Sector 7, PURBACHAL Terminal
	3-2		**Underground Station**	Finishing Works (Kamalapur B1 5,410m2, B2 2,384m2, Rajarbagh B1 5,410m2 B2 2,384m2, Malibagh B1 4,399m2, B2 3,464m2, B3 1,900m2, Rampura B1 4,399m2, B2 3,466m2, Hatir Jheel B1 3,992m2, B2 2,200m2, Badda B1 3,992m2, B2 2,200m2, Uttr Badda B1 3,699m2, B2 2,923m2, Notun Bazar B1 10,948m2 B2 6,928m2, Future Park B1 4,099m2 B2 3,464m2 B3 3,464m2, Khliket B1 4,099m2 B2 3,464m2 Terminal 3 B1 4,099m2 B2 3,464m2, Airport B1 4,099m2 B2 3,464m2)
4			**Track**	
	4-1		**Main Line**	Rail for 62.482 km, Plinth, Fatener, Turnout
		4-1-1	**Main Line**	Rail for 62.482 km, Plinth, Fatener, Turnout
		4-1-2	**Depot Access Line**	Rail for 2.0 km, Plinth, Fatener, Turnout
	4-2		**Depot**	Ballast 17,586 m3, Rail for 13.67 km, Sleeper and Fasting 20403 pcs. Turnout 41 nos, Buffer steop and others
5			**Depot Facilities**	
	5-1		**Soil Improvement and Land Development**	
		5-1-1	**Soil Improvement**	Sand Compaction Piles 172,000m2, Dynamic Compaction 10,200m2
		5-1-2	**Land Development**	Earthwork 935,400 m3
		5-1-3	**Retaining Wall**	None
	5-2		**Approach Track**	Viaduct Single Track 750m
	5-3		**Retaining Wall H=3m, L=10,209m**	Structural Concrete 41,857m3
	5-4		**Civil Works**	Civil Works Lump Sum
	5-5		**Box Culvert H=2.5m x W=3.5m, L=290m**	Structural Concrete 1,334m3
	5-6		**Architectural Work (Shed & Building)**	Shed and Building, Electrical/Equipment Works Lump Sum
	5-7		**Electrical / Equipment**	Electrical / Equipment
	5-8		**Rolling Stock Equipment**	Rolling Stock Equipment
	5-9		**Others**	General Requirement Lump Sum

SQ	Subject			Main Works
6	**Electric and Mechanical Facilities**			
	6-1	**Electric Facilities**		
		6-1-1	**RSSS (2)**	132kv GIS 2 sets, 132kv/33kv main transfomer 4 sets, EHV Relay & Control Panel 2 sets, 33kv switch gear 2 sets, UPS & Changer 2 sets, RTU 2 sets, Cables 33kv 1 lot, Spareparts
		6-1-2	**TSS (8)**	33kv Switchgear 8 sets, Rectfier Transformaer 24 sets, Rectifier Set 24 sets, DC Switchgear 8 sets, Distribution Panel 8 sets, Energy Storage System 8 sets, UPS & Changer 8 sets, RTU 8sets, Spareparts & Mannuals, Earthing work 8 sets
		6-1-3	**ASS (15)**	33kv Switchgear 18 sets, 33kv/415v Transformer 36 sets, Distributin Panel 18 sets, UPS & Changer 18 sets, RTU 18 sets, Spareparts, Earthing 18 sets
		6-1-4	**OCC**	Power SCADA, Spareparts
		6-1-5	**OCS (Overhead Contact System)**	Pole 564 sets, Beam 44 sets, Depot OHC Beam 77 sets, Contact Wire 170mm2 22,493m, Feeding Messenger wire 44,493m, Contacto Wire 110mm2 26,554m Steel wire 26,554m, Copper Standed conductor 10,934m, Rigit Conductor 50,984m, Rigit Conductor Accessories 850 sets, Power Cable 62,480m, Supprting Insulator 87,784m Automatic Tension Device 26 sets, Steady Equipment and Accessaries 564 sets, Pull-off Equipment and Accessaries 564 sets, Lightning Arrestor 564 sets, Disconecting Switch 10 sets, Spare Parts
	6-2	**Mechanical Facilities (Elevated Station)**		
		6-2-1	**Bashundhara St.**	Air Conditioning and Ventilation 8,977m2, Plumbing 8,977m2, Station Equipment 8,977m2
		6-2-2	**POHS St.**	Air Conditioning and Ventilation 7,613m2, Plumbing 7,613m2, Station Equipment 7,613m2
		6-2-3	**Mastul St.**	Air Conditioning and Ventilation 7,613m2, Plumbing 7,613m2, Station Equipment 7,613m2
		6-2-4	**Purbachal West St.**	Air Conditioning and Ventilation 7,613m2, Plumbing 7,613m2, Station Equipment 7,613m2
		6-2-5	**Purbachal Central St.**	Air Conditioning and Ventilation 8,977m2, Plumbing 8,977m2, Station Equipment 8,977m2
		6-2-6	**Purbachal Sector 7 St.**	Air Conditioning and Ventilation 8,977m2, Plumbing 8,977m2, Station Equipment 8,977m2
		6-2-7	**Purbachal Terminal St.**	Air Conditioning and Ventilation 13,466m2, Plumbing 8,977m2, Station Equipment 15,710m2
	6-3	**Mechanical Facilities (Underground Station)**		
		6-3-1	**Kamalapur St.**	Air Conditioning and Ventilation 15,194m2, Plumbilg System 15,194m2, Station Electric Equipment 15,194 m2
		6-3-2	**Rajarbagh St.**	Air Conditioning and Ventilation 7,794m2, Plumbilg System 7,794m2, Station Electric Equipment 7,794m2
		6-3-3	**Malibagh St.**	Air Conditioning and Ventilation 6,192m2, Plumbilg System 6,192m2, Station Electric Equipment 6.192m2
		6-3-4	**Rampura St.**	Air Conditioning and Ventilation 9,763m2, Plumbilg System 9,763m2, Station Electric Equipment 9,763m2
		6-3-5	**Hatir Jheel St.**	Air Conditioning and Ventilation 6,192m2, Plumbilg System 6,192m2, Station Electric Equipment 6.192m2
		6-3-6	**Badda St.**	Air Conditioning and Ventilation 6,192m2, Plumbilg System 6,192m2, Station Electric Equipment 6.192m2
		6-3-7	**Uttr Badda St.**	Air Conditioning and Ventilation 10,878m2, Plumbilg System 10,878m2, Station Electric Equipment 10,878m2
		6-3-8	**Notun Bazar St.**	Air Conditioning and Ventilation 21,676m2, Plumbilg System 21,676m2, Station Electric Equipment 21,676m2
		6-3-9	**Future Park St.**	Air Conditioning and Ventilation 12,927m2, Plumbilg System 12,927m2, Station Electric Equipment 12,927m2
		6-3-10	**Khilhet St.**	Air Conditioning and Ventilation 12,927m2, Plumbilg System 12,927m2, Station Electric Equipment 12,927m2
		6-3-11	**Airport Terminal 3 St.**	Air Conditioning and Ventilation 12,927m2, Plumbilg System 12,927m2, Station Electric Equipment 12,927m2
		6-3-12	**Airport St.**	Air Conditioning and Ventilation 12,927m2, Plumbilg System 12,927m2, Station Electric Equipment 12,927m2

SQ	Subject			Main Works
	6-4	**Lifts and Escalators**		
		6-4-1	**Lift**	Kamalapur 3 nos, Rajarbagh 3 nos, Malibagh 3 nos, Rampura 3 nos, Hatr Jheel 3 nos, Badda 3 nos, Uttr Badda 3 nos, Notun Bazar 4 nos, Future Park 4 nos, Khilket 3 nos, Terminal 3 3 nos, Airport 3, and 4 nos for each Elevated Station
		6-4-2	**Escalators**	Kamalapur 12 nos, Rajarbagh 10 nos, Malibagh10 nos, Rampura 8 nos, Hatir Jheel 10 nos, Badda 10 nos, Uttr Badda 10 nos, Notun Bazar 12 nos, Future Park 11 nos, Khilket 10 nos, Terminal 3 12 nos, Airport 10, Bashundhara 12, POHS 12 nos, Matul 12 nos, PURBACHAL West 12 nos, PURBAHAL Central 12 nos, PURBACHAL East 12 nos, Terminal 12 nos
7	**Signal and Telecommunication Facility and Equipment**			
	7-1	**Signalling System**		
		7-1-1	**Main Line Facilities**	OCC Central Equipment 1 set, CBTC Electrical Interlocking 1 set, Wayside Equipment 1 set (Operation Display, Operation Control Terminal, CTC Equipment, PRC Equipment, Dispatcher Training Equipment, Timetable Maker, UPS Equipment, CBTC Station Control Equipment, WRS Set, Signalling Equipment on Board(24 Trains), Transponder, Electrical Interlocking Equipment, Station I/O Equipment, UPS Equipment, Emegrency Alarm Equipment,Axel Counter, Point Machine, Repeater of Signal, Route Indicator, Sign for Operation, Tunnel Alar Equipment
		7-1-2	**Depot Facilities**	Depot Signal System 1 set (Electrical Interlocking Equipment, CBTC Equipment, Track circuit, Point Machine, Shunting Indicator, Rout Indicator, UPS Equipment)
	7-2	**Telecommunication System**		
		7-2-1	**Depot Facilities**	Data Transmission System, Telephone System, CCTV, PA, Clock, Radio, Disaster Prevention, UPS, On board facilities
		7-2-2	**Elevated Facilities**	11.369 km in length Data Transmission System, Telephone System, CCTV, PA, Clock, Radio, Disaster Prevention,Passenger Information Display, UPS
		7-2-3	**Underground Facilities**	19,872km in length Data Transmission System, Telephone System, CCTV, PA, Clock, Radio, Disaster Prevention,Passenger Information Display, UPS
		7-2-4	**Rolling Stock**	CCTV
	7-3	**SCADA and Depot BMS/BAS**		
		7-3-1	**Station F-SCADA (Main line : Station 1 to 16)**	Workstation, Software Development
		7-3-2	**Depot F-SCADA**	Workstation, Software Development
		7-3-3	**Depot BMS/BAS**	Workstation, Software Development, PLC
	7-4	**Platform Screen Door (PSD)**		
		7-4-1	**Full Height PSD**	14 stations
		7-4-2	**Half Height PSD**	8 stations
	7-5	**Automatic Fare Collection System (AFC)**		
		7-5-1	**AFC System for station**	Station system, Common system
8	**Rolling Stock**			200 cars

Source: JICA Study Team

Table 4.15.9 Setup of Unit Price

Unit Cost of Major Works

		Unit	Unit Cost			Unit Cost Ratio		Remarks
			Yen	BDT	Total Yen	Yen	BDT	
1. Civil/Structure Works								
1.1	Bored Pile	m						Exchange Rate
	Bored Pile dia 1,000mm		6,402	30,537	45,795	0.1	0.9	1.29
	Bored Pile dia 1,200mm		7,810	39,473	58,730	0.1	0.9	
	Bored Pile dia 1,500mm		12,227	61,797	91,945	0.1	0.9	
	Bored Pile dia 1,800mm		16,739	84,597	125,869	0.1	0.9	
1.2	Concrete	m3						
	Elevated Section		2,351	28,731	39,414	0.1	0.9	
	Underground Section		5,601	9,471	17,819	0.3	0.7	
1.3	Reignforcing Bar (Re-bar)	ton						
	Elevated Section		50,922	86,100	161,991	0.3	0.7	
	Underground Section		50,922	86,100	161,991	0.3	0.7	
1.4	Excavation (steel sheet pile)	m3						
	Elevated Section		490	5,993	8,221	0.1	0.9	
	Underground Section		4,899	8,283	15,584	0.3	0.7	
	Backfilling Underground Station		1,018	1,722	3,239	0.3	0.7	
1.5	PC Box Gierder							
	PC Box Gierder 30m double tracks	nos	4,437,291	7,181,879	13,701,915	0.3	0.7	
	PC Box Gierder 30m single track	nos	3,222,134	5,215,112	9,949,628	0.3	0.7	
1.6	90m lenghth steel bridge	nos	60,000,000	10,000,000	72,900,000	0.8	0.2	
1.7	D-wall	m	3,075,000	0	3,075,000	1.0	0.0	
1.8	Soil Inprovement	m3	9,166	15,498	29,158	0.3	0.7	
1.9	Temporaly Decking	m2	49,200	101,844	180,579	0.3	0.7	
1.10	Water Proofing	m2	917	1,550	2,917	0.3	0.7	
1.11	Entrance	nos	21,402,000	36,186,957	68,083,175	0.3	0.7	
1.12	Ventilation Shaft	nos	10,698,712	18,089,610	34,034,309	0.3	0.7	
1.13	Transport TBM	set	70,000,000		70,000,000	1.0	0.0	
1.14	Tunneling by TBM							
	TBM	set	1,230,000,000	0	1,230,000,000	1.0	0.0	
	Surplus soil	m3	2,546	4,305	8,099	0.3	0.7	
	Steel Girder	ton	36,155	61,131	115,014	0.3	0.7	
	Soil Inprovment	m3	25,461	43,050	80,996	0.3	0.7	
	Excavation and Segment	m	234,241	396,060	745,158	0.3	0.7	
	Invert Concrete	m3	10,694	18,081	34,018	0.3	0.7	
	Tuneling Facility	set	738,000,000	0	738,000,000	1.0	0.0	
	Back Anchor	set	3,691,845	6,242,250	11,744,348	0.3	0.7	
	Removal of TBM	set	22,140,886	37,436,280	70,433,687	0.3	0.7	
	TBM Entrance Nomst	set	3,691,845	6,242,250	11,744,348	0.3	0.7	
1.15	Underpass beneath Kamalapur Road	set	464,842,072	447,846,915	1,056,000,000	0.56	0.44	
2. Architectural Works								
2.1	Elevated Station Architectural Work	set	27,650,000	337,980,000	463,644,200	0.1	0.9	
2.2	Underground Section Finishing	m2	7,646	68,264	95,707	0.1	0.9	
3. Depot								
3.1	Soil Inprovment							
	Sand Compaction Pile	m2	12,361	4,565	18,250	0.7	0.3	
	Dynamic Compaction	m2	7,425	502	8,073	0.9	0.1	
3.2	Land Development Earthwork	m3	218	1,739	2,461	0.1	0.9	
3.3	Retaining Wall							
	Concrete	m3	1,662	20,733	28,408	0.1	0.9	
	Reinforcing Bar	ton	6,787	82,941	113,781	0.1	0.9	
	Boundary Fence	m	6,824	85,160	116,680	0.1	0.9	
4. Electrical & Mechanial Work								
4.1	Electrical Facility							
	RSST	set	1,877,880,000	370,800,000	2,356,212,000	0.8	0.2	
	TSS	set	1,210,875,000	58,822,500	1,286,756,025	0.9	0.1	
	ASS	set	119,900,000	9,610,000	132,296,900	0.9	0.1	
	OCC	set	630,000,000	0	630,000,000	1.0	0.0	
	OHC	set	251,680,242	68,005,339	339,407,129	0.7	0.3	Per Double Track KM
4.2	Mechanical Facility (Elevated Station)							
	Air condition, Ventilation	m2	16,300	6,500	24,685	0.6	0.4	
	Plumbing	m2	500	4,600	6,434	0.1	0.9	
	Electrical Work	m2	3,400	16,570	24,775	0.1	0.9	
	Spareparts and Manual	set						
4.3	Mechanical Facility (Underground Station)							
	Air condition, Ventilation	m2	40,900	16,140	61,721	0.6	0.4	
	Plumbing	m2	700	7,730	10,672	0.1	0.9	
	Electrical Work	m2	4,800	23,670	35,334	0.1	0.9	
	Spareparts and Manual							
4.4	Lift and Escalator							
	Lift	nos	8,480,741	687,186	9,367,211	0.9	0.1	
	Escalator	nos	12,993,122	1,106,765	14,420,849	0.9	0.1	

			Unit	Unit Cost			Unit Cost Ratio		Remarks
				Yen	BDT	Total Yen	Yen	BDT	
5. Signal, Telecommunication and other equipment									
	5.1	Signal							
		OCC Central Equipment	set	979,001,870	0	979,001,870	1.0	0.0	
		CBTC Electrical Interlocking	set	4,115,714,014	0	4,115,714,014	1.0	0.0	
		Wayside Equipment	set	983,632,695	0	983,632,695	1.0	0.0	
		Depot	set	1,031,217,807	0	1,031,217,807	1.0	0.0	
	5.2	Telecommunication							
		Depot Facility	set	955,993,400	0	955,993,400	1.0	0.0	
		Elevated Track	set	2,049,951,805	0	2,049,951,805	1.0	0.0	
		Underground Track	set	4,796,835,840	0	4,796,835,840	1.0	0.0	
		On Board Facility	set	150,194,444	0	150,194,444	1.0	0.0	
	5.3	SCADA and depot BMS/BAS							
		Station F-SCADA (Main Line)	set	19,950,000	0	19,950,000	1.0	0.0	
		Depot F-SCADA	set	16,800,000	0	16,800,000	1.0	0.0	
		Depot BMS/BAS	set	24,000,000	0	24,000,000	1.0	0.0	
	5.4	Platform Screen Door (PSD)							
		Full Height type	nos	4,689,787,200	467,661,600	5,293,070,664	0.9	0.1	
		Half Height type	nos	1,517,414,400	157,795,200	1,720,970,208	0.9	0.1	
	5.5	Automatic Fare Collection (AFC)							
		Station System	set	2,680,064,475	157,795,200	2,883,620,283	0.9	0.1	
		Common System	set	618,884,880	33,848,400	662,549,316	0.9	0.1	
6. Rolling Stock									
		EMU	nos	232,359,800	6,146,200	240,288,398	1.0	0.0	
7. Track Work									
	7.1	Rail 60E, R350HT	km	31,407,075	2,528,750	34,669,163	0.9	0.1	
	7.2	Plinth	km	11,598,888	19,611,647	36,897,913	0.3	0.7	
	7.3	Fasting System	km	26,137,471	2,104,466	28,852,232	0.9	0.1	
	7.4	Turnout	km	8,015,731	645,389	8,848,283	0.9	0.1	
	7.5	Mass Spring System	km	61,381,037	4,942,113	67,756,363	0.9	0.1	
	7.6	Ballast	m3	6,724	2,088	9,418	0.7	0.3	
	7.7	Sleeper	nos	2,898	4,900	9,219	0.3	0.7	
	7.8	Turnout in Depot	nos	5,002,776	402,800	5,522,388	0.9	0.1	
	7.9	Others	ls	87,933,600	7,080,000	97,066,800	0.9	0.1	
	7.10	Maintenance Equipment	ls	1,319,825,000	0	1,319,825,000	1.0	0.0	

Source: JICA Study Team

Table 4.15.10 Construction Cost Estimate (Direct Cost)

Construction Cost Estimate (Direct Cost) **Total**

Item				Foreing (Yen)	Local (BDK)	Total in Yen	Remarks
1	**Elevated Civil Structures**			**3,374,920,465**	**11,185,153,729**	**18,139,323,387**	
	1-1	**Viaduct Structure**		**2,914,734,778**	**8,603,791,839**	**14,271,740,005**	
		1-1-1	Substructures - Standard Type (Main Line)	793,335,162	4,439,085,660	6,652,928,233	
		1-1-2	Substructures - Portal Type (Main Line)	137,452,458	774,973,368	1,160,417,304	
		1-1-3	Superstructures (Main Line)	1,726,106,199	2,793,750,931	5,413,857,428	
		1-1-4	Substructures (Depot Access Line)	68,034,720	50,606,560	134,835,379	
		1-1-5	Superstructures (Depot Access Line)	60,920,879	336,770,840	505,458,388	
		1-1-6	Superstructures (Depot Access Line)	128,885,360	208,604,480	404,243,274	
	1-2	**Elevated Station Structure**		**267,355,848**	**1,416,933,848**	**2,137,708,528**	
		1-2-1	Bashundhara St.	35,451,446	186,527,313	281,667,500	
		1-2-2	POHS St.	35,451,446	186,527,313	281,667,500	
		1-2-3	Mastul St.	35,451,446	186,527,313	281,667,500	
		1-2-4	Purbachal West St.	35,451,446	186,527,313	281,667,500	
		1-2-5	Purbachal Central St.	35,451,446	186,527,313	281,667,500	
		1-2-6	Purbachal Sector 7 St.	35,451,446	186,527,313	281,667,500	
		1-2-7	Purbachal Terminal St.	54,647,170	297,769,970	447,703,530	
	1-3	**Transition Section Structues**		**192,829,839**	**1,164,428,042**	**1,729,874,854**	
		1-3-1	Box Culvert	123,211,683	776,732,275	1,148,498,286	
		1-3-2	U Shape Retaining Wall	33,191,980	198,268,996	294,907,056	
		1-3-3	Half Underground Section	36,426,175	189,426,771	286,469,513	
2	**Underground Civil Structures**			**90,725,683,720**	**64,881,152,346**	**176,368,804,816**	
	2-1	**Underground Stations and Launching Shaft**		**38,189,341,148**	**28,332,891,864**	**75,588,758,408**	
		2-1-1	Kamalapur St.	3,016,486,231	2,142,205,344	5,844,197,285	
		2-1-2	Rajarbagh St.	3,017,015,170	2,143,099,685	5,845,906,755	
		2-1-3	Malibagh St.	2,891,446,710	3,073,798,943	6,948,861,315	
		2-1-4	Rampura St.	2,563,233,730	2,143,099,685	5,392,125,315	
		2-1-5	Hatir Jheel St.	2,353,527,234	2,011,048,737	5,008,111,567	
		2-1-6	Badda St.]	2,747,063,755	1,923,938,892	5,286,663,092	
		2-1-7	Uttr Badda St.	2,353,443,160	2,010,906,583	5,007,839,849	
		2-1-8	Notun Bazar St.	3,537,581,399	3,877,109,390	8,655,365,794	
		2-1-9	Future Park St.	4,136,286,324	2,414,445,361	7,323,354,201	
		2-1-10	Khilhet St.	2,894,838,788	2,029,052,232	5,573,187,734	
		2-1-11	Airport Terminal 3St.	2,837,553,454	1,930,113,262	5,385,302,960	
		2-1-12	Airport St.	2,751,943,387	1,930,113,262	5,299,692,893	
		2-1-13	Launching shaft	2,248,921,806	703,960,488	3,178,149,650	
		2-1-14	Transportation costs for Equipment	840,000,000	0	840,000,000	
	2-2	**Tunneling Works (Track Section)**		**33,333,523,851**	**18,047,518,735**	**57,156,248,581**	
		2-2-1	CP-01 Kamalapur St. to Malibagh St.	6,165,688,386	3,324,784,198	10,554,403,527	
		2-2-2	CP-02 Malibagh St. to Badda St.	6,245,506,986	3,489,021,475	10,851,015,333	
		2-2-3	CP-03 Badda St. to Notun Bazar St.	5,039,576,110	1,865,949,944	7,502,630,036	
		2-2-4	CP-04 N. Bazar St. to Khilkhet St. and N. Bazar St. to Launching shaft	11,009,170,521	7,782,479,801	21,282,043,858	
		2-2-5	CP-05 Khilket St. to Airport St.	4,873,581,847	1,585,283,317	6,966,155,826	
	2-3	**Cut and Cover Tunnelling Works (Track Section)**		**18,737,976,650**	**18,052,894,832**	**42,567,797,828**	
		2-3-1	CP-01 Kamalapur St. to Malibagh St.	5,357,951,095	4,536,281,869	11,345,843,162	
		2-3-2	CP-02 Malibagh St. to Badda St.	701,327,145	708,090,262	1,636,006,291	
		2-3-3	CP-03 Badda St. to Notun Bazar St.	3,312,835,354	4,058,158,483	8,669,604,552	
		2-3-4	CP-04 N. Bazar St. to Khilkhet St. and N. Bazar St. to Launching shaft	2,247,103,728	2,741,847,108	5,866,341,910	
		2-3-5	CP-05 Khilket St. to Airport St.	7,118,759,327	6,008,517,110	15,050,001,913	
	2-4	Underpass beneath the Kamalapur Road with Box Culvert		464,842,072	447,846,915	1,056,000,000	
3	**Architectural Works**			**986,594,152**	**9,491,770,768**	**13,515,731,566**	
	3-1	**Elevated Station**		**207,375,000**	**2,534,850,000**	**3,553,377,000**	
		3-1-1	Bashundhara St.	27,650,000	337,980,000	473,783,600	
		3-1-2	POHS St.	27,650,000	337,980,000	473,783,600	
		3-1-3	MastulSt.	27,650,000	337,980,000	473,783,600	
		3-1-4	Purbachal West St.	27,650,000	337,980,000	473,783,600	
		3-1-5	Purbachal Central St.	27,650,000	337,980,000	473,783,600	
		3-1-6	Purbachal Sector 7 St.	27,650,000	337,980,000	473,783,600	
		3-1-7	Purbachal Terminal St.	41,475,000	506,970,000	710,675,400	
	3-2	**Underground Stations**		**779,219,152**	**6,956,920,768**	**9,962,354,566**	
		3-2-1	Kamalapur St.	59,592,924	532,049,616	761,898,417	
		3-2-2	Rajarbagh St.	59,592,924	532,049,616	761,898,417	
		3-2-3	Malibagh St.	60,120,498	536,759,832	768,643,476	
		3-2-4	Rampura St.	60,120,498	536,759,832	768,643,476	
		3-2-5	Hatir Jheel St.	47,344,032	422,690,688	605,295,740	
		3-2-6	Badda St.	47,344,032	422,690,688	605,295,740	
		3-2-7	Uttr Badda St.	50,631,812	452,044,208	647,330,167	
		3-2-8	Notun Bazar St.	136,679,896	1,220,287,264	1,747,459,084	
		3-2-9	Future Park St.	84,312,442	752,747,128	1,077,938,651	
		3-2-10	Khilket St.	57,826,698	516,280,632	739,317,132	
		3-2-11	Airport Terminal 3 St.	57,826,698	516,280,632	739,317,132	
		3-2-12	Airport St.	57,826,698	516,280,632	739,317,132	
4	**Track Works**			**7,518,500,715**	**1,825,885,678**	**9,928,669,810**	
	4-1	**Main Line**		6,279,170,877	1,603,682,445	8,396,031,704	
		4-1-1	Main Line	4,821,059,007	1,555,192,719	6,873,913,396	
		4-1-2	Depot Access Line	138,286,869	48,489,726	202,293,307	
		4-1-3	Maintenance Machinery, Toll etc	1,319,825,000	0	1,319,825,000	
	4-2	**Depot**		1,239,329,839	222,203,233	1,532,638,106	
		4-2-1	Depot	1,239,329,839	222,203,233	1,532,638,106	

Item					Foreing (Yen)	Local (BDK)	Total in Yen	Remarks
5	**Depot Facilities Works**				**13,644,036,241**	**8,148,711,743**	**24,400,335,742**	
	5-1		**Soil Improvement and Land Development**		2,405,744,200	2,416,961,000	5,596,132,720	
		5-1-1	Soil Improvement		2,201,827,000	790,300,400	3,245,023,528	
		5-1-2	Land Development		203,917,200	1,626,660,600	2,351,109,192	
		5-1-3	Retaining Wall		0	0	0	Refer to 5-3
	5-2		**Approach Track Viaduct**		597,750,000	741,000,000	1,575,870,000	
	5-3		**Retaining Wall H=3m L=10,209m**		98,405,807	1,118,879,467	1,575,326,703	
	5-4		**Civil Works (Drainage, Paving, Washing Machine Foundation etc)**		254,000,000	784,000,000	1,288,880,000	
	5-5		**Box Culvert H=2.5m x W=3.5 L=10,290m**		3,136,234	35,659,154	50,206,317	
	5-6		**Architectural Works (Shed & Building)**		3,964,000,000	2,651,000,000	7,463,320,000	
	5-7		**Electrical / Equipment Works**		1,425,000,000	56,818,182	1,500,000,000	(Foreign 95%, Local 5%)
	5-8		**Rollingstock Equipment**		4,750,000,000	189,393,940	5,000,000,001	(Foreign 95%, Local 5%)
	5-9		**Others (General Requirement)**		146,000,000	155,000,000	350,600,000	
6	**Electric and Mechanical Facilities**				**29,933,196,285**	**10,646,461,237**	**43,986,525,117**	Direct + Indirect Cost
	6-1		**Electric Facilities**		19,092,312,672	2,158,312,700	21,941,285,436	Equipment, Plant and Mechanical works
		6-1-1	RSSS	Two(2) RSS	3,755,760,000	741,600,000	4,734,672,000	
		6-1-2	TSS	Eight(8) TSS	9,687,000,000	470,580,000	10,308,165,600	
		6-1-3	ASS	Fifteen(15) ASS	2,158,200,000	172,980,000	2,386,533,600	
		6-1-4	OCC		630,000,000	0	630,000,000	
		6-1-5	OCS (Overhead Contact System)		2,861,352,672	773,152,700	3,881,914,236	
	6-2		**Mechanical Facilities (Elevated Station)**		1,282,743,300	1,766,266,408	3,614,214,958	
		6-2-1	Bashundhara St.		181,335,400	248,393,590	509,214,939	
		6-2-2	POHS St.		153,782,600	210,651,710	431,842,857	
		6-2-3	MastulSt.		153,782,600	210,651,710	431,842,857	
		6-2-4	Purbachal West St.		153,782,600	210,651,710	431,842,857	
		6-2-5	Purbachal Central St.		181,335,400	248,393,590	509,214,939	
		6-2-6	Purbachal Sector 7 St.		181,335,400	248,393,590	509,214,939	
		6-2-7	Purbachal Terminal St.		277,389,300	389,130,508	791,041,570	
	6-3		**Mechanical Facilities (Underground Station)**		6,291,329,600	6,445,901,060	14,799,918,999	
		6-3-1	Kamalapur St.		705,001,600	722,322,760	1,658,467,643	
		6-3-2	Rajarbagh St.		361,641,600	370,526,760	850,736,923	
		6-3-3	Malibagh St.		287,308,800	294,367,680	675,874,138	
		6-3-4	Rampura St.		453,003,200	464,133,020	1,065,658,786	
		6-3-5	Hatir Jheel St.		287,308,800	294,367,680	675,874,138	
		6-3-6	Badda St.		287,308,800	294,367,680	675,874,138	
		6-3-7	Uttr Badda St.		504,739,200	517,140,120	1,187,364,158	
		6-3-8	Notun Bazar St.		1,005,766,400	1,030,477,040	2,365,996,093	
		6-3-9	Future Park St.		599,812,800	614,549,580	1,411,018,246	
		6-3-10	Khilket St.		599,812,800	614,549,580	1,411,018,246	
		6-3-11	Airport Terminal 3 St.		599,812,800	614,549,580	1,411,018,246	
		6-3-12	Airport St.		599,812,800	614,549,580	1,411,018,246	
	6-4		**Lifts and Escalators**		3,266,810,713	275,981,069	3,631,105,724	
		6-4-1	Lifts		551,248,186	44,667,108	610,208,768	
		6-4-2	Escalators		2,715,562,527	231,313,961	3,020,896,956	
7	**Signal and Telecommunication Facility and Equipment**				27,601,169,659	3,104,161,299	31,698,662,575	Direct + Indirect Cost
	7-1		**Signalling System**		7,109,566,366	0	7,109,566,366	Equipment, Plant and Mechanical works
		7-1-1	Main Line Facilities		6,078,348,559	0	6,078,348,559	
		7-1-2	Depot Facilities		1,031,217,807	0	1,031,217,807	
	7-2		**Telecommunication System**		7,952,975,489	0	7,952,975,489	
		7-2-1	Depot Facilities		955,993,400	0	955,993,400	
		7-2-2	Elevated Facilities		2,049,951,805	0	2,049,951,805	
		7-2-3	Underground Facilities		4,796,835,840	0	4,796,835,840	
		7-2-4	Rolling Stock		150,194,444	0	150,194,444	
	7-3		**SCADA and Depot BMS/BAS**		60,750,000	0	60,750,000	
		7-3-1	Station F-SCADA (Main line : Station 1 to 16)		19,950,000	0	19,950,000	
		7-3-2	Depot F-SCADA		16,800,000	0	16,800,000	
		7-3-3	Depot BMS/BAS		24,000,000	0	24,000,000	
	7-3'		**Shipping, Installation etc.**		2,971,726,849	2,321,425,299	6,036,008,245	7-1 ～7-3
			Spare Parts and Special Tools		1,512,329,185	0	1,512,329,185	10% of Direct Materials, Equipment and Plant Cost
			Ocean Freight and Insurance		431,013,818	22,684,938	460,957,936	3% of Materials and Accessories Costs (Foreign 95%, Local 5%)
			Inland transportation and Insurance		120,986,335	181,479,502	360,539,277	2% of Materials and Accessories Costs (Foreign 40%, Local 60%)
			Erection and Commissioning Cost		907,397,511	2,117,260,860	3,702,181,846	20% of Materials and Accessories Costs (Foreign 30%, Local 70%)
	7-4		**Platform Screen Door (PSD)**		6,207,201,600	625,456,800	7,032,804,576	
		7-4-1	Full Height PSD		4,689,787,200	467,661,600	5,307,100,512	
		7-4-2	Half Height PSD		1,517,414,400	157,795,200	1,725,704,064	
	7-5		**Automatic Fare Collection System (AFC)**		3,298,949,355	157,279,200	3,506,557,899	
		7-5-1	AFC System for station		3,298,949,355	157,279,200	3,506,557,899	
8	**Procurement of Rolling Stock**				46,471,960,000	1,229,240,000	48,094,556,800	Direct + Indirect Cost
	A. Direct Cost							
	8-1		Rollingstock		46,471,960,000	1,229,240,000	48,094,556,800	200 cars
		8-1-1	Rollingstock		46,471,960,000	1,229,240,000	48,094,556,800	
9	**Security Cost**							
	9-1		Security Cost		64,193,550	622,767,566	886,246,737	
10	**Dispute Board (Borrower & Contractors)**							
	10-1		Dispute Board		1,428,845,000	0	1,428,845,000	
			Grand Summary		221,749,099,788	111,135,304,365	368,447,701,550	

Source: JICA Study Team

3) Consultant Services Fee

Prior to the estimation of the consulting services fee, expected tasks and durations were estimated and divided among three professionals: Pro-A (Expatriate), Pro-B (Bangladesh Expert) and Pro-C (Supporting Staff).

Table 4.15.11 Number of Required Consultants and Man-Months at Design Phase and Bid Management Phase

Stage	Professional (A)	Professional (B)	Supporting Staff	Duration
Design and Tender Documents Preparation & Bidding Assistance	87 Experts 787 Man-Months	99 Engineers 1119 Man-Months	65 Staff 1483 Man-Months	Months

Source: JICA Study Team

Table 4.15.12 Number of Required Consultants and Man-Months at Construction Phase

Stage	Professional (A)	Professional (B)	Supporting Staff	Duration
Construction Supervision	100 Experts 3125 Man-Months	152 Engineers/ 5,747 Man-Months	247 Staff 13,617 Man-Months	82 Months Defects Liability Period (24 months)

Source: JICA Study Team

Note Number of Staff & MM show after opening.

Presumable billing rates are as follows:

Table 4.15.13 Assumed Billing for Consultants

Billing Rate	FC (Yen)	LC (BDT)
Pro- (A)	3,073,000	
Pro- (B)		614,600
Pro- (C)		100,000

Source: JICA Study Team

4) Land Acquisition and Compensation

This cost refers to the RAP (draft) drawn up by the JICA Study Team.

5) Administrative Cost

Estimating expenditure of relevant government authority includes relevant budget of PMU, which shall be established according to progress.

This expenditure occupies 3.5% of total cost of construction, consulting services, land acquisition and transfer compensation according to confirmed similar project.

This report regards this percentage as expenditure of relevant government authority.

6) Contingencies

To cope with an exceptional event or circumstance when the project starts, inevitable design changes and sudden change of economic condition/society, it is vital to include a contingency cost in the budget. Five percent (5.0%) of the total construction cost is presumed based on previous contracts.

Cost escalation, on the other hand, is defined according to the finance loan project by Japanese ODA, as follows:

- Foreign currency contingency against escalation cost: 1.0-1.5% per year
- Local currency contingency against escalation cost: 2.0-2.5% per year

This escalation cost is not included in the construction cost.

7) Project Cost

The total project cost is shown in the following table.

Table 4.15.14 Total Project Cost

	Total (Million Japanese Yen)		
	JICA Portion	Others	Total
Construction Cost	368,448	0	368,448
Price Escalation	66,508	0	66,508
Physical Contingency	43,496	0	43,496
Consulting Services	28,197	0	28,197
Interest during Construction	0	26,865	26,865
Front End Fee	0	1,013	1,013
Land Acquisition	0	25,168	25,168
Administration Cost	0	26,591	26,591
VAT, Import Tax and Other Taxes	0	134,216	134,216
Total	506,649	213,853	720,502

Source: JICA Study Team

4.15.6 Operation and Maintenance Cost Estimation

1) Introduction

Estimating O&M cost for the following seven items is required:

1) Electric Power, 2) Staff Salary 3) Operation cost of System and Stations, 4) Rolling Stock Maintenance Cost, 5) Facility Maintenance Cost 6) Additional Car, and 7) Replacement of Facility.

The durability of EMU is presumed to be 30 years and replacement time is in 2055.

2) Traction Power

Estimated Electric Power Consumption is presumed according to car-km indicated in Tables 4.8.7 and 4.8.9. Electrical Power Consumption rate is set at 47.6kW/t/km per car-km according to the figure proposed by Japan Railways Electric Organization (http://www.rail-e.or.jp/).

・E-power Comsumption	47.6	(kWh/t·km)	Source from Japan Railway Technical Association
・Fare	7.49	(Tk./kWh)	
	78.4	Tk/1USD	

Year		Section	Distance (km)	Nos. Train (day)(nos)	E-power (kWh)	Fare (Tk.)	Fare (USD.)	Car-km
2025	6 Cars	Notun Bazar ~ Airport	6.32	193	116,121	869,747		
		Notun Bazar ~ Purbachal Terminal	15.03	133	190,304	1,425,376		
		Kamalapur ~ Notun Bazar	8.44	326	261,937	1,961,909		
	8 Cars	Notun Bazar ~ Airport	6.32	146	87,843	657,944		14,764
		Notun Bazar ~ Purbachal Terminal	15.03	121	173,134	1,296,770		29,098
		Kamalapur ~ Notun Bazar	8.44	200	160,698	1,203,625		27,008
					421,674	3,158,339	40,285	70,870
2035	8Cars	Notun Bazar ~ Airport	6.32	224	134,773	1,009,448		22,651
		Notun Bazar ~ Purbachal Terminal	15.03	131	187,442	1,403,942		31,503
		Kamalapur ~ Notun Bazar	8.44	278	223,370	1,673,039		37,541
					545,585	4,086,428	52,123	91,695

3) Staff Salary

Staff of HQ have already been hired at the previous Line 6; therefore, staff cost in HQ is not included in this estimation of Line 1.

Total number of staff is discussed in section 4.17, Recruitment Plan of DMTC Staff, in which the number of staff to be hired is 987, but this number is too big. Also, staff who are assigned in HQ for the work of Line 1 are necessary. JST presumed that 75% efficiency of 987 people is possible to operate Line 1. A total of 760 people is assumed and details are given below.

Table 4.15.15 Basic Salary Level

Monthly Salary Level (USD)		Number	Monthly	Annual
5 %	3,500	38	133,000	1,596,000
10 %	2,500	76	190,000	2,280,000
20 %	1,750	152	266,000	3,192,000
45 %	1,250	342	427,500	5,130,000
20 %	1,000	152	152,000	1,824,000
Total		760	1,168,500	14,022,000
2025-2029	80% of 2035			11,217,600
2030-2034	90% of 2035			12,619,800

Source: JICA Study Team

The salary of staff may increase by 10% every five years from 2025. Increasing cost based on this salary is shown below.

Table 4.15.16 Total Annual Staff Salary

		Basic Salary	Add 10% to Previous BR	Total
2025-2029	80% of 2035	11,217,600		11,217,600
2030-2034	90% of 2035	12,619,800	1,121,760	13,741,560
2035-2039		13,741,560	1,374,156	15,115,716
2040-2044		15,115,716	1,511,572	16,627,288
2045-2049		16,627,288	1,662,729	18,290,016
2050-2054		18,290,016	1,829,002	20,119,018
2055		20,119,018	2,011,902	22,130,920

Source: JICA Study Team

4) Operation Cost of System and Stations

Service cost of station and other train operation system is appropriated as transportation cost in Japanese balance sheet. Three percent (3%) of an initial investment is presumed for this service as shown in the table below.

Table 4.15.17 Operation Cost of Railway System

		Initial Investment	Operation Cost	Ration
Electric and Mechanical Facilities	JPY/1000	22,039,851	661,196	3.0%
Power Supply System	JPY/1000	15,233,096	456,993	3.0%
S&T, others	JPY/1000	24,285,053	728,552	3.0%
Track	JPY/1000	10,282,185	308,466	3.0%
		Sum	2,155,206	
		In USD	19,919	Ex USD1=Yen 108.2

Source: JICA Study Team

5) Car Maintenance Cost

USD320 per 1000km is presumed. The table below shows the maintenance and repair cost of Japanese main private railway companies in 2016.

Table 4.15.18 Car Maintenance Cost of Japanese Private Railway Companies

Main private railway company

USD/1000km

Company name	Maintenace and repair cost
Tobu	392
Seibu	250
Keisei	288
Keio	358
Odakyu	308
Tokyu	438
Keikyu	349
Sotetsu	270
Meitetsu	266
Kintetsu	336
Nankai	293
Keihan	345
Hankyu	402
Hanshin	335
Nishitetsu	305
Average	336

Source: JICA Study Team based on MLIT Railway Annual Report

6) Facility Maintenance Cost

USD320 per Car-Km USD 329 is presumed. The cost includes rail replacement.

Table 4.15.19 Annual Expense for Facility Maintenance

USD

2025–2029	20,038,068
2030–2034	23,001,071
2035 –	25,964,074

7) Additional Rolling Stock

According to Demand Study, in order to transport forecast passengers under a 180% congestion ratio, a railcar fleet of 31 consisting of eight cars/train in 2030, and a railcar fleet of 36 in 2035 are required.

Presumable durability of rolling stock is 30 years; accordingly, rolling stock is replaced in 2055 due to depreciation.

8) Replacement of Facility

As an example, the following chart shows the durability period of railway facility denoting the depreciation period in Yokohama City, Japan. Based on this chart, JST presumes the replacement period and cost.

Table 4.15.20 Durable Year and Replacement Year

Items	Duable Year	Replace		
Track and Accessaries	20	25		1. Refer to Yokohama City Depriciation of Assets (Appendix 1) 2. Rail Replacement Cost is included in 5. Facility Maintenance Cost
Ballastbed	60	60		
Various Cables (Sig, Com. Power)	30	30		
Signal Post	30	30		
Catenary	20	20		
OHC Supporting System	30	50		

Table 4.15.21 Facility Replacement Cost

Replacement Cost	After Inaug.	1000Yen	In USD	Remarks
Signal System	10, 20,30	1,688,430	15,349,364	1/3 of Initial Cost
Communication	10, 20,30	2,650,992	24,099,924	1/3 of Initial Cost
OHC	10, 20,30	1,430,676	13,006,145	1/2 of Initial Cost
Sub-station	30	13,092,800	119,025,455	
Station Facilities	15,30	4,053,053	36,845,932	1/2 of Initial Cost
Track				Included in Facility Maintenance
Lift & Escalator	10,20,30	1,210,369	11,003,352	1/3 of Initial Cost
Others				
Rolling Stock	30			200 cars

Table 4.15.22 Operation and Maintenance Cost

Year	Train Operation	Staff Salary	Services	Car Maintenance	Facility Maintenance	Additional Car	Replacement of Facility	Total
2025	0	0	0	0	0			0
2026	0	0	0	0	0			0
2027	14,704,002	11,217,600	19,918,720	8,277,569	18,107,183			72,225,075
2028	14,704,002	11,217,600	19,918,720	8,277,569	18,107,183			72,225,075
2029	14,704,002	11,217,600	19,918,720	8,277,569	18,107,183			72,225,075
2030	14,704,002	11,217,600	19,918,720	8,277,569	18,107,183			72,225,075
2031	16,864,414	13,741,560	19,918,720	9,493,766	20,767,612	76,800,000		157,586,072
2032	16,864,414	13,741,560	19,918,720	9,493,766	20,767,612			80,786,072
2033	16,864,414	13,741,560	19,918,720	9,493,766	20,767,612			80,786,072
2034	16,864,414	13,741,560	19,918,720	9,493,766	20,767,612			80,786,072
2035	16,864,414	13,741,560	19,918,720	9,493,766	20,767,612			80,786,072
2036	19,024,825	15,115,716	19,918,720	10,709,962	23,428,042	96,000,000	63,458,785	184,197,265
2037	19,024,825	15,115,716	19,918,720	10,709,962	23,428,042			88,197,265
2038	19,024,825	15,115,716	19,918,720	10,709,962	23,428,042			88,197,265
2039	19,024,825	15,115,716	19,918,720	10,709,962	23,428,042			88,197,265
2040	19,024,825	15,115,716	19,918,720	10,709,962	23,428,042			88,197,265
2041	19,024,825	16,627,288	19,918,720	10,709,962	23,428,042		36,845,932	126,554,769
2042	19,024,825	16,627,288	19,918,720	10,709,962	23,428,042			89,708,837
2043	19,024,825	16,627,288	19,918,720	10,709,962	23,428,042			89,708,837
2044	19,024,825	16,627,288	19,918,720	10,709,962	23,428,042			89,708,837
2045	19,024,825	16,627,288	19,918,720	10,709,962	23,428,042			89,708,837
2046	19,024,825	18,290,016	19,918,720	10,709,962	23,428,042			91,371,566
2047	19,024,825	18,290,016	19,918,720	10,709,962	23,428,042		63,458,785	154,830,351
2048	19,024,825	18,290,016	19,918,720	10,709,962	23,428,042			91,371,566
2049	19,024,825	18,290,016	19,918,720	10,709,962	23,428,042			91,371,566
2050	19,024,825	18,290,016	19,918,720	10,709,962	23,428,042			91,371,566
2051	19,024,825	20,119,018	19,918,720	10,709,962	23,428,042			93,200,567
2052	19,024,825	20,119,018	19,918,720	10,709,962	23,428,042			93,200,567
2053	19,024,825	20,119,018	19,918,720	10,709,962	23,428,042			93,200,567
2054	19,024,825	20,119,018	19,918,720	10,709,962	23,428,042			93,200,567
2055	19,024,825	20,119,018	19,918,720	10,709,962	23,428,042			93,200,567
2056	19,024,825	22,130,920	19,918,720	10,709,962	23,428,042			95,212,469
2057	19,024,825	22,130,920	19,918,720	10,709,962	23,428,042	480,000,000	219,330,171	794,542,640

4.15.7 Procurement Plan

1) Construction Equipment and Materials

(1) Basic policy

General Construction Materials such as cement and rebars are mostly available to obtain in Bangladesh, but there are materials that are not available such as construction aggregates. Because Bangladesh has few mountains, aggregates are imported from India. Now, in Bangladesh, there are so many construction works such as elevated road construction and others are under way, the JST is concerned about the number of equipment once the construction starts at the same time with MRT Line 5. This kind of environment affects the Project Cost.

In Bangladesh, MRT Line 1 construction is the first case of TBM, and the machines are going to be brought from overseas.

There are many construction companies in Bangladesh and the population of workers is 70 million based on ILO survey, 2015.

Driving the Shield Tunnelling Method and Mass Structure Work like underground Railway Stations require skilled labourers to implement the civil works. Employing foreign workers, labourers and management staff is inevitable. But JST thinks there are available domestic workers to implement general civil works, architectural work and track laying work under foreign supervisors since they have enough experience.

(2) Construction Material

Presumable construction materials and import list are as follows. This is a tentative list as items change depending on the progress of the Line 6 project.

Therefore, a procurement plan of materials should be considered at implementation phase.

Table 4.15.23 Presumable construction materials and import list

Kind of work	Import	Domestic
Civil , architecture	✓ Aggregate ✓ Segment form work	✓ Cement ✓ Brick ✓ Rebar ✓ Scaffolding ✓ Form (general) ✓ Asphalt
Machine	✓ Span by span method ✓ Shield machine and relevant facility ✓ Shoring machine	✓ Cranes ✓ Excavation machine ✓ Trucks ✓ Piling machine
Station facility	✓ Air conditioning facility ✓ Ventilation facility ✓ Mechanical facility ✓ Disaster prevention system ✓ Elevator and Escalator	
Railway system	✓ AFC System including Gates ✓ TVM ✓ PSD ✓ Signal.communication system	
Track rail	✓ Rail（UIC60） ✓ Crossing	✓ PC Sleeper
Depot	✓ All facility	
Rolling Stock	✓ EMU and Maintenance Equipment	

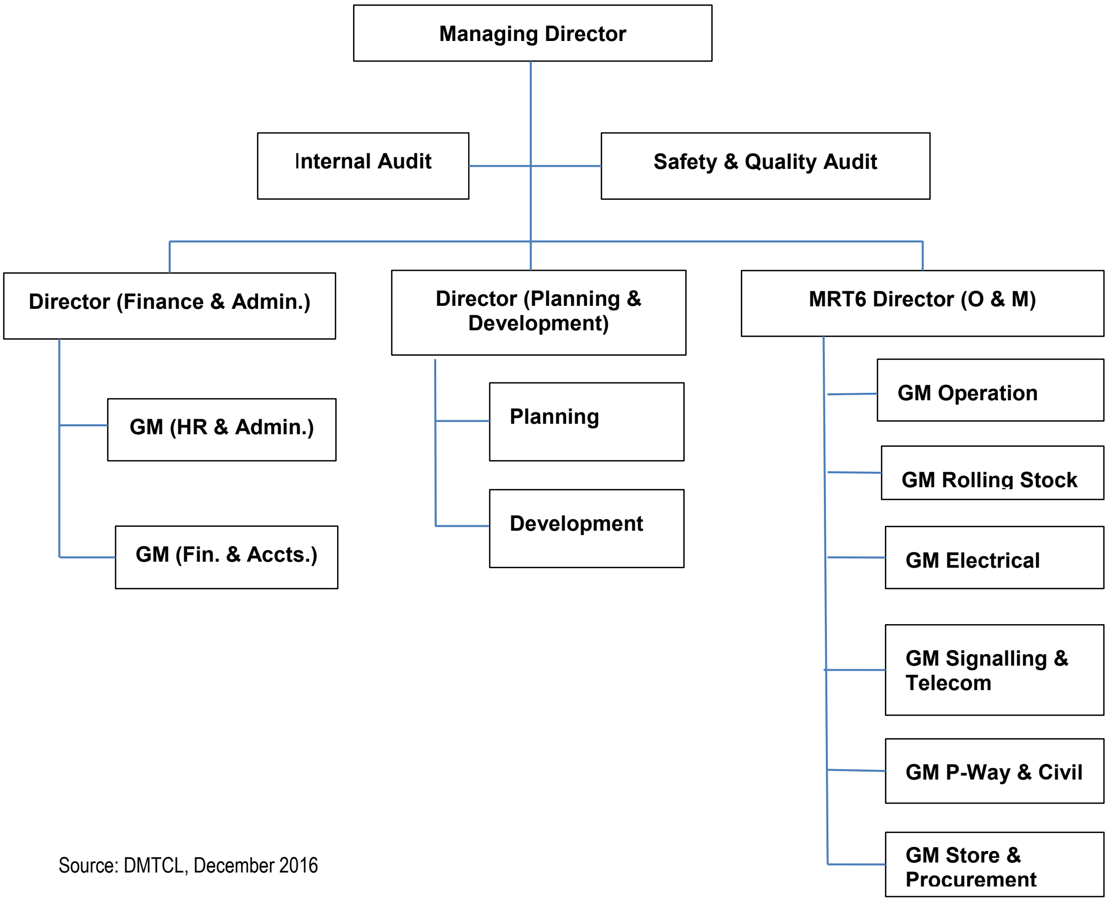
Source: JICA Study Team

4.16 Operation and Maintenance Systems

4.16.1 Examination of Operation and Maintenance Systems

Operation and Maintenance for MRT Line 6 is conducted by the DMTCL (Dhaka Mass Transit Company Limited). MRT Line 1 and Line 5 can be examined by either same organization with MRT Line 6 or different organization with MRT Line 6. From the efficient operation point of view, it should be considered as same organisation with MRT Line 6. DMTCL will be conducted operation and maintenance for both of MRT Line 1, Line 5 and Line 6.

Operation and Maintenance organization for MRT Line 6 is divided into 2 major sections, which is consisting of HDQs function and MRT Line 6 operation and maintenance function. DMTCL for MRT Line 6 is shown in Figure 4.16.1.



Source: DMTCL, December 2016

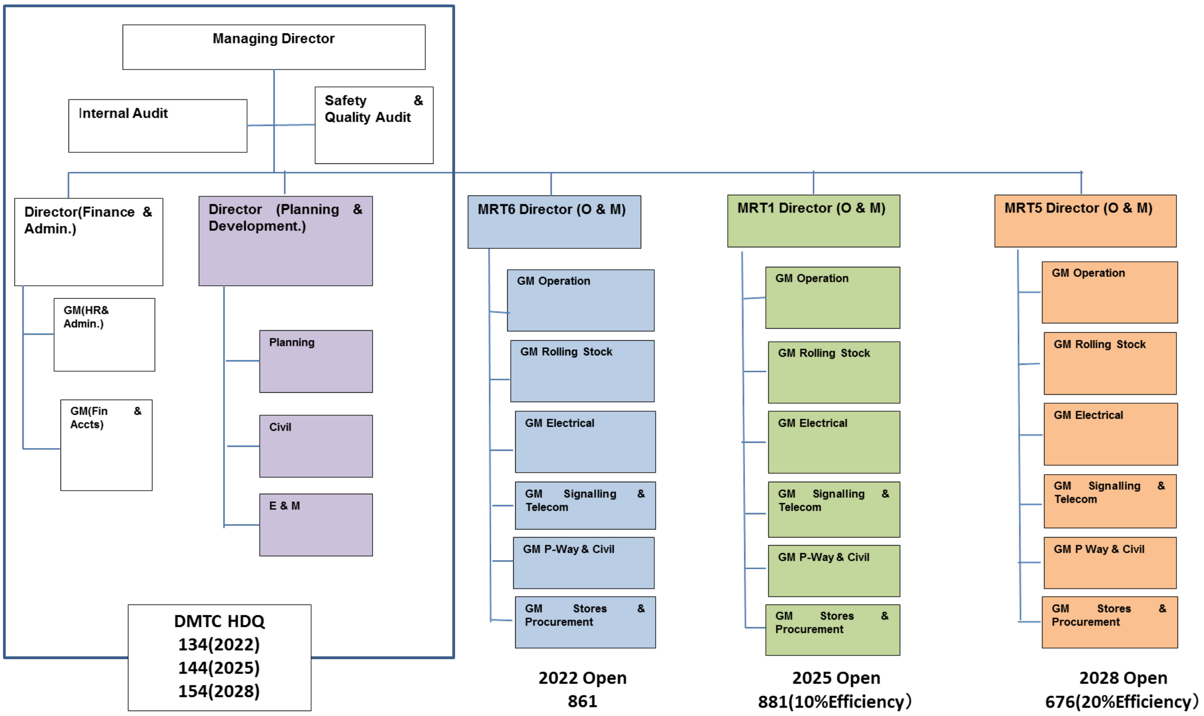
Figure 4.16.1 DMTCL Organization for MRT Line 6

Personnel of MRT Line 6 are considered as follows.

According to the recruitment plan until 2023, HDQs are 170, outsourced personnel are 110, and in total the number will be 280. Operation and Maintenance section for MRT Line 6 will be 861 staff and 824 outsourced personnel, in total 1,685.

Operation and Maintenance organization for MRT Line 1 and Line 5 are considered by DMTCL same as MRT Line 6. HDQs of DMTCL should be strengthened at Planning & Development Dept. and own operation and maintenance section for MRT Line 1 and Line 5 should be established separately.

New DMTCL will be shown in Figure 4.16.2.



Source: JICA Study Team

Figure 4.16.2 New Organization of DMTCL at the operation of MRT Line1 and Line 5

4.16.2 Local Budget of Executing Agency

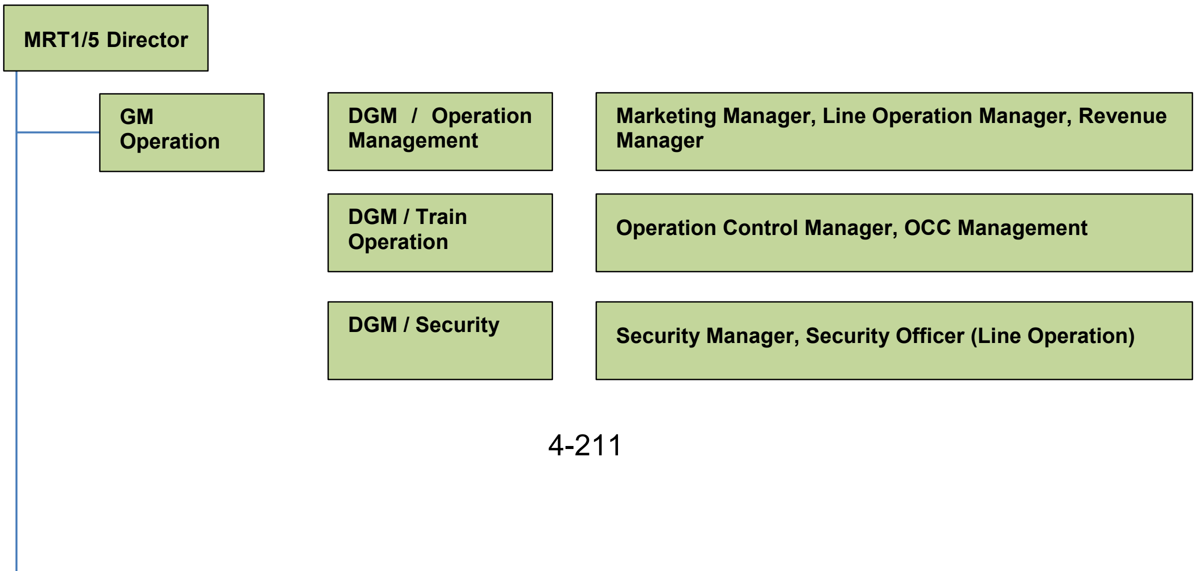
Local Budget for construction of MRT will be covered by Ministry of Finance and Ministry of transport. Local Budget will be transferred from those Ministries to Executing Agency DMTCL.

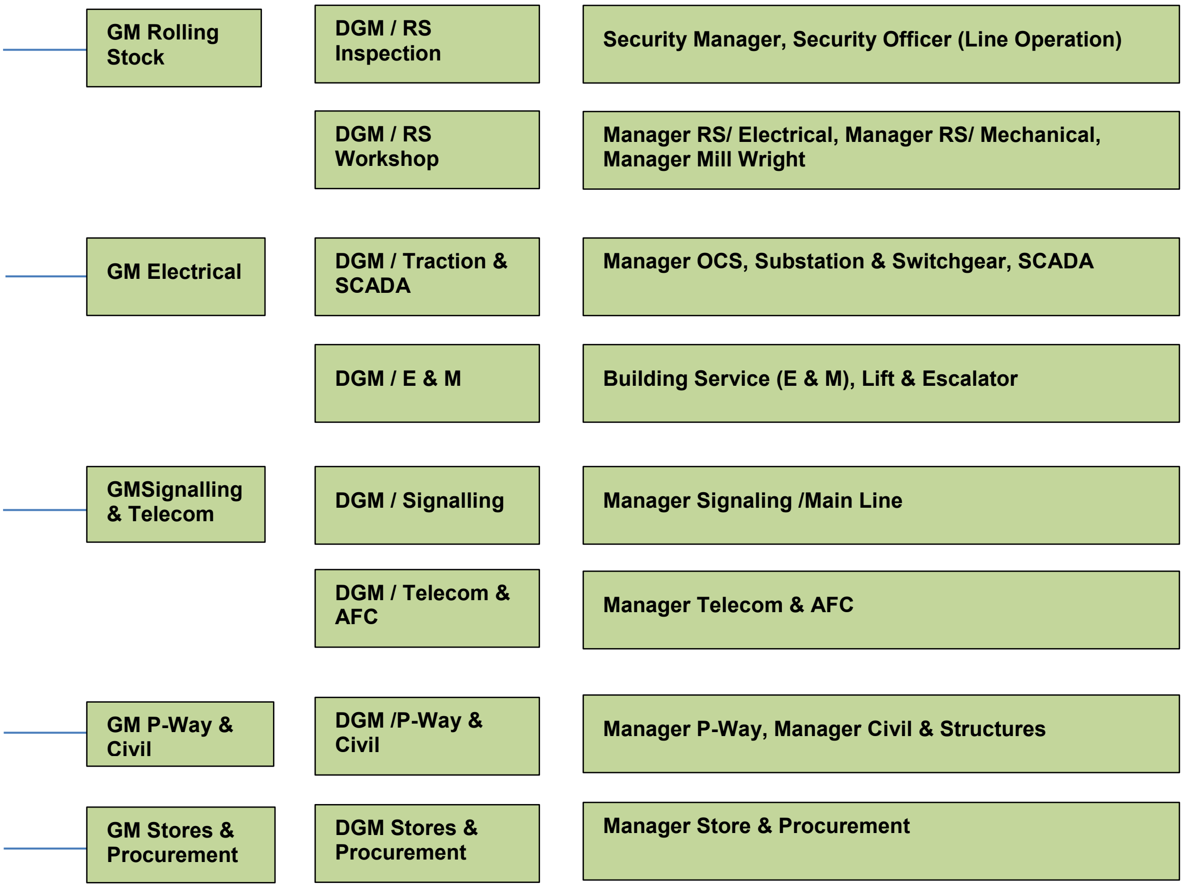
A huge budget is necessary to establish a new government railway operating company which is Dhaka Metro Transport Company Limited (DMTCL). Bangladesh Government would secure enough budgets to recruit necessary staff of DMTCL.

4.16.3 Operation and Maintenance for MRT Line 1, Line 5 and Line 6

Staff of own operation and maintenance section for MRT Line 1 and Line 5 will be employed around 700~800 each.

The Operation and Maintenance section for MRT Line 1 and Line 5 is almost same as MRT Line 6. The function of each Operation and Maintenance department is described as follows.





Source: JICA Study Team

Figure 4.16.3 Operation and Maintenance Section for MRT Line1, Line 5 and Line 6

4.17 Recruitment Plan of DMTCL Staff

The considered management organization for MRT Line 1 and Line 5 is the same as that for Line 6. The opening schedule of MRT Line 6 will be in 2023, MRT Line 1 will be in 2025 and MRT Line 5 will be in 2028. The number of personnel for MRT Line 1 and MRT Line 5 is calculated on the basis of the number of personnel of MRT Line 6.

The staffing of MRT Line 1 and MRT Line 5 is considered by the efficiency rating according to the operating practice and experience of MRT Line 6 in some years. Line 1 is considered to have a 10% rating and Line 5 is considered to have a 20% rating according to the years of experience, and HQ personnel are considered to increase by ten people for planning and accounting sections in each of Line 1 and Line 5.

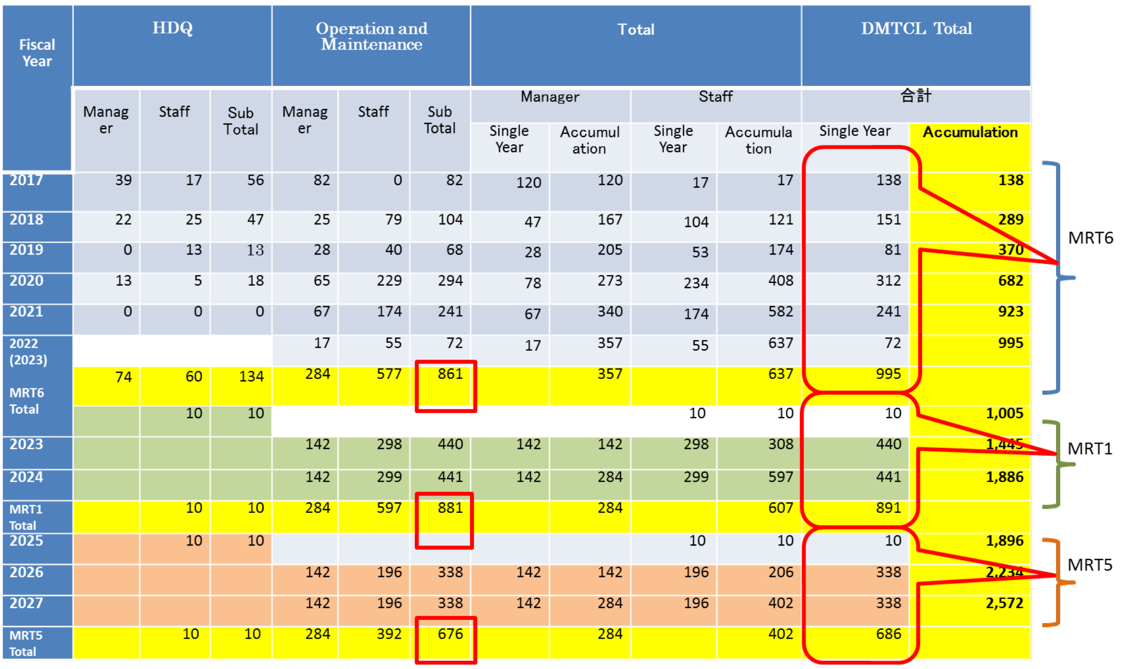
Recruitment Plan for MRT Line 1 and Line 5 is shown in Table 4.17.1. It indicates that staff should be recruited two years before the commencement year and should start training according to the plan. (Note: In Operating and Maintenance section for MRT Line 6, the number of outsourced personnel is 830 broken down as follows: ticketing machine 150, cleaning 280, security 300, car drivers 40 and workers 60.)

Yearly recruitment plan for MRT Line 6, Line 1 and Line 5 is shown in Table 4.17.2.

Table 4.17.1 Calculation of Personnel for MRT Line 1 and Line 5

Department	Sub department	MRT Line 6		MRT Line 1		MRT Line 5	
		Con.	No.	Con.	No.	Con.	No.
Operation	Operation	16 St.	134	19St.	159	14 St.	117
	OCC	1	25	1	25	1	25
	Driver	24 Trains	96	31 Trains	124	30 Trains	120
	Security	16 St.	39	19	34	14 St.	25
Rolling Stock	RS Inspection	24	28	31	36	30	35
	Inspection Shed	24	50	31	65	30	63
	RS Workshop	1	146	1	146	1	146
Electrical	OCS	1	38	1	38	1	38
	Sub Station	16	28	19	33	14	25
	SCADA-OCC	1	20	1	20	1	20
	E&M（Station）	16	89	19	106	14	78
Signal & Telecom	Signal	16	49	19	58	14	43
	Telecom & AFC	16	50	19	59	14	44
P-Way & Civil	P-Way & Depot	1	30	1	30	1	30
	Civil Structure	16	25	19	31	14	22
Total			861		987		845
10% Efficiency					881		760
20% Efficiency					783		676

Table 4.17.2 Yearly Recruitment Plan of DMTCL for MRT Line 6, Line 1 and Line 5



Fiscal Year	HDQ			Operation and Maintenance			Total				DMTCL Total	
							Manager		Staff		合計	
	Manager	Staff	Sub Total	Manager	Staff	Sub Total	Single Year	Accumulation	Single Year	Accumulation	Single Year	Accumulation
2017	39	17	56	82	0	82	120	120	17	17	138	138
2018	22	25	47	25	79	104	47	167	104	121	151	289
2019	0	13	13	28	40	68	28	205	53	174	81	370
2020	13	5	18	65	229	294	78	273	234	408	312	682
2021	0	0	0	67	174	241	67	340	174	582	241	923
2022 (2023)				17	55	72	17	357	55	637	72	995
MRT6 Total	74	60	134	284	577	861		357		637	995	
		10	10						10	10	10	1,005
2023				142	298	440	142	142	298	308	440	1,445
2024				142	299	441	142	284	299	597	441	1,886
MRT1 Total		10	10	284	597	881		284		607	891	
2025		10	10						10	10	10	1,896
2026				142	196	338	142	142	196	206	338	2,234
2027				142	196	338	142	284	196	402	338	2,572
MRT5 Total		10	10	284	392	676		284		402	686	

5 Environmental and Social Considerations

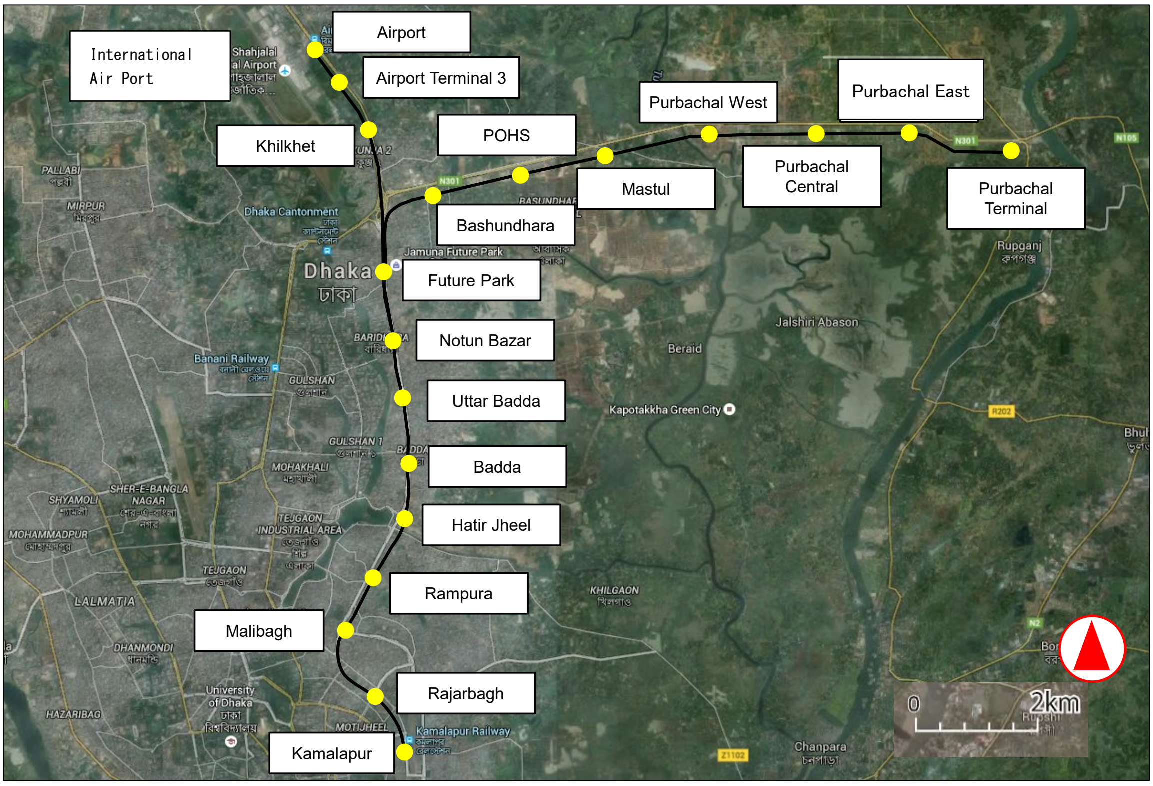
5.1 Project Component which Affects Environmental and Social Considerations

This project is a railway in Dhaka Metropolitan Area (DMA). The objective of the project is to satisfy the traffic demand in DMA, to contribute an economic development, and to mitigate air pollution.

Table 5.1.1 Project Components

Construction of alignment	Viaduct and substructure	Total length: 31.2km (including overlapping section and supplementary track) Length between stations: 17.5km (Underground: Kamalapur Station ~ Airport Station, Future Park Station ~ Bashundhara Station) 10.7km (Viaduct: Bashundhara Station ~ Purbachal Terminal Station)
Construction of stations	Underground structure and viaduct structure including entrance and exit, elevator and ventilation facility	19 stations
Depot	Ground leveling, construction of depot and maintenance facility, and approach	38.993 ha: 25 ha for Depot, 13.993 ha for Construction Yard (South of Purbachal Terminal Station)
Others	Construction yard	Unfixed

Source: JICA study team



Source: JICA study team

Figure 5.1.1 Route of MRT Line 1

Construction works and the existence and operation of the project may cause negative impact on the environment and social matters and would require land acquisition and involuntary resettlement in Right of Way (ROW).

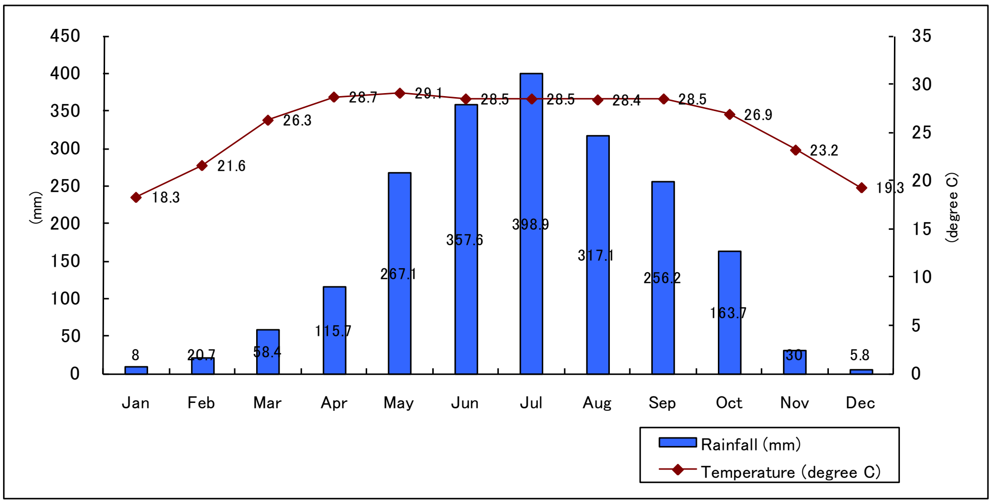
Accompanied with the project. it is expected that the vicinity of stations will be developed. However, since it is due to private developers, as of now, prediction and evaluation of the environment is difficult. Therefore, the evaluation of the development of the surroundings is out of the environmental and social considerations of the project.

As cumulative impacts caused by the project, some traffic projects planned in Dhaka may cause negative impacts. The cumulative impacts are examined on 6.6.2. Operation of borrow pits, quarry sites and construction yards have potential negative impacts, however as of now the location of the facilities are unfixed. Therefore the mitigation policies of negative impacts are examined in this study.

5.2 Environmental and Social Baseline

5.2.1 Location and Climate

The climate of Dhaka is categorised as tropical monsoon of Keppen climate classification. The annual average temperature is 25 degrees Celsius; the annual precipitation is approximately 2,000mm. Seasons are divided to hot and rainy season (May to October), cool and dry season (November to February), and hot and dry season (March to April). Eighty percent of the annual precipitation is observed during May to September (see Figure 5.2.1). Because water levels of rivers rise in the rainy season, high intensity rain often causes inundation in Dhaka city.



Source: http://www.worldclimate.com/

Figure 5.2.1 Monthly average precipitation and temperature

5.2.2 Topography and Geology

RAJUK area including the project area is formed with an alluvial plain including highland swamp, lowland and natural bank. Swamp and wetland distribute in urban Dhaka and the vicinity.

Low lying swamps and marshes located in and around the city are other major topographic features. The elevation of DCC area varies from 2 to 13 m above the mean sea level. Most of the developed areas in RAJUK area are at an elevation of 6 to 8 meters above the mean sea level.

Part of the RAJUK area is covered by Pleistocene Madhupur Clay and Holocene sediments of the Ganges- Brahmaputra floodplain. The Madhupur Clay is situated in north-west part and lies elongated from the middle of the north to south of the project area and these are oxidized Pleistocene sediments. In the east, south and western half of the

RAJUK area are covered by the Ganges-Brahmaputra floodplain sediments.

Regarding the seismology, the National Seismic Zoning Map (Geological Survey of Bangladesh (GSB)) divides the country into three regions (see Figure 5.2.2). The city of Dhaka falls within the medium-risk zone (zone 2). In the medium risk zone, shocks of moderate intensity are possible, with a probable maximum magnitude of 6-7 on the Richter scale.

Source: Ministry of Power, Energy & Mineral Resources Division

Figure 5.2.2 National Seismic Zoning Map of Bangladesh

5.2.3 Hydrology

1) Hydrology in/around Dhaka city

Dhaka is surrounded with tributary rivers of three major rivers (Ganges River, Brahmaputra River and Meghna River). The water levels of rivers around of Dhaka city are linked to those of the major rivers, and rise up to 5.0~6.0m during rainy seasons, 1.0~2.0m during dry seasons.

2) Current condition of groundwater in Dhaka city

The groundwater extraction from groundwater table is an important water source in Dhaka city. Since most of the water resource in Dhaka depends on the extraction of groundwater, this extraction causes a drop of groundwater level. In addition, developments such as roads, buildings and embankment by rapid expansion of urban area are hampering groundwater cultivation from rainfall and rivers[1]. Water network formed by lakes, canals and small rivers have not only function of urban drainage against flood but also cultivation of underground water. However, recent disordered developments had these water bodies dropped sharply, and caused to deteriorate the function of groundwater cultivation.

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[1] Dhaka Structure Plan 2016-2035 (draft) 11.3.4 Ground Water Depletion

3) Depletion of groundwater in Dhaka city

In Dhaka city, groundwater is pumped up from approximately 100m to 300m below the ground level. The level of the groundwater tends to decline year by year. In future, a lot of well may become to be unable to use, and cost of water supply may raise.

5.2.4 Wetland characteristics

1) Function of wetland

The wetland distributed on the low land around Dhaka city plays important roles of control and environment protection.

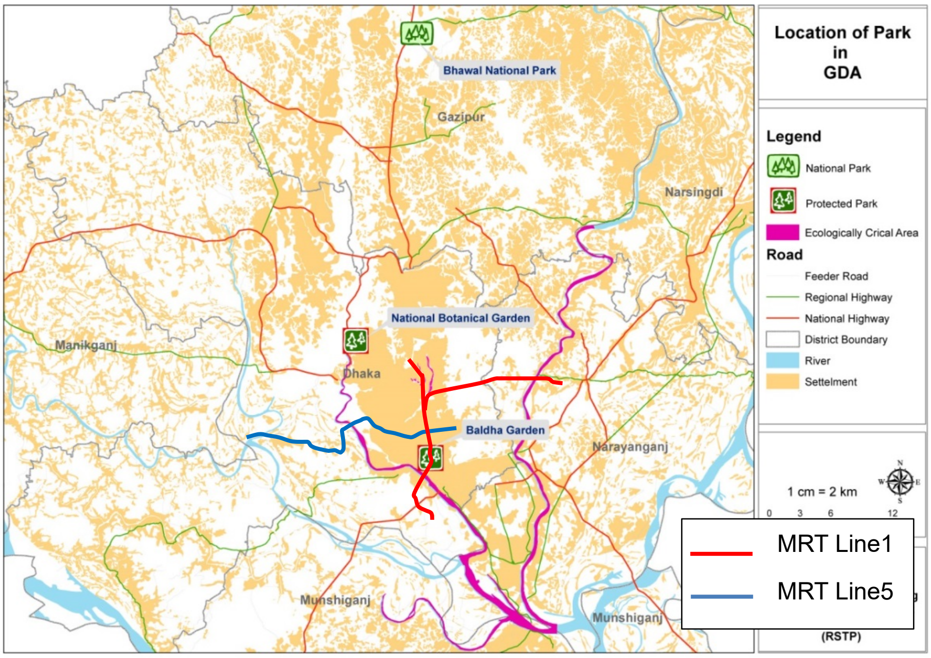
(a) Water retention for flood water
(b) Drainage of rain water from urban district
(c) Recharge of groundwater
(d) Preservation of ecological system and biodiversity
(e) Contribution to local economy: it is utilized as fertile rice paddies in dry seasons, or fishing ground in rainy seasons.
(f) Field of recreation activities

2) Wetland loss

In 1960, the area of the open water body was about 2,952 ha, which became about 1,991 ha in the year 2008. The amount of the open water body reduction is 961 ha. From 2005 to 2011 in just six years, the wetlands adjacent to Dhaka shrank from 5.85 km2 to 3.95 km2 when local water bodies and lowlands were converted to commercial, industrial and residential zones. If the current trend continues, experts said, by the year 2037 all wetland of Dhaka will disappear, posing a serious threat to the city's existence.

5.2.5 Natural park, sanctuaries and other conservation sites

Based on Bangladesh Wildlife Preservation Order 1973, Protected Areas (PAs) is classified into national parks, wildlife sanctuaries, game reserves and private game reserves. The protected areas in GDA are shown on Figure 5.2.3. In GDA, there is Bhawal National Park which is the only national park in GDA. In/around the project sites, there is no protected area such as natural park, sanctuary and conservation site. National Botanical Garden and Baldha Garden is botanical gardens which are located on over 2km from the project sites.



Source: The Project on the Revision and Updating of the Strategic Transport Plan for Dhaka, 2nd Draft Final Report, February 2016, JICA

Figure 5.2.3 Natural Preservation Areas in GDA

5.2.6 Environmentally critical area

The 1995 Bangladesh Environment Conservation Act includes provision for Ecologically Critical Area (ECA) declarations by the director general of the Department of the Environment in certain cases where the ecosystem is considered to be in danger of reaching a critical state. ECA is an area that “has been already quite polluted, and should prevent more pollution”, and does not prohibit development. Wild reserves and cultural heritage reserves are designated under Bangladesh Wildlife Preservation Order and Forest Act. In ECA, GOB restricts activities and process of manufacture in the view of preventing deterioration of the environment. In RAJUK, there are five ECA including one lake (Gulshan Banani-Baridhara Lake) and four rivers (Buriganga, Turag, Balu and Shitalakshya). (see Figure 5.2.3) MRT Line1 crosses Balu river by viaduct structure.

5.2.7 Ecosystem

1) Ecosystem

The ecosystem of Bangladesh is categorized territorial ecosystem and aquatic ecosystem. The territorial ecosystem includes forest and hill ecosystems, agro-ecosystem and homestead ecosystem; while seasonal and perennial wetlands, rivers, lakes, coastal mangroves, coastal mudflats and chars, and marine ecosystem fall into the aquatic category. In RAJUK area, there are Moist Deciduous Forest (Sal Forest ecosystem), Agro-ecosystem and Homestead ecosystem.

In the project sites which are urbanized, the only Agro-ecosystem, Homestead ecosystem and wetland ecosystem are still existed in Purbachal area of Line1.

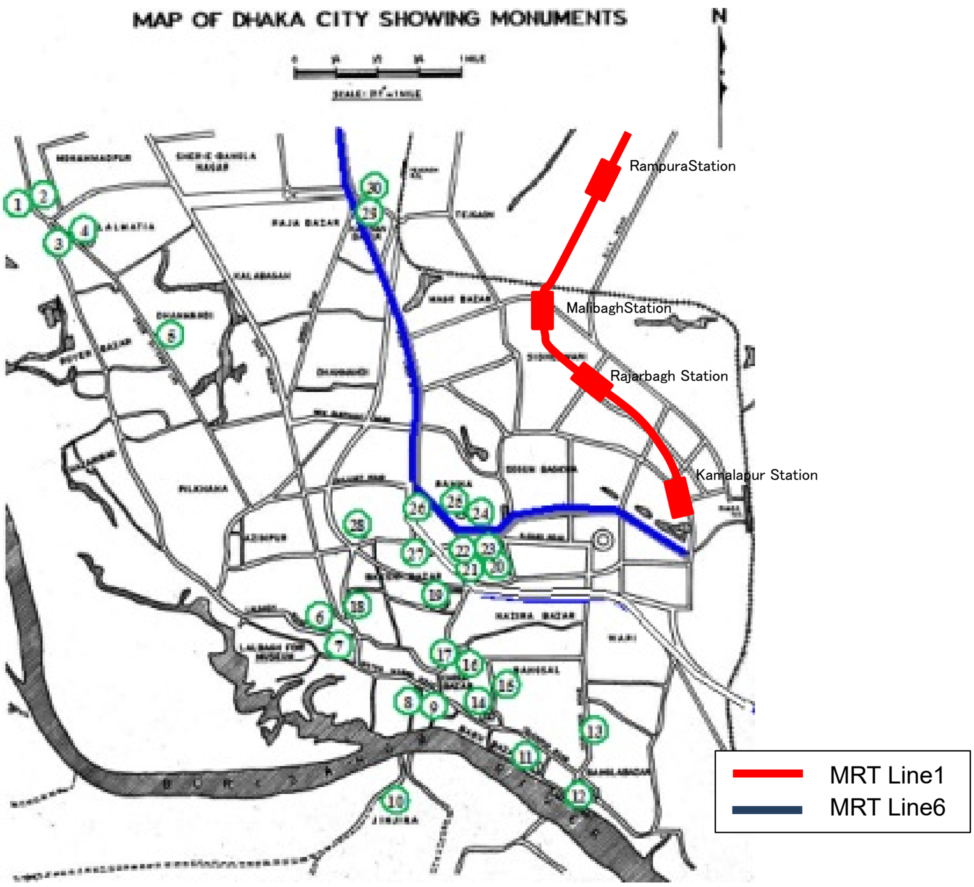
2) Endangered species

Bangladesh possesses extremely various species. As of July 2014, International Union for Conservation of Nature designates 106 animal species and 16 plant species as Critically Endangered(CR), Endangered(EN) and Vulnerable(VU).

5.2.8 Cultural Heritage

In RAJUK area, seventy four archaeological heritages including the followings are preserved. Major archaeological heritages in Dhaka city are shown below.

1. Sat Gumbad Mosque
2. Unknown Tomb near Sat Gumbad Mosque
3. Alakuris Mosque
4. Dara Begum's Tomb
5. Old Eidgah
6. Khan Muhammad Mridha Mosque
7. Lalbagh Fort
8. Bara Katra
9. Chhoto Katra
10. Kadamtali Circle
11. Ahsan Manzil
12. Northbrook Hall
13. St. Mary's Cathedral
14. The American Church
15. Sitara Mosque
16. Baoli
17. Kartalab Khan Mosque
18. Dhakeswari Temple
19. Hussaini Dalan
20. Fazlul Huq Hall
21. Curzon Hall
22. Dhaka City Corporation
23. Musa Khan Mosque
24. Greek Memorial
25. Tomb and Mosques of Haji Khawaja Shahbaz
26. Salimullah Hall
27. Dara Begum's Tomb
28. BUET
29. Khwaja Ambar Mosque
30. St. Augustin Church



Source: Department of Archaeology、Bangladesh

Figure 5.2.4 Archaeological Heritage in Dhaka city

Since the archaeological heritages concentrate on the south of the city, it seems that there are no heritages affected directly in/along the project. In this survey, cultural heritage in/around the project site is confirmed.

5.2.9 Pollution Control

1) Air Pollution

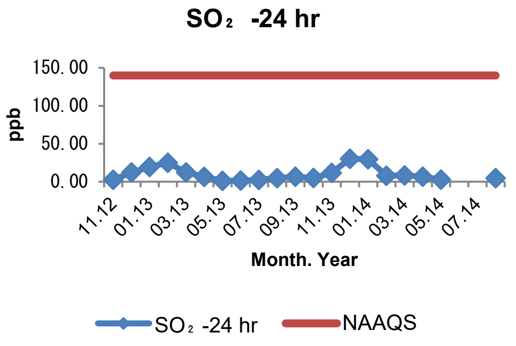
Deterioration of the air quality is one of the major environmental issues in Dhaka. Major pollutants are NOx, SO2, PM, PM10 PM2.5 CO, O3 and Lead. Major origins of air pollutants are vehicles and traditional brick manufacturers. A lot of the brick manufactures around Dhaka city operates during dry season (November to April). The emissions including SO2, NOx and organic hydrogen worsen the air quality. Table 5.2.1 shows National Ambient Air Quality Standards (NAAQ) in Bangladesh with WHO Guidelines.

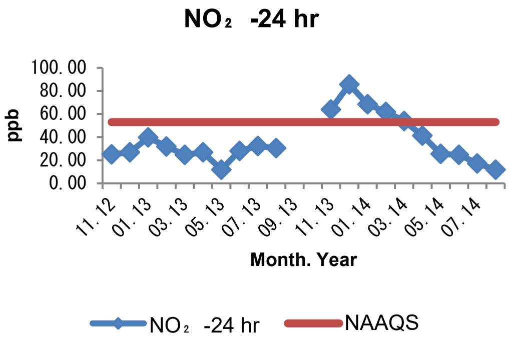
Table 5.2.1 National Ambient Air Quality Standards (NAAQ) in Bangladesh

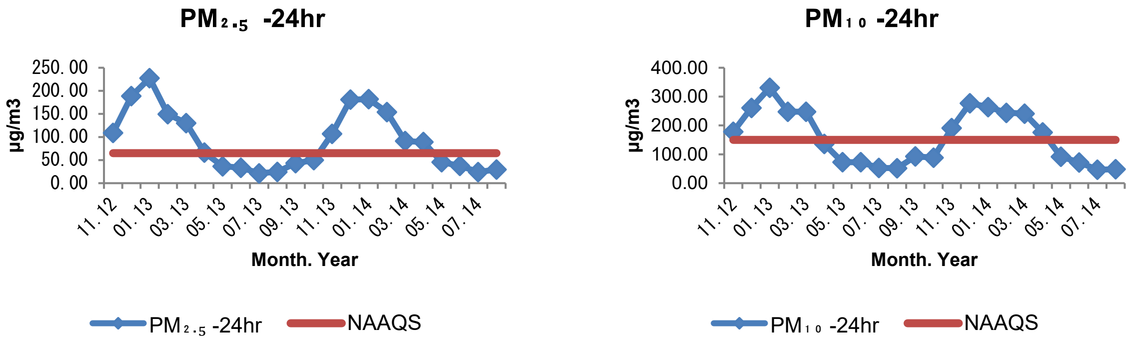
Air Pllutants	Unit	Measurement Time	Standards	WHO Guidelines
CO	mg/m^3	8 hours(a)	10 (9 ppm)	10
	mg/m^3	1 hour(a)	40 (35 ppm)	30
Pb	μg/m^3	Annual	0.5	0.5
NO$_x$	μg/m^3	Annual	100 (0.053 ppm)	40 (as NO$_2$)
PM$_{10}$	μg/m^3	Annual (b)	50	20
	μg/m^3	24 hours (c)	150	50
PM$_{2.5}$	μg/m^3	Annual	15	10
	μg/m^3	24 hours	65	25
O$_3$	μg/m^3	1 hour (d)	235 (0.12 ppm)	-
	μg/m^3	8 hours	157 (0.08 ppm)	100
SO$_2$	μg/m^3	Annual	80 (0.03 ppm)	-
	μg/m^3	24 hours (a)	365 (0.14 ppm)	20

Source: Statutory Rules and Order No. 220、 GOB (2005); Air Quality Guidelines for Europe、 2nd ed.、 WHO (2005);.and Air Quality Guidelines for Particulate Matter、 Ozone、 Nitrogen Dioxide and Sulfur Dioxide、 WHO (2006).

Figure 5.2.5 shows concentrations of the air pollutants on the vicinity of the project site by Clean Air and Sustainable Environment Project. The concentrations of the air pollutants change seasonally. The concentration rises during the dry season (December to February) and declines during the rainy season (May to September). Particularly the concentration of PM is high.







Source: The Project on the Revision and Updating of the Strategic Transport Plan for Dhaka, 2nd Draft Final Report, February 2016, JICA

Figure 5.2.5 Concentrations of Air Pollutants measured on November 2012 to August 2014（Darus-Salam）

2) Noise

Noise level is high in Dhaka city. This is a major issue for citizens. In most area of the city noise level exceeds standards. Table 5.2.2 shows the noise standard of Bangladesh and WHO Guidelines.

Table 5.2.2 Noise Standard of Bangladesh and WHO Guidelines

Category of Area	Noise Standard of Bangladesh *1 (LAeq: dBA)		Guidelines of Community Noise (WHO, 1999)	
	Daytime (6:00-21:00)	Night (21:00-6:00)	Daytime (7:00-22:00)	Night (22:00-2:00)
Silent zone	45	35	-	-
Residential area	50	40	55	45
Mixed area	60	50	-	-
Commercial area	70	60	70	70
Industrial area	75	70	70	70

Source: Study Team

Note: 1)noise standards of ECR, 1997

Table 5.2.3 shows noise levels which were measured around the project site. Totally the noise levels are high. Particularly in areas except residential area high noise exceeding 80dB(A) were observed. The high noise is originated by horn of vehicles, demonstration parade and audio player.

Table 5.2.3 Noise Levels around the Project Site

Locations		Noise Level (dBA)
Sayedabad Bus Terminal	South of Kamalapur Station	106
Mowchak	Vicinity of Future Park Station	103
Gulistan	South west of Kamalapur Station	90
Sapla Chattar Motijheel	West of Kamalapur Station	89

Source: Dey, A. R., N. Kabir and D. Efroymson, 2010, Noise Pollution in Dhaka: Current Situation and Suggestions for Action.

3) Water Quality

There are lots of rivers, canals and wetlands which contribute formation of water environment. On the other hand, recent rapid increase of population makes water pollution severe. Table 5.2.4 shows results of water quality survey around the project area and standards of water quality of Bangladesh. No.2 and No.3 which are small river and drainage in urban area are highly polluted.

Table 5.2.4 Results of water quality survey around the project site (2010)

No.	Location	Date	pH	Dissolved Oxygen (DO) ppm	Chemical Oxygen Demand (COD) ppm	Total Suspended Solid (TSS) g/l	Total Coliform number/100ml
1	Pond in Northern Pallabi	2 Oct.	7.5	5.8	45.6	288	500,000
2	Mirpur Khal	2 Oct.	7.3	0.6	164.0	636.4	500,000
3	Begunbari Drain	2 Oct.	7.6	1.4	141.6	502.1	1,100,000
1	Pond in Northern Pallabi	12 Dec.	7.6	7.2	64	149	1,000
2	Mirpur Khal	12 Dec.	7.7	Under DL*	480	392	910,000
3	Begunbari Drain	12 Dec.	7.7	Under DL*	448	367	960,000
Bangladesh Standard for Inland Surface Water Quality (Water usable by various process)			6.5-8.5	5 or more	Not yet set	Not yet set	5,000 or less

*: Detection Limit

Source: Preparatory Survey on Dhaka Urban Transport Network Development Project – Phase II

4) Ground Water

Bangladesh had used surface water including lake and river and drinking water. However, because water pollution created difficulty to utilize, utilization of groundwater has been developed since 1970. Meanwhile, arsenic pollution for groundwater has become a serial problem since 1990. A cause of the pollution still has not been clear. Now 270 districts are arsenic contaminated areas. Approximately 30 million persons has been affected by arsenic contaminated water.

GOB has taken emergency measures for arsenic mitigation, and adopted National Policy for Arsenic Mitigation and the implementation plan in 2004. However, since alternative water sources are limited safety supply of drinking water is still significant issues. There are lot of unresolved issues including care for arsenic poisoning and negative impacts to foods.

There are no standards of underground water quality in Bangladesh.

5.2.10 Basic Information on Social Economy

1) Population and Social Economy

Though issues are arisen due to so many population in Bangladesh (according to the World Development Index of World Bank it is reported that the census shows 142.5 million in 2011 and expected to increase 156.6 million in 2015), the country is persisting a development which aims at building a prosperity and pluralistic society. According to WB, though the income per capita is 1,096 UDS (actual achievement in 2014), however, annual economic growth rate is more than 6% in a past decade and Gross Domestic Product (GDP) has achieved 195.1 billion USD (reported by WB in 2015). Considering it was 65.1 billion USD in 2004, it has rapidly grown up four times in a decade.

The prime of economic development is export industry. Specially, export of texture is ranked second, subsequently to China. The break down presents 21.6 billion USD owed to the production of knitwear and ready-made clothes which occupies 80% of total export amount. Other industries are pharmaceutical, shipbuilding, chinaware, leather goods and home electric appliances. In addition, Bangladesh has extremely fertile soil in terms of the primary industry, and rice, jute, tea, cotton and sugar cane are cultivated as cash crop. The fishery and marine products is ranked fifth in the world. Last, overseas remittances by migrant workers are brought up 14 billion USD (actual achievement in 2014). Economic share by sectors are agriculture: 16%, industry: 28% and services: 56% (WB's report in 2013), respectively.

The GDA which includes target area of the Study is the most developed area and its Gross Regional Domestic Product (GRDP) is approximately 25% of GDP. From sector point of view, the weight of agriculture is decreasing however industry is increasing. Furthermore, from census point of view, population in GDA is 23,459,577 which occupy 16.29% of Bangladesh.

Table 5.2.5 District Based Population and Area

District	Area （km^2）	Population		Annual Average growth rate
		2001	2011	
Dhaka	1,463.6	9,036,647	12,043,977	2.91%
Gazipur	1,806.4	2,143,200	3,403,912	4.73%
Mnikganj	1,383.7	1,343,749	1,392,867	0.35%
Mushiganj	1,004.3	1,353,483	1,445,660	0.66%
Narayanganj	684.4	2,300,514	2,948,217	2.51%
Narsingdi	1,150.1	1,983,449	2,224,944	1.15%
Total	7,492.5	18,161,042	23,459,577	2.59%

Source: Census（2011）、Area:STATISTICAL YEAR BOOK BANGLADESH 2015

As described above, in GDA it is assumed that the population is 23.48 million in 2011 will increase 32.59 million in 2025. Rapid increase makes Dhaka disordered and high-density city which is one of the fragile against disaster due to low quality buildings. In addition, influx from rural district to urban area is in progress which increase low income (6,000 taka per year) group, expansion of slum area, traffic congestion, insufficient power supply and expansion of environmental pollution.

The present urban transport significantly depends on traffic transport. Traffic volume exceeds its capacity and severe traffic congestion arises because the various kinds of transportation system are running together such as, automobile, bus, rickshaw etc. Accordingly, many problems such as, increase of trip hour, deterioration of transport efficiency, increase of traffic accidents, increase of fuel consumption and public nuisance by air pollution/health hazard are arisen.

Poverty rate shows those who are living under poverty line against whole population. According to Bangladesh Bureau of Statistic in 2011, poverty rate was 31.5% which consist of 35.2% in rural district and 21.3% in urban. On the other hand, poverty rate in 2005 was 40.0% which consist of 43.8% in rural district and 28.4% in urban. That is to say between 2005 and 2015, poverty rate decreased 8.5% in Bangladesh which consist of 8.6% in rural and 7.1% in urban. Considering the poverty rate was 56.7% between 1991 to 1992, it decreased 25.2% in the past decade.

Table 5.2.6 GRDA in GDA

	Nominal GRDP (million USD)						Average Annual Growth Rate	
	1995		1999		2005		1995-1999	1999-2005
	million USD	Percent (%)	million USD	Percent (%)	million USD	Percent (%)	AAGR (%)	AAGR (%)
Bangladesh	39,065	100.0	45,447	100.0	59,748	100.0	3.1	5.6
GDA	9,206	23.6	10,762	23.7	15,004	25.1	3.2	6.9
Dhaka	5,714	14.6	6,742	14.8	9,497	15.9	3.4	7.1

Gazipur	1,132	2.9	1,309	2.9	1,850	3.1	2.9	7.2
Manikganji	342	0.9	401	0.9	503	0.8	3.2	4.6
Munshiganji	325	0.8	372	0.8	465	0.8	2.7	4.6
Narayanganji	1,097	2.8	1,246	2.7	1,751	2.9	2.6	7.0
Narsinghdi	596	1.5	692	1.5	938	1.6	3.0	6.3

Source: Growth, Income Inequality and Poverty Trends in Bangladesh: Implications for Development

Strategy by Center for Policy Dialogue (CPD)

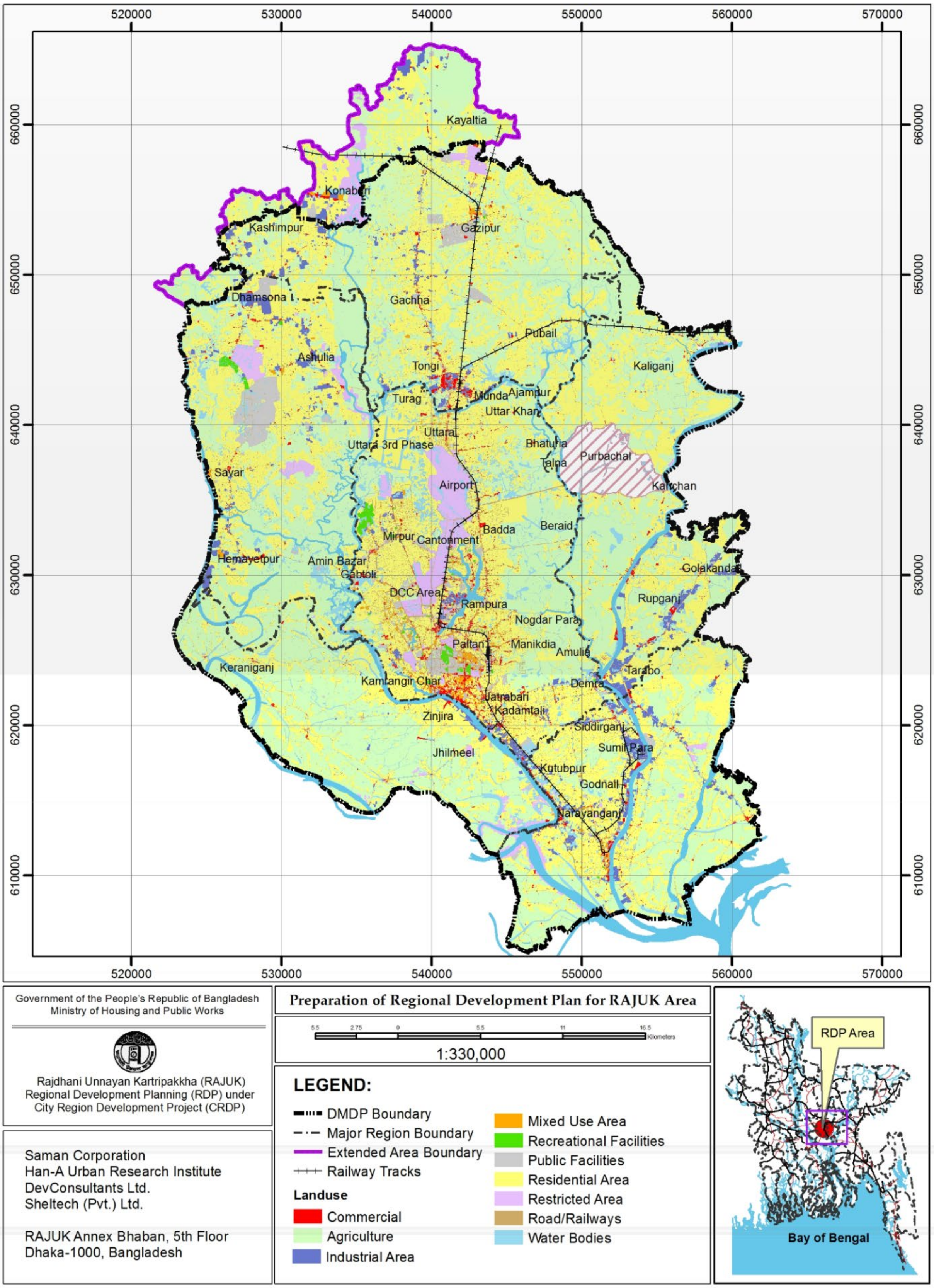
According to Rushidan I. Rahman and Rizwanul Islam (2013), Female labour force participation in Bangladesh: trends, drivers and barriers, ILO Asia-Pacific Working Paper Series, thanks to the economic development female participation rate in urban was 20.5% in 1995/96, then increased 27.4% in 2005/06 and 34.5% in 2010/11. Female participation rate in Dhaka was 36.4% in 2010/11. In this country, there had been a custom called Purda which requires female group “to stay within home and do not go to work outside home”, however, because of increase of female participation and extension of educational opportunity, this custom has changed in urban especially, and liberalization of movement of female is expected to increase more in future.

The detail on female participation will be studied at project area, however, according to the site reconnaissance and opinion by executing agency, the trend will basically be same as in whole country.

2) Land-use

In the jurisdiction of RAJUK, the land-use has changed related to the progress of urbanization of Dhaka. Especially, the 209,969 hectare of water body in 1967 decreased 5,520 hectare, approximately one fourth of year 2010. These conversions were happened due to the absence of land-use management, incomplete urban planning which cause the expansion of urban poor and flood disaster. Same urbanization is extending to the north: Savar Ashulia and Uttra, specifically.

RAJUK is divided in Dhaka Central, North, East, West, South and South-West areas and out of 152,000 hectare North occupy 23%, Dhaka Central occupy 20% and West occupy 17%. From land-use point of view, agricultural land is 40% and extended to North and West. Residential land is second rank which occupy 37% and extended to Dhaka central and North. Commercial land and mixed land-use have same tendency like residential land. On the other hand, many Industry lands are situated in North and South. The land-use map under jurisdiction of RAJUK is attached in Figure 5.2.6.



Source: Regional Development Planning (RDP) Survey Report (RAJUK, 2014)

Figure 5.2.6 Land-use Map Prepared by RAJUK

3) Assumed Land Acquisition and Resettlement

Land acquisition and Resettlement on MRT Line 1 is assumed in Table 5.2.7.

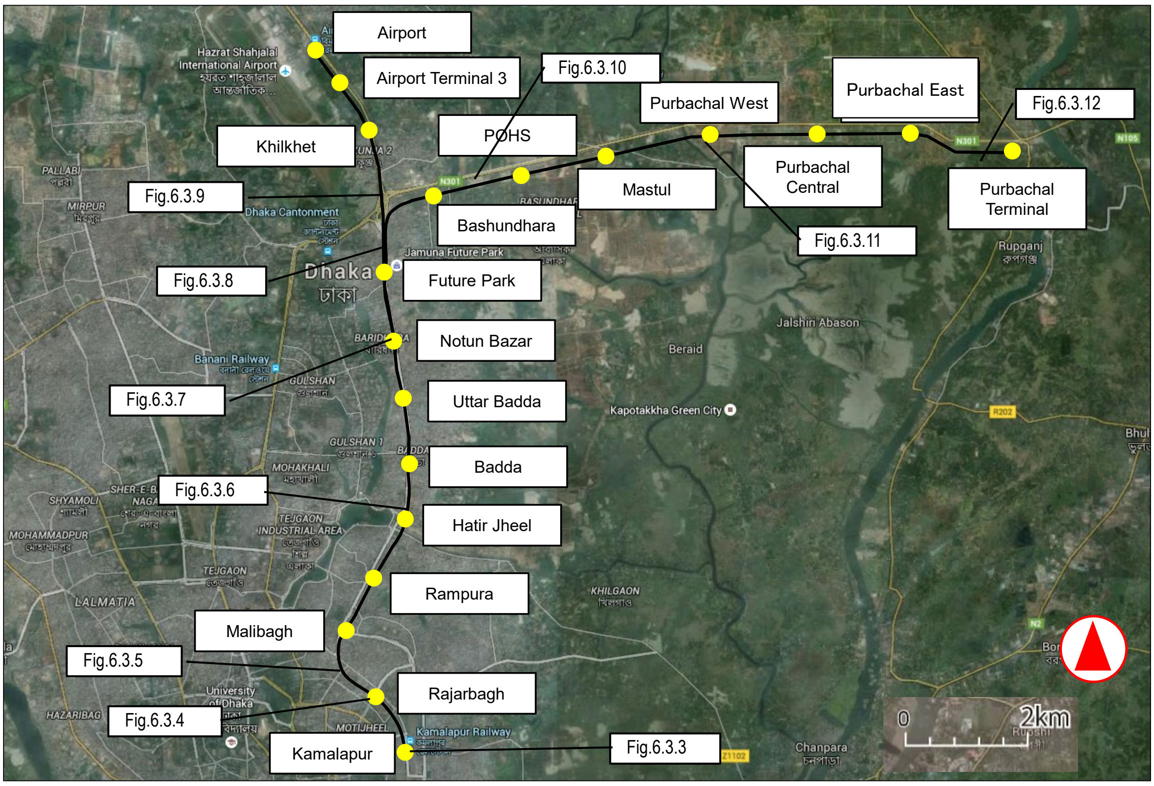
Table 5.2.7 Assumed Land Acquisition and Resettlement

MRT	Elevated・Tunnel Section	Station	Depot	Access to Depot	Construction Yard
Line 1	Elevated section : Structure of metro will be built within the ROW which belong to Road and Highway Department (RHD). Therefore, further land acquisition will not be required. However, for the construction of exit, entrance and ventilation duct etc. some extent of private land acquisition will be required.	Land acquisition on private land and resettlement related to the station construction are assumed as follows. Land acquisition: 0.23 hectare Resettlement: 421 households	Presently it is a land for private (tentatively) use. Assumed land acquisition and resettlement are; Land acquisition: 38.003 hectare Resettlement: 698 households	Assumed Land acquisition: Included in Depot Resettlement: Included in Depot	Review on proposed site and size are on-going.

Source: JICA Study Team

5.2.11 Environmental Conditions of the Project Site

MRT Line1 connects south north corridor and east in Dhaka. The line goes within ROW of existing roads between Rajarbagh – Malibagh, and Future Oark – Bashundhara, and out of ROW except those sections. There is no facility which is source of pollution such as factories within the ROW.



Source: JICA Study Team

Figure 5.2.7 Route of MRT Line1

Kamalapur Station (see Figure 5.2.8) which is located at south point is close to Kamalapur Station of Bangladesh National Railway. The alignment goes under Outer Circular Road from here to Rajarbagh Station. (See Figure 5.2.9) Medium-rise housings, government facilities and commercial facilities (shops) stand along the alignment.

Source: JICA Study Team

Figure 5.2.8 Surroundings of Kamalapur Station

Source: JICA Study Team

Figure 5.2.9 Surroundings of Rajarbag Station

The area between Rajarbagh Station and Rampura Station where medium high rise commercial buildings are standing is much crowded. This section will require underground structure because viaduct road is being developed. (Figure 5.2.10)

The area from here to Future Park is mixed area of medium high rise offices, commercial buildings and houses. Major intersections on the alignment such as Notun Bazar (Figure 5.2.12) congest. The Line1 crosses and connects with the Line 5 at Notun Bazar Station(Figure 5.2.12).

Source: JICA Study Team

Figure 5.2.10 Surroundings of Rajarbagh Station – Malibagh Station

Source: JICA Study Team

Figure 5.2.11 Surroundings of Hatirjheel Station

Source: JICA Study Team

Figure 5.2.12 Surroundings of Notun Bazar Station

Source: JICA Study Team

Figure 5.2.13 Surroundings of Future Park Station

The alignment from Future Park station (Figure 5.2.13) diverges airport and east (Purbachal area). Interchange road called Kuril Flyover is developed around the divergence(Figure 5.2.14). The Line1 requires underground structure or high-rise structure which exceeds the existing structure.

The alignment goes through Purbachal Express Highway which has vast ROW, and reaches Purbachal Terminal Station at east end point. Medium and high rise building is being developed from Future Park Station and Bashundhara Station (see Figure 5.2.15).

Source: JICA Study Team

Figure 5.2.14 Surroundings of Kuril Station

Source: JICA Study Team

Figure 5.2.15 Surroundings of Bashundhara Station

The vicinity of the alignment to Purbachal Terminal Station consists of swamp, forest and agricultural area. On the other hand, the area is being developed. (Figure 5.2.16) Depot site is planned in the south of Purbachal Terminal Station. Here is vacant, agricultural and developed land. (See Figure 5.2.17)

Source: JICA Study Team

Figure 5.2.16 Developing Purbachal Area

Source: JICA Study Team

Figure 5.2.17 Surroundings of Depot Site of Line1

5.3 Legal and Institutional Framework Regarding Environmental Consideration

5.3.1 Legal Framework

1) Relevant Laws on Environmental Protection

Table 5.3.1 shows major environmental laws and legislations of Bangladesh.

Table 5.3.1 Relevant Laws on the Environment

Law, Policy	Outlines
Environmental Policy 1992	Basic policy of the environment in Bangladesh. The policy is formed by environmental policy, legal framework in 15 sectors. This policy shows a basis of EIA implementation.
Environmental Action Plan	It was established in 1992. The plan shows a tangible action plan of Environmental Policy 1992, and designates relevant agencies. The publication of white paper on the environment is stipulated on this plan.
National Environment Management Action Plan	It was established in assistance with UNEP in 1995. Purposes of the plan are: understanding of important environmental issues relevant to Bangladesh, mitigation of environmental deterioration, protection of biodiversity, promotion of sustainable development and action of improving life quality. Not only government agencies NPO and residents proceeded the formulation of the plan.
Bangladesh Environment Conservation Act	It was established by Ministry of Environment and Forests in 1995 as substitute of Environment Preservation Act. The act covers fundamental domains of environmental preservation.
The Environmental Conservation Rules	The rule stipulates the environmental standards including air quality, water quality, industrial waste water, exhaust gas, noise and odor. Submission of project plan, EIA, and environmental management plan is stipulated in the rule.
Environmental Court Law	It was established in 2000. The law stipulates a legal procedure on pollution.

Source: METI, MRI (2012)

2) Policy on Climate Change

Bangladesh is one of vulnerable areas on flood. Rise of sea level caused by climate change becomes factor that expands flood damage. Moreover, the increase of drought and cyclone may become significant issues on social and economic activities in Bangladesh.

Bangladesh is a party of United Nations Framework Convention on Climate Change (UNFCC). Under the framework of UNFCC, Bangladesh formulated Bangladesh Climate Change Strategy and Action Plan. The action plan which consists of 6 items builds adaptation and durability against climate change aiming action during 10 years (2009-2018).

- Security of food, social security and health control
- Comprehensive disaster control
- Fundamental facility management
- Study relevant to climate change, and improvement of knowledge
- Mitigation of GHG emission, and low carbon development
- Capacity building, expansion of relevant facilities

As tackling reduction of greenhouse gasses, GOB signed Joint Crediting Mechanism (JCM) which is a promoting mechanism of low carbon technique by Japan in 2013. Under the mechanism, Bangladesh is introducing energy saving and technique and renewable energy technique of Japan.

In Intended Nationally Determined Contributions, GOB is aiming to 20% reduction of GHG emission of energy, traffic and industrial sectors by 2030. Since the MRT Line1 and Line5 projects will reduce the emission of GHG by modal shift from vehicles to railway, the projects contribute the policy of climate change of Bangladesh.

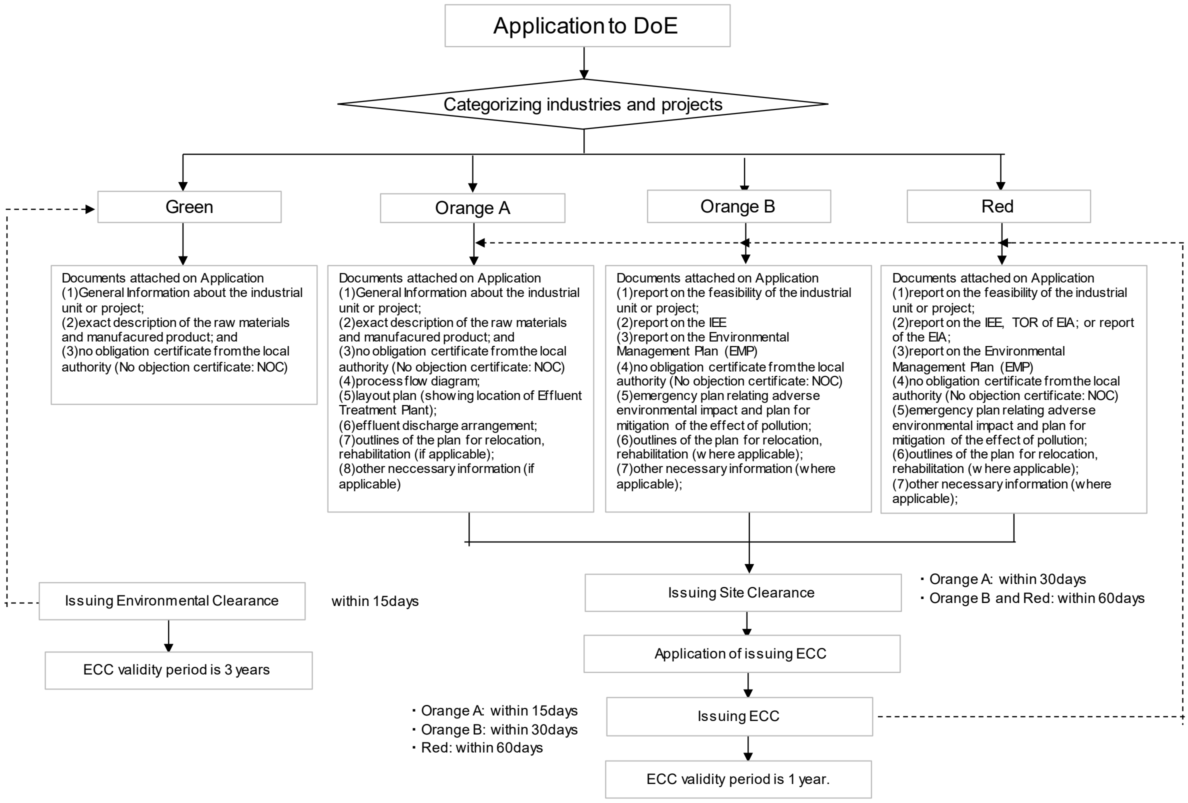
5.3.2 Institution of EIA

Bangladesh stipulates EIA system on the Environmental Conservation Act (ECA: 1995) and Environmental Conservation Rules (ECR: 1997). GOB has promoted a lot of industrial policy to solve poverty and employment issues. However, developments without an environmental consideration caused deterioration of the environment. Under this lesson, the said legislations were established for the purpose of environmental conservation.

5.3.3 EIA Procedure

Implementation of whole industries and projects needs ECC issued by DoE. (ECA, Section12) Industries, activities and projects are categorized Green, Orange A, Orange B and Red with magnitudes of negative impacts and location, and needs procedure along each activity. Projects categorized Green are small scale and environmentally insignificant. Orange A, Orange B and Red categories include large and environmentally significant project. Red projects are the most environmentally significant project.

Green and Orange A projects require submission of summary report of the project and approval of local government. Orange B and Red projects require Initial Environmental Examination (IEE) and Environmental Management Plan (EMP) in addition to above.



Source: Environmental Profile of Bangladesh (11,2016, Japan Bank International Cooperation)

Figure 5.3.1 Flow of ECC acquisition

5.3.4 EIA Projects and Report

Red category projects require EIA. The Red projects are shown on Table 5.3.2.

Table 5.3.2 Red Category Projects

1. Leather processing (tannery)
2. Formaldehyde
3. Urea fertiliser
4. T.S.P. fertiliser
5. Chemical dyes, polishes, varnishes and enamels
6. Power plants
7. All mining projects (coal, limestone, hard rock, natural gas, mineral oil, etc.)
8. Cement
9. Fuels (oil refineries)
10. Artificial rubber
11. Paper and pulp
12. Sugar
13. Distillery
14. Fabric dyeing and chemical processing
15. Caustic soda, potash
16. Other alkalis
17. Iron and steel manufacturing
18. Raw materials for medicine and basic drugs
19. Electroplating
20. Photo films, photo paper and photo chemicals
21. Chemicals derived from petroleum or
26. Asbestos
27. Fibreglass
28. Pesticides, fungicides and herbicides
29. Phosphorus and its compounds/derivatives
30. Chlorine, fluorine, bromine, iodine and their compounds/derivatives
31. Industrial gases (excluding nitrogen, oxygen and carbon dioxide)
32. Waste incinerators
33. Other chemicals
34. Ordinance factory
35. Nuclear power
36. Alcoholic beverages
37. Non-metallic chemicals not listed elsewhere
38. Non-metals not listed elsewhere
39. Industrial estate
40. Basic industrial chemicals
41. Non-iron basic metals
42. Detergent
43. Landfilling by household/industrial/commercial waste
44. Sewage treatment plants
45. Lifesaving drugs
51. Hospitals
52. Ship manufacturing
53. Tobacco (processing/cigarette/bin-making)
54. Metallic boat manufacturing
55. Wooden boat manufacturing
56. Refrigerator, air conditioner/air cooler manufacturing
57. Tyres and tubes
58. Board mills
59. Carpets
60. Engineering works (capital above 10 hundred thousand taka)
61. Repairing of motor vehicles (capital above 10 hundred thousand taka)
62. Water treatment plants
63. Laying down/replacement/expansion of sewerage pipelines
64. Laying down/replacement/expansion of water, power and gas distribution lines
65.Exploration/extraction/distribution of mineral resources
66.Construction/reconstruction/expansion of flood control embankment, polder, dike, etc.

coal 22. Explosives 23. Acids and their salts (organic and inorganic) 24. Nitrogen compounds (cyanide, cyanamide, etc.) 25. Production of plastic raw materials (PVC, PP/iron, polystyrene, etc.)	46. Animal glue 47. Rodenticide 48. Refractories 49. Industrial gas (nitrogen, oxygen, carbon dioxide) 50. Batteries	67.Construction/reconstruction/expansion of roads (regional, national and international) 68.Construction/reconstruction/expansion of bridge (length 200 m or more) 69. Muriate of potash (manufacturing

Source: Schedule-I, Rule7(2) of Environment Conservation Rules 1997

In infrastructure projects, construction of flood control embankment, polder, road and bridge (length is 200m and more than). Although a railway project is not included in the table, MRT Line1 and Line5 projects fall into Red category because the project has viaduct which length is more than 200m.

Project proponents submit required documents to a Division Office of DoE. The red category projects are required the following documents.

(1) Feasibility study of the project

(2) IEE, TOR of EIA, flow of EIA and EIA report

(3) EMP report

(4) No objection certificate of local governments

(5) Emergency plan against significant negative impacts, and mitigation plan

(6) Outlines of involuntary resettlement and rehabilitation plan

(7) Others

5.3.5 Stakeholder Meetings and Disclosure of Information

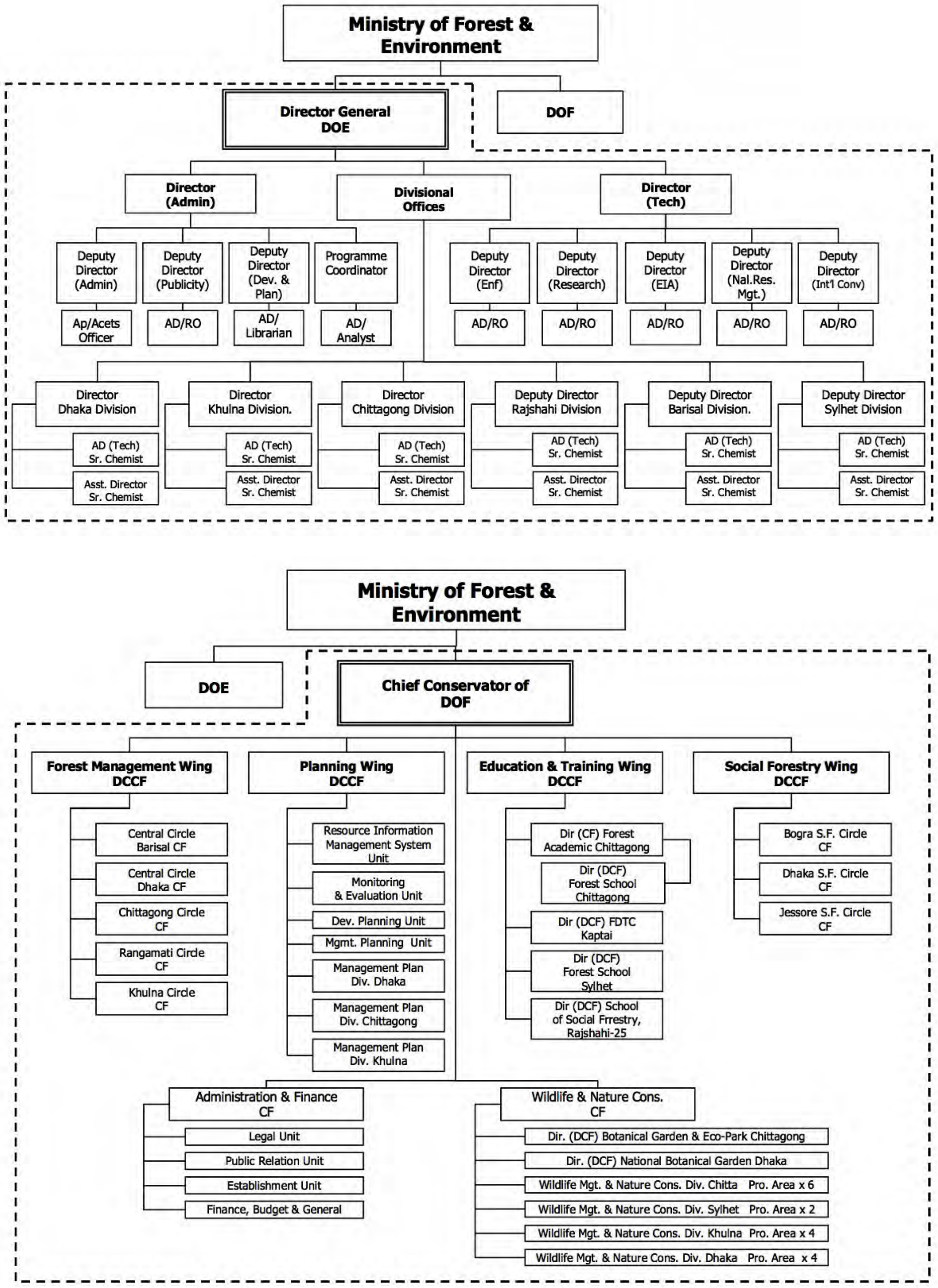
The matters of stakeholder meetings and disclosure of information have not been described in relevant legislations. These should be coordinated to JICA Guidelines.

5.3.6 Relevant Authorities of EIA

DoE completely involves the process to ECC issue. Project proponents requires to acquire No-objection certificate (NOC) of local governments and submit with an ECC application.

An ECC application is submitted to a Division Office of DoE who is responsible for the project location. After receiving the application, the Division Office appraises the application. As needed, central office of DoE can appraise.

Environmental administration in Bangladesh is handled by DoE and Department of Forest (DoF) under MoEF. DoE mainly handles the procedure of EIA: MoF handles forest reservation and biodiversity.



Source: Profile on Environmental and Social Considerations in Bangladesh (July 2012, JICA)

Figure 5.3.2 Organogram of DoE and DoF

5.3.7 Comparison of JICA Guidelines and EIA System of Bangladesh

Table 5.3.3 shows the comparison of policies of JICA Guidelines and EIA system of Bangladesh, gaps and policies of gap filling.

Table 5.3.3 Comparison of JICA Guidelines and EIA System of Bangladesh

	Policies of JICA Guidelines	EIA System of Bangladesh	Policies of Gap Filing
Basic Matters	Environmental impacts that may be caused by projects must be assessed and examined in the earliest possible planning stage. Alternatives or mitigation measures to avoid or minimize adverse impacts must be examined and incorporated into the project plan. (JICA Guidelines Appendix1 1.1)	Regarding selection of project site, comparison of alternatives is recommended. (EIA Guidelines for Industries, DoE, 1997)	Institution of Bangladesh does not obligate the comparison of alternatives. Based on the policy of JICA Guidelines, alternatives and mitigation measures that minimize negative impacts are examined and reflect to the project.
Disclosure	EIA reports must be written in the official language or in a language widely used in the country in which the project is to be implemented. When explaining projects to local residents, written materials must be provided in a language and form understandable to them; EIA reports are required to be made available to the local residents of the country in which the project is o be implemented. The EIA reports are required to be available at all times for perpetual by project stakeholders such as local residents and copying must be permitted. (JICA Guidelines Appendix1, 2)	There is no description on written language of EIA report. There is no description of disclosure of EIA report.	Explanation is done by language which is available to local persons (Bengal). That the EIA report is available at all times is proposed to the counter parts.
Social Acceptability	For projects with a potentially large environmental impact, sufficient consultations with local stakeholders, such as local residents, must be conducted via disclosure of information at an early stage, at which time alternatives for project plans may be examined. The outcome of such consultations must be incorporated into the contents of the project plans. (JICA Guidelines, Appendix1. 5.Social acceptability) In preparing EIA reports, consultations with stakeholders, such as local residents, must take place after sufficient information has been disclosed. Consultations with relevant stakeholders, such as local residents, should take place if necessary throughout the preparation and implementation stages of a project. Holding consultations is highly desirable, especially when the items to be considered in the EIA are being selected, and when the draft report is being prepared. (JICA Guidelines, Appendix 2) Multiple alternatives must be examined in order to avoid or minimize adverse impacts and to choose better project options in terms of environmental and social considerations.	There is no description about public participation on the EIA system in Bangladesh.	On the explanation before the EIA survey, draft scoping and DFR stage, stakeholder meetings are held. Result of the meetings are incorporated in EIA report.

	Policies of JICA Guidelines	EIA System of Bangladesh	Policies of Gap Filing
Items of Impact Assessment	The impacts to be assessed with regard to environmental and social considerations include impacts on human health and safety, as well as on the natural environment, that are transmitted through air, water, soil, waste, accidents, water usage, climate change, ecosystems, fauna and flora, including trans-boundary or global scale impacts. These also include social impacts, including migration of population and involuntary resettlement, local economy such as employment and livelihood, utilization of land and local resources, social institutions such as social capital and local decision-making institutions, existing social infrastructures and services, vulnerable social groups such as poor and indigenous peoples, equality of benefits and losses and equality in the development process, gender, children's rights, cultural heritage, local conflicts of interest, infectious diseases such as HIV/AIDS, and working conditions including occupational safety. (JICA Guidelines, Appendix 1, Scope of Impacts to Be Assessed)	There is no tangible description of survey items in the EIA report. DoE presents TOR to each project. Based on the TOR, EIA study is conducted.	Based on the survey items on JICA Guidelines, scoping is conducted and survey items are decided.
	In addition to the direct and immediate impacts of projects, their derivative, secondary, and cumulative impacts as well as the impacts of projects that are indivisible from the project are also to be examined and assessed to a reasonable extent. It is also desirable that the impacts that can occur at any time throughout the project cycle should be considered throughout the life cycle of the project.	In the EIA system of Bangladesh, there is no description about derivative, secondary, and cumulative impacts.	As needed, derivative, secondary, and cumulative impacts with other projects are examined.
Monitoring / Grievance Redress Mechanism	Project proponents etc. should make efforts to make the results of the monitoring process available to local project stakeholders. (JICA Guidelines, Appendix 1, Monitoring 3) When third parties point out, in concrete terms, that environmental and social considerations are not being fully undertaken, forums for discussion and examination of countermeasures are established based on sufficient information disclosure, including stakeholders' participation in relevant projects. Project proponents etc. should make efforts to reach an agreement on procedures to be adopted with a view to resolving problems. (JICA Guidelines, Appendix 1, Monitoring 4)	On ECC acquisition, EMP report is required. However, there are no obligation of report and no penalty for violation.	There is no description about monitoring. On the EIA study, environmental management plan is formulated, and implementation of monitoring is proposed and agreed with the counterpart.
Ecosystem and Biota	Projects must not involve significant conversion or significant degradation of critical natural habitats and critical forests.	In Bangladesh, significant habitats are protected as reserves and activities in the reserves are restricted.	There may be no wild habitat in / around the project site.
Indigenous Peoples	Any adverse impacts that a project may have on indigenous peoples are to be avoided when feasible by exploring all viable alternatives. When, after such an examination, avoidance is proved unfeasible, effective measures must be taken to minimize impacts and to compensate indigenous peoples for their losses.	There is no ordinance on indigenous people.	In case that affected indigenous people are confirmed in this survey, effective measurements for protection of the indigenous people are examined in RAP study.

Source: JICA Study team

5.4 Comparisons on Alternatives

5.4.1 Comparisons of public transportation projects on RSTP

The RSTP proposed traffic development policy in the view of future of Dhaka. One of the traffic policies is strength of public transportation including 5 MRTs and 2 BRTs. And based on results of demand forecast and conformity with urban development, MRT Line1 and Line5 were recommended as prioritised projects.

For these public transportation projects, in the view of the environmental and social considerations, comparisons of IEE level were examined based on a strategic environment assessment. (see Table 5.4.1)

MRT Line1 may cause negative impacts including noise and vibration on viaduct section, however has less impacts on the number of PAHs, preservation areas and biodiversity. Therefore MRT Line1 was selected as a priority project.

Table 5.4.1 Comparisons of public transportation projects on RSTP

Impact Items	MRT Line1		MRT Line 2	MRT Line 4	MRT Line 5		BRT Line 7
Social Environment							
Land acquisition and Involuntary Resettlement	[All Elevated] In order to pass over Kuril Flyover and Moghbazar - Mouchak Link Flyover with elevated structure, a massive resettlement of affected persons due to additional ROW acquisition will be unavoidable. [Partial Underground] The tracks go partially underground in Kuril area and from Maribag to Kamulapur BR station and further Buriganga River.		[All Elevated] The route goes the narrow existing roads from Gabtali to Dhaka University. A large number of structures might be affected. The existing highway in Western Fringe area can accommodate the viaduct.	[All Elevated] The elevated structure will be built within the BR ROW. There are hundreds of informal settlers and illegal vendors in BR ROW. If the BR line will be double tracked, there might be no more informal settlers.	[All Elevated] The line 5 covers the center portion of Dhaka, congested area. Thus a large number of affected structures are expected. Eastern Fringe Area is not heavily populated. [Partial Underground] The tracks go partially underground at the section from Kachukhet to Notun Bazar (under cantonment), and from Dhanmondi to Bashundahara City.		[At Grade] Since there is no existing roads. The 60m width of ROW acquisition will be needed.
Number of Affected Households	Elevated	Underground	1,100	500	Elevated	Underground	1,000
	500	100			620	120	
Number of Affected Persons[*1]	Elevated	Underground	5,500	2,500	Elevated	Underground	5,000
	2,500	500			3,100	600	
Natural Environment							
Protected Area	The line will not go through any protected area.		The line will not go through any protected area.	The line will not go through any protected area.	The line will not go through any protected area.		The line will not go through any protected area.
Biodiversity (wetland)	Because the line will go through the existing road and BR ROW in the built-up area, wetlands will not be directly affected. There are some small swamps along the track around Tongi to Gazipur and Purbachar areas.		The line will go through the existing road in the built-up area from Gabtali to Kamalapur. From Gabtali to Hemayetpur the highway is surrounded by wetland. The wetland might be affected during construction.	The line will go through the existing BR ROW in the built-up area. There will be no impacts on wetlands.	Because the line will go through the existing road in the built-up area, there will be no direct impacts on wetlands. The route will extend to the Eastern Fringe area, therefore, wetland and agricultural land will be reclaimed.		Since the route will go through the wetland and agricultural land in Eastern Fringe area, a significant impact on biodiversity will be expected.
Flood Risk	The line will go through the existing road. The risk of flooding is low.		The line will pass through the flood flow zone in the western side of Dhaka city. There will be a high risk of inundation.	The line will go through the existing BR ROW. The risk of flooding is very low.	The route will extend to the Eastern Fringe water retention area. There will be a high risk of inundation.		Since the route will go through the flood flow zone and water retention area in Eastern Fringe, there will be a high risk of flooding.

Impact Items	MRT Line1	MRT Line 2	MRT Line 4	MRT Line 5	BRT Line 7
Pollution Control					
Noise and vibration	Because the line will go through the existing road and BR ROW in the built-up area, mitigation measures to abate the noise and vibration levels should be considered especially for sensitive receptors at the elevated section.	The line will go through the existing road in the built-up area of Dhaka CBD and Savar, mitigation measures to abate the noise and vibration levels should be considered especially for sensitive receptors.	Because the line will go through the BR ROW in the built-up area, the mitigation measures to abate the noise and vibration levels should be considered especially for sensitive receptors.	The line will go through the existing road in the built-up area, mitigation measures to abate the noise and vibration levels should be considered especially for sensitive receptors at the elevated section. There might be lesser impacts in the Eastern Fringe area.	There are a few communities in the Eastern Fringe area. Noise and vibration will not cause a significant impact.
Air Pollution	Because the line will go through the built-up area, dust generated during construction will cause a nuisance along the route, especially for residential areas.	The line will go through the built-up area of Dhaka CBD and Savar, dust generated during construction will cause a nuisance along the route, especially for residential areas.	Because the line will go through the BR ROW in the built-up area, dust generated during construction will cause a nuisance along the route, especially for residential areas.	The line will go through the built-up area dust generated during construction will cause a nuisance along the route, especially for residential areas. There might be fewer impacts in the Eastern Fringe area.	There are a few communities in the Eastern Fringe area generated during construction will not cause a significant impact.
Water pollution	Since the route will not pass though the wetland, turbid water will not directly deteriorate water quality of the wetland.	Water quality of wetland will be likely to be deteriorated by suspended solids discharged from construction sites.	Since the route will not pass though the wetland, turbid water will not directly deteriorate water quality of the wetland.	Water quality of wetland in the Eastern Fringe area will be likely to be deteriorated by suspended solids discharged from construction sites.	Water quality of wetland in the Eastern Fringe area will be likely to be deteriorated by suspended solids discharged from construction sites.
Overall Assessment	O: The lowest number of affected households both all elevated case and partial underground case O: Less impact on protected area and biodiversity O: Low risk of flooding X: Impact due to noise and vibration at the elevated section. The smallest number of affected households and fewer impacts on natural environment. Recommended as a priority project from the viewpoints of environmental and social considerations.	X: The largest number of affected households X: Impact on biodiversity in the wetland X:Risk of flooding X:Impact due to noise and vibration The largest number of affected households and moderate impacts on natural environment. The BRT should be considered for the short to midterm term plan in CBD.	△: A large number of informal settlers occupy the BR ROW. O: Less impact on protected area and biodiversity O: Low risk of flooding X: Impact due to noise and vibration A large number of informal settlers occupy the BR ROW. If the BR line will be double tracked, then the plan has to be reconsidered. Fewer impacts on natural environment.	O: The second lowest number of affected households in the partial underground case. X: Impact on biodiversity in the wetland X:Risk of flooding X:Impact due to noise and vibration The second lowest number of affected households. The extension to the Eastern Fringe will cause a significant impact on natural environment and increase the risk of flooding.	X: The second largest number of affected households X: Impact on biodiversity in the wetland X:Risk of flooding O:Impact due to noise and vibration The large number of affected households. A significant impact on natural environment. The risk of flooding is very high. The eastern fringe road should be carefully planned to minimize the environmental impacts.

Source: The Project on the Revision and Updating of the Strategic Transport Plan for Dhaka, 2nd Draft Final Report, February 2016, JICA

5.4.2 Comparisons of Alternatives on MRT Line1

Comparisons on alternatives on MRT Line 1 are described as the followings.

1) No Action Option

No action option is a case that MRT Line1 is not implemented. In DMA, chronic traffic congestion has become significant problem. Expected population increase and economic growth will cause expansion of traffic congestion, deterioration of environment and economic loss.

In case that MRT Line1 and Line5 are not implemented, no land acquisition and involuntary resettlement are expected. However sustainable growth of local industry will be hampered. The environment of the area will deteriorate further by the traffic congestion and air pollution.

2) Comparison of Structure Types

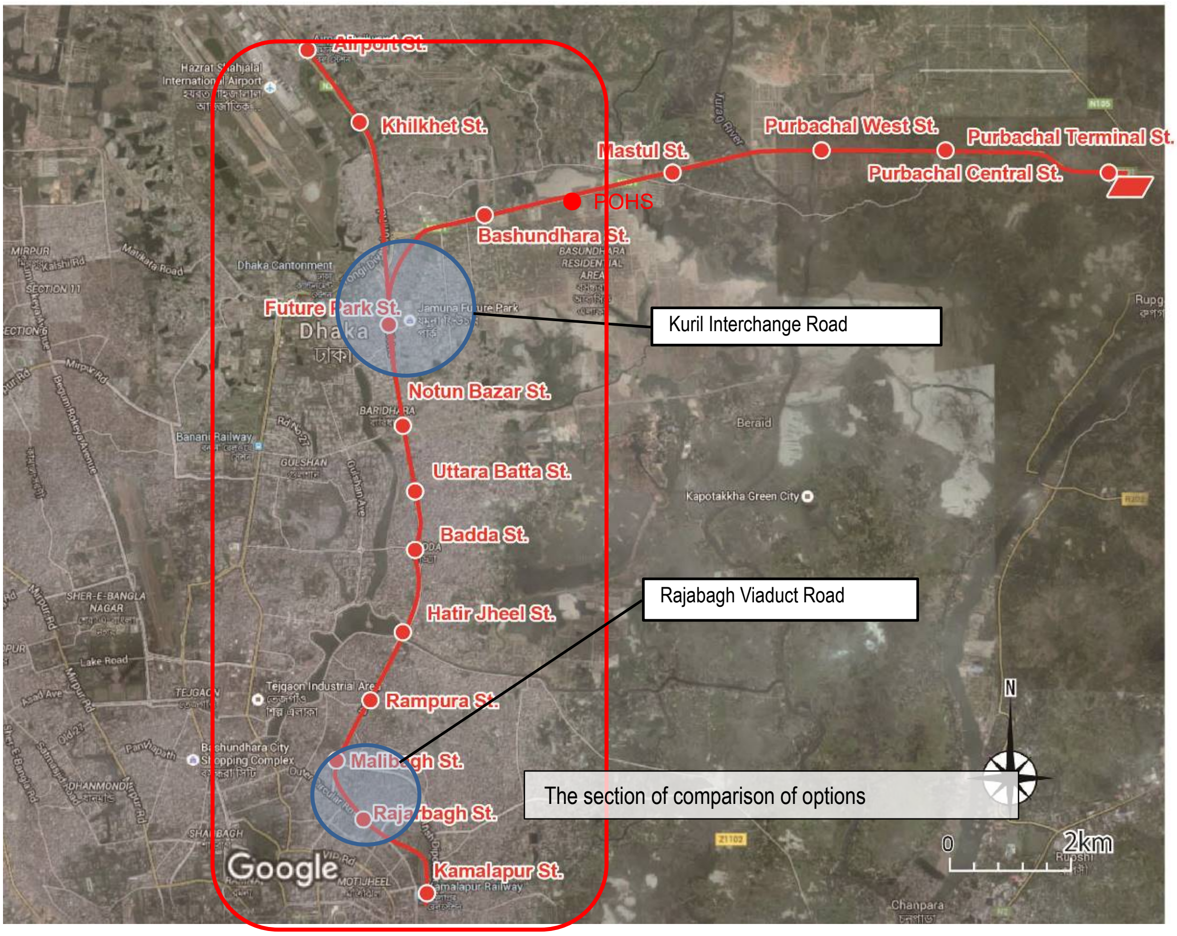
As structures of urban railway, there are (1)at grade, (2)viaduct, (3)underground (tunnel). Because the project runs in a density area, at grade structure is excluded.

Since Purbachal Line is constructed on the existing wide road, there are no alternatives except viaduct structure. On the other hand, structure of Airport Line should be discussed considering the conditions along the alignment. The section between Kamalapur and Malibagh which is a control point because of a construction of viaduct road needs underground structure. On Kuril area, the existing viaduct road should be considered. Based on these points, the study team proposed and compared following three structures of the Airport line.

(1) Underground plan

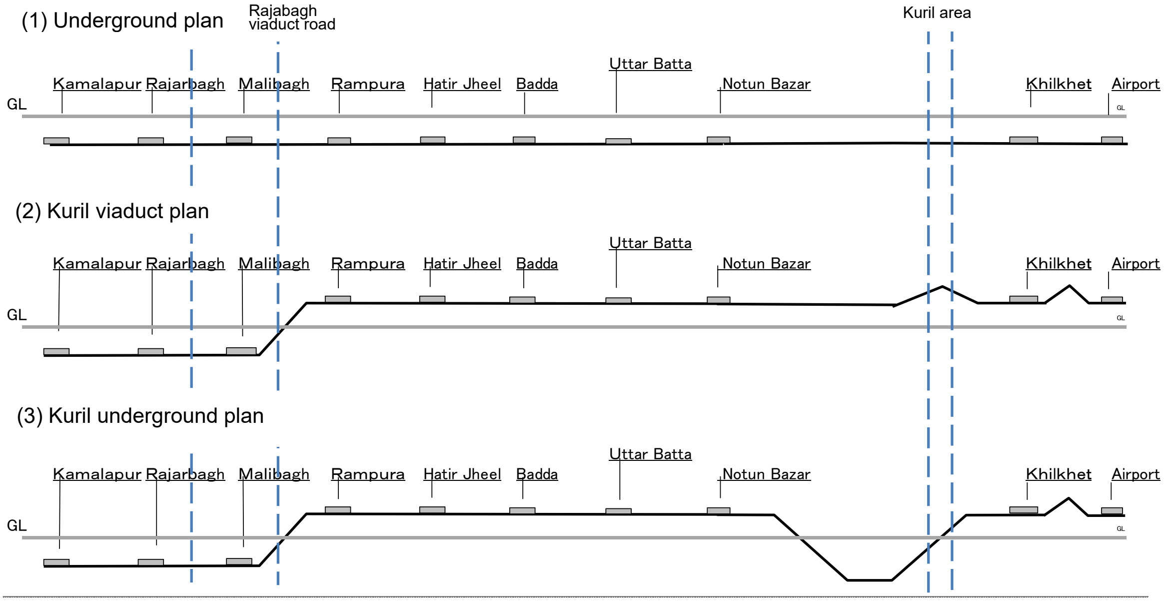
(2) Kuril viaduct plan

(3) Kuril underground plan



Source: JICA Study Team

Figure 5.4.1 Scope of Kuril viaduct plan and Kuril underground plan



Source: JICA Study Team

Figure 5.4.2 Structure of the Options

The project is a railway project which goes through the urban areas in Dhaka city. Therefore main evaluation items are; deterioration of living environment, pollution, mitigation of land acquisition and involuntary resettlement, construction costs, and construction methods.

The results of the comparison are shown on Table 5.4.2.

(1). Underground Plan has a priority on difficulty and safety of construction, traffic regulation, the least resettlement, and the least negative impacts on the environment including noise and landscape. On the other hand, construction cost is most expensive, excavation soil is most, and risk of inundation is highest.

(2). Kuril Viaduct Plan has a priority on construction cost. Because the underground section is shortest, excavation soil and the risk of inundation least. On the other hand, the plan needs transit structure on the center of the city, and causes more negative impacts on land acquisition and resettlement, and noise and landscape along the viaduct section.

(3). Kuril Underground Plan needs three transit structures in the center of the city. Therefore negative impacts on land acquisition and resettlement and traffic on construction are maximum. Other negative impacts are evaluated as middle of (1) and (2).

As a result of comparing three alternatives, the study team recommended (1) Underground Plan which has a priority on land acquisition, environmental impacts and difficulty of construction.

Table 5.4.2 Comparison of Structures of MRT Line1

Options / Items	1) Underground Plan	2) Kuril Viaduct Plan	3) Kuril Underground Plan
Construction/Project			
Length	Underground: 17.2km Viaduct: 12.9km	Underground: 3.5km Viaduct: 26.6km	Underground: 7.8km Viaduct: 22.3km
Stations	16 (Viaduct 5, Underground 11)	16 (Viaduct 13, Underground 3）	16 (Viaduct 12, Underground 4）
Social Environment			
Land Acquisition and Involuntary Resettlement	Land Acquisition and Involuntary Resettlement	Land Acquisition and Involuntary Resettlement	Land Acquisition and Involuntary Resettlement
Number of PAHs	◎: 115	○: 129	○: 133
Dividing of local community	◎: Underground structure does not divide local communities.	◎: Underground and viaduct structures do not divide local communities.	◎: Underground and viaduct structures do not divide local communities.
Natural Environment			
Preservation Area	○ : The alignment does not run in preservation areas.	○ : The alignment does not run in preservation areas.	○ : The alignment does not run in preservation areas.
Biodiversity (Wetland)	○ : The alignment goes through the center of Dhaka city. There are no wetland and biodiversity area.	○ : The alignment goes through the center of Dhaka city. There are no wetland and biodiversity area.	○ : The alignment goes through the center of Dhaka city. There are no wetland and biodiversity area.
Damage to the project by inundation	○ : Because there is a possibility of inundation from an entrance and exit, appropriate measures are required.	◎: Because there is a possibility of inundation from an entrance and exit, appropriate measures are required. There has no expectation of inundation on viaduct stations.	◎: Because there is a possibility of inundation from an entrance and exit, appropriate measures are required. There has no expectation of inundation on viaduct stations.

Options Items	1) Underground Plan	2) Kuril Viaduct Plan	3) Kuril Underground Plan
Landscape	◎: Negative impacts on landscape are least.	△: High rise viaduct exceeding the existing viaduct has the most negative impacts among three options.	○: Although viaduct structures are installed, the viaduct is lower than Kuril viaduct. The option has less negative impacts than Kuril viaduct plan.
Ecologically Critical Area (ECA)	○: There are no ECA along the Airport Line.	○: There are no ECA along the Airport Line.	○: There are no ECA along the Airport Line.
Pollution Control			
Noise and Vibration	◎: Noise around construction sites of stations is expected. However, it is expected less than the other options. Negative impacts by the railway operation are least.	○: Noise by construction of stations and viaducts is expected. Affected area is wider than the underground plan. Railway operation causes noise along viaduct section.	○: Noise by construction of stations and viaducts is expected. However, affected area is narrower than Kuril viaduct plan. Railway operation causes noise along viaduct section.
Air Pollution	◎: Air pollution around construction sites of stations is expected. However, it is expected less than the other options.	○: Because construction areas are wide, negative impacts of air pollution is expected to be wider than the underground plan.	○: Although the plan is expected to affect wider than the underground plan, negative impacts are limited than Kuril viaduct plan.
Groundwater	△: Because underground section is longest, it is expected that negative impacts on groundwater is most.	◎: Because underground section is shortest, it is expected that negative impacts on groundwater is least.	○: Although the plan has a longer underground section than Kuril viaduct plan, it is expected that negative impacts is less than the underground section.
Waste	△: Volume of excavation soil is most.	○: Volume of excavation soil is least.	○: Volume of excavation soil is less than Kuril viaduct plan.
Engineering			
Construction Cost	△: 380 billion JPY	◎: 290 billion JPY	○: 300 billion JPY
Feature of Structure	Whole section of Airport section is underground. Purbachal section is viaduct. Notun Bazar station is a junction.	Three stations on the south side (Kamalapur, Rajarbagh 、Malibagh) are set on underground considering the existing flyover and commercial activities along the alignment. A station at the Klyle flyover requires high rise structure over 30m above the ground.	Three stations on the south side (Kamalapur, Rajarbagh, Malibagh) and Kuril area are set on underground. Moreover, the section of Kuril area is set on underground to avoid the construction of huge viaduct.
Difficulty of Construction	○: Construction work is a kind of common construction technique. However, the construction needs expert workers. Because there is no experience in Bangladesh, technical training for workers is required. Regarding procurement of materials, launching of plant is required. High technique of tunnel excavation is required to avoid the structures around Kuril area.	△: Transition structure at narrow space is required. To build viaduct, considerations for road traffic and safety for public is required. Regarding procurement of materials, launching of plant is required. High technique of tunnel excavation is required to avoid the structures around Kuril area.	△: Transition structure at narrow space is required. To build viaduct, considerations for road traffic and safety for public is required. Regarding procurement of materials, launching of plant is required. High technique of tunnel excavation is required to avoid the structures around Kuril area.

Options Items	1) Underground Plan	2) Kuril Viaduct Plan	3) Kuril Underground Plan
Traffic	◎: Although lane control is needed, the option has the least negative impacts on the traffic around the project site.	△: Lane control during the construction of viaduct will cause traffic congestion.	○: Lane control during the construction of viaduct will cause traffic congestion. However, impacts will be less than Kuril viaduct plan.
Liquefaction by earthquake	◎: Less damage by liquefaction is expected.	○: Liquefaction may damage footings of viaduct	○: Liquefaction may damage footings of viaduct
Safety	◎: Because there is no railroad crossing, traffic accident is not expected.	◎: Because there is no railroad crossing, traffic accident is not expected.	◎: Because there is no railroad crossing, traffic accident is not expected.
Total Evaluation	◎: Although construction cost is most expensive, magnitude of resettlement is least and change of environment is small. Therefore it is most suitable for the project. Risk of inundation is avoidable by appropriate measures.	△: Although construction cost is most minimum, pretty resettlement and change of environment is expected. Therefore the option is inferior to the underground plan.	○: The plan has shorter viaduct section than Kuril underground plan, and is superior to the underground plan in the view of construction cost. However, the plan is inferior to the underground plan in the social views. Risk of inundation is avoidable by appropriate measures.

Note ◎: most suitable ○: suitable △: required more considerations

Length of line, number of stations and construction costs is as of alternative comparison, and different from as of now.

Source: JICA Study Team

3) Comparisons of Alternative Depot Sites

Policy of selecting location of depot site are followings:

(a) Near stations, less operation loss of crew members and rolling stocks
(b) Less idleness of loading and unloading
(c) Shorter approach to depot site
(d) To secure vast land
(e) Less negative impacts on natural environment, land acquisition and resettlement

The project is a railway connecting urban areas in Dhaka. In the view of cost of land acquisition and avoidance of large scale resettlement, Purbachal area where is undeveloped is most suitable (e). On the other hand, even in Purbachal area, development is progressing. Based on suitable area in Purbachal recommended by the counterpart, the study team proposed and compared four options. (Figure 5.4.3) Those options are located close areas, and the natural environment of four options is almost same. It is estimated that construction plans of the options is almost similar too. On the other hand,

Option 1 does not need switchback, and has a priority on smooth access to depot site. However, land acquisition and resettlement are more than other options. And it is expected that public facilities such as mosque, school and cemetery are affected. Generally the mosque is one of facilities that are difficult to move. And it is expected that land acquisition is hampered.

Option 2 does not need switchback as same as Option 1, and has a priority on smooth access to depot site. However, as same as Option 1, land acquisition and resettlement are more than other options. And it is expected that public facilities. Since an approach is longer than Option1, negative impacts on the environment is more than Option 1.

Option 3 needs switchback on the access to the depot site, and effectiveness of the operation is inferior to other options.

On the time of this comparison, it has been confirmed that land of Option 3 is owned by 4 private developers. (referred to 6.15.4) The counterpart was consulting with them about land acquisition, however, land acquisition has not agreed. Therefore, new option, Option 4 came to be studied. Option 4 is located on the east of other 3 options. Option 4 has an operational advantage as same as Option 1, 2. Finally the study team conducted environmental baseline survey and RAP survey and examined feasibility on the environmental and social considerations.

Considering merits on the operation and the negative impacts on land acquisition and resettlement, the study team was recommending Option 4 as the most feasible option.

Table 5.4.3 Comparisons of Depot Site Options

	Option 1	Option 2	Option 3	Option 4
Construction / Project				
Costs	◎ : Because the approach is shorter, costs is cheaper.	○: Because the approach is longer, costs is more expensive than Option 1.	○: Because the approach is longer, costs is more expensive than Option 1.	◎: Because the approach is shorter, costs is cheaper.
Operation	◎ : Because of no switchback, operation is smooth.	◎: Same as Option 2.	○: Because switchback is required, operation is more difficult than other options.	◎ : Because of no switchback, operation is smooth.
Social Environment				
Land Acquisition and Resettlement	△: It is expected large scale of land acquisition and resettlement is required. Public facilities such as mosque, school and cemetery are affected.	△: Same as Option 1	○: It is expected that resettlement is less than other options.	△: It is expected large scale of land acquisition and resettlement is required.
Pollution Control				
Noise and Vibration	◎: Because approach is shorter, negative impacts of noise and vibration is less than other options.	○: Because approach is longer, negative impacts of noise and vibration is more than other option 1.	○Because approach is longer, negative impacts of noise and vibration is more than other option 1.	◎: Because approach is shorter, negative impacts of noise and vibration is less than other options.
Total Evaluation	△: Because it is expected that land acquisition and resettlement is difficult in spite of priority of other items, it is difficult to select.	△: Because it is expected that land acquisition and resettlement is difficult in spite of priority of other items, it is difficult to select.	○: Because it is expected that land acquisition and resettlement are easier.	○: Though large scale of resettlement is anticipated, however land acquisition might be easier than Option 3.

Source: JICA Study Team

Source: JICA study team prepared based on Google Earth

Figure 5.4.3 Options of Depot Site

5.5 Scoping of EIA

5.5.1 Scoping Matrix

Based on the comparisons of the alternatives, scoping of Line1 projects are carried out.

The study team confirmed current situation of the environment and social matters in/around the site of MRT Line1 by field reconnaissance, and developed a draft scoping of the MRT Line1 including pollution control, natural environment and social environment. A draft scoping is shown on Table 5.5.1.

Table 5.5.1 Draft Scoping (MRT Line1)

No	Items	Evaluation		Reason of evaluation
		Before/ under construction	Operation	
Pollution Control				
1	Air Pollution	B-	B+	Construction Phase: ･Construction works and operation of construction equipment will generate dust and exhaust gas. Operation Phase: ･Air pollution will be mitigated by reducing traffic congestion.
2	Water pollution	B-	B-	Construction Phase: ･Turbid water derived from construction sites may deteriorate water quality of rivers. Operation Phase: ･Waste water from stations and maintenance facility may deteriorate water quality of rivers.
3	Soil pollution	B-	B-	Construction Phase: ･Bad maintenance construction machinery and vehicles may cause soil contamination by leak of oil. Operation Phase: ･Maintenance facility of depot may cause soil contamination by leak of oil.
4	Waste	B-	B-	Construction Phase: ･Construction works will cause waste including excavated soil. Operation Phase: ･Illegal dumping from stations and depot may cause negative impacts on the environment.
5	Noise and Vibration	B-	B-	Construction Phase: ･Construction works will cause noise and vibration. Operation Phase: ･Driving of trains may cause noise around viaduct sections.
6	Ground subsidence	C	C	Construction /Operation Phase: ･Appropriate methods should be selected to avoid ground subsidence in case of soft soil.
7	Offensive odors	D	D	Construction / Operation Phase: ･In terms of the project character (railway), offensive odors are unlikely to occur.
8	Bottom sediment	B-	D	Construction Phase: ･Turbid water from the construction activity may deteriorate bottom sediment of rivers.
Natural Environment				
9	Protected areas	D	D	Construction / Operation Phase: ･ The Project site and the vicinity include no protected areas.
10	Ecosystem	B-	B-	Construction Phase: ･Vegetation and wetland may be lost by construction works. ･Agricultural ecosystem will be lost or disturbed by construction activity. Operation Phase: ･Activity of depot may have negative impacts on the ecosystem.
11	Hydrology	C	C	Construction / Operation Phase: ･Piers in river may cause negative impacts on a flow of the river.

No	Items	Evaluation		Reason of evaluation
		Before/ under construction	Operation	
12	Groundwater	B-	D	Construction / Operation Phase: ･Excavation and installation of underground structure may cause negative impacts on groundwater level and quality.
13	Geographical features	B-	D	Construction Phase: ･Excavation and installation of underground structure may cause collapse of ground.
Social Environment				
14	Resettlement/ Land Acquisition	A-	D	Pre-Construction Phase: ･Large scale land acquisition and resettlement is anticipated (115 households including 12 residents). Operation Phase: ･Additional physical resettlement and land acquisition will not be required for this Project.
15	Poor people	A-	A-	Construction Phase: ･Poor who are living in the project sites may be affected. Operation Phase: ･ In case of no mitigation measures, poverty may Poverty of poor who are resettled involuntarily may become severe.
16	Ethnic minorities and indigenous peoples	C	C	Construction / Operation Phase: ･Impacts is unclear as of now.
17	Local economies, such as employment, livelihood, etc.	B-/B+	C	Construction Phase: ･Involuntary resettlement may cause negative impacts on Rikisya or taxi. On the other hand, construction work will increase employment. Operation Phase: ･Rikisya and taxi will be used as para transit from stations.
18	Land use and utilization of local resources	B-/B+	B+	Construction Phase: ･Development of the depot will change current land use. Operation Phase: ･Effective use of land will accelerate undeveloped suburb.
19	Water usage	C	C	Construction / Operation Phase: ･Impacts is unclear as of now.
20	Existing social infrastructures and services	C	C	Construction / Operation Phase: ･Impacts is unclear as of now.
21	Social structure such as social capital and local decision-making institutions	C	C	Construction / Operation Phase: ･Impacts is unclear as of now.
22	Misdistribution of benefits and damages	B-	B-	Construction Phase: ･There may be misdistribution between affected households and no-affected households. Operation Phase: ･Since the vicinity of stations has convenience, misdistribution of benefits and damages is expected.
23	Local conflicts of interest	B-	B-	Construction Phase: ･Implementation of land acquisition and payment of compensation may cause local conflicts of interest Operation Phase: ･Since the vicinity of stations has convenience, local conflicts of interest.

No	Items	Evaluation		Reason of evaluation
		Before/ under construction	Operation	
24	Cultural heritage	C	C	Construction / Operation Phase: ・Impacts is unclear as of now.
25	Landscape	B-	B-	Construction Phase: ・Small scale and short duration impacts are expected. Operation Phase: ・In case that viaduct exceeds other structures, the viaduct may cause negative impacts on landscape
26	Gender	C	C	Construction / Operation Phase: ・Impacts is unclear as of now.
27	Children's rights	C	C	Construction / Operation Phase: ・Impacts is unclear as of now.
28	Infectious diseases such as HIV/AIDS	B-	D	Construction Phase: ・Infection risks of HIV/AIDS may be increased among construction workers. Operation Phase: ・Since the Project aims improvement of urban traffic, the project will not directly concern spread of infection risks of HIV/AIDS.
29	Working conditions (including occupational safety)	B-	B-	Construction Phase: ・Inappropriate safety measures of contractor will deteriorate occupational safety. Operation Phase: ・Inappropriate safety measures of railway operator will deteriorate occupational safety.
Others				
30	Trans-boundary impacts or climate change	B-	B+/-	Construction Phase: ・Operation of construction machinery and vehicles will occur greenhouse gas (CO2). Operation Phase: ・Modal shift to from vehicles to railway will reduce greenhouse gas.
31	Accidents	B-	B-	Construction Phase: ・There is a risk of accident on construction activity. Operation Phase: ・Collision of vehicle and viaduct, and accident in depot are expected.
32	Risk of flood	C	C	Construction / Operation Phase: ・Although the project site may not be flood prone areas, flood risk should be confirmed.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected
* Impact Items refer to "JICA Guidelines for Environmental and Social Considerations April 2010"

Source: JICA Study Team

5.5.2 TOR of EIA

Based on the draft scoping, the study team prepared TORs of EIA of MRT Line1 which are shown on Table 5.5.2.

Table 5.5.2 TOR of EIA of MRT Line1

Category	Items	Before/during Construction	Operation	Survey Items and Methods of Survey and Forecast	Methods of Evaluation
Pollution Control	Air Pollution	B-	B＋	Current condition of air quality by field survey Outlines of construction works Air quality estimation on construction	Comparison with air quality standards of Bangladesh Considerations on vulnerable facilities including school and hospital (PM2.5 and PM10)
	Water pollution	B-	B-	Current condition of water quality of rivers and lakes in/around the project site by review of existing materials and field survey Review of plan of the project and past examples of other projects	Comparison with water quality standards of Bangladesh, and evaluation of turbid water derived from the implementation of the project
	Soil pollution	B-	B-	Outlines of construction works Review of past examples of other projects Review of depot plan of the project in the view of possibility of oil leak	Evaluation of the possibility of oil leak, and study of mitigation plan
	Waste	B-	B-	Review of estimated volume of excavation soil and construction waste Review of operation plan of the project and other project Review of disposal measures	Evaluation of possibility of pollution by excavation soil and construction waste Study of mitigation plan in case that high pollution is expected comparing other projects
	Noise and Vibration	B-	B-	Current condition of noise by field survey Review of construction works Estimation of construction noise by noise transmission models Estimation of railway noise on viaduct sections by noise estimation model of railway	Comparison with noise standards of Bangladesh or other countries Study of mitigation plan if needed
	Ground subsidence	C	C	Review of construction plan and geological survey	Confirmation of taking appropriate measures to avoid ground subsidence on soft ground
	Bottom sediment	B-	D	Review of construction works Estimation of an influx of turbid water and oil leak	Study of mitigation plan in case that an influx of turbid water and oil leak
Natural Environment	Ecosystem	B-	B-	Current condition of fauna and flora in/around the depot site by existing materials and field survey Estimation of area where trees and vegetation are cleared based on construction plan	Estimation of environmental impacts Study of mitigation plan if needed
	Hydrology	C	C	Review of the project plan Confirmation of structures installed in crossing rivers	Confirmation of appropriate measures for river flow in case that structure is installed in rivers
	Groundwater	B-	D	Current condition of groundwater level and quality around the project site by existing geological survey Review of the project plan and construction plan Estimation of impacts on groundwater level	Comparison with water quality standard of Bangladesh Study of mitigation plan if needed
	Geographical features	B-	D	Review of existing geological survey Review of construction plan of the project Estimation of negative impacts on geographical features	Study of mitigation plan if structures around the project site is expected to affect

Category	Items	Before/during Construction	Operation	Survey Items and Methods of Survey and Forecast	Methods of Evaluation
Social Environment	Resettlement/ Land Acquisition	A-	D	Current condition of PAPs by census and socio-economic survey Collecting opinions of the PAPs by consultation meetings, focus group discussion and interviews Estimation of negative impacts on the PAPs Discussion with counterparts and review of other countries examples on property rights	Development of policies of land acquisition and resettlement Preparation of RAP
	Poor people	A-	A-	Estimation of negative impacts on poor people included in the PAPs	Study of mitigation measures for the poor people included in the PAPs
	Ethnic minorities and indigenous peoples	C	C	Existence of ethnic minorities and indigenous peoples by RAP survey	Study of mitigation measures if needed
	Local economies, such as employment, livelihood, etc.	B-/B+	C	Current condition of livelihoods of the PAPs Estimation of negative impacts to employment and livelihoods of the PAPs Collecting opinions of rikisha and taxi drivers by stakeholder meetings	Preparation of entitlement, compensation policy
	Land use and utilization of local resources	B-/B+	B+	Review of existing materials including land use plan Collecting information by field reconnaissance	Estimation of impacts based on review of the project plan and opinions on the public consultation meetings
	Water usage	C	C	Review of existing materials on ground water usage around the project site Field survey on ground water usage around the project site Review of construction plan and project plan	Study of mitigation measures if significant negative impacts are expected
	Existing social infrastructures and services	C	C	Review of existing materials on existing social infrastructures and services Review of the project plan	Evaluation of impacts on existing social infrastructures and services based on current condition of existing social infrastructures and services
	Social structure such as social capital and local decision-making institutions	C	C	Review of existing materials and hearing on social structure such as social capital and local decision-making institutions Review of the project plan	Comparison with current condition of social structure and the project plan
	Misdistribution of benefits and damages	B-	B-	Review of the project plan	Evaluation on misdistribution of benefits and damages by project implementation
	Local conflicts of interest	B-	B-	Economic status of PAPs by the RAP study Confirmation of local conflicts of interest by hearing	Consideration avoiding significant gaps between PAPs and non PAPs on the preparation of RAP Comparison of PAPs income before/after resettlement
	Cultural heritage	C	C	Existence of cultural heritage in/around the project site by review of maps and existing materials Field reconnaissance	Evaluation of negative impacts and study of mitigation measures in case that there is a cultural heritage in/around the project site
	Gender	C	C	Ratio of widow households in poor households Necessity of special assistance on the widow households Review of the gender action plan which is developed in this preparation survey	Considerations on women and traffic disadvantaged on the project plan
	Children's rights	C	C	Existence of school around the project site by review of maps Review of the project plan in terms of blocking school-commuting roads	Evaluation of negative impacts on school-commuting roads

Category	Items	Before/during Construction	Operation	Survey Items and Methods of Survey and Forecast	Methods of Evaluation
	Infectious diseases such as HIV/AIDS	B-	D	Current condition of prevalence of infectious diseases such as HIV/AIDS in Bangladesh by review of existing materials Review of other projects on prevalence of HIV/AIDS by influx of construction workers	Evaluation of the prevalence of HIV/AIDS on the construction stage of the project
	Working conditions (including occupational safety)	B-	B-	Safety measures on the project by review of the project plan	Evaluation of safety on construction work in the light of other projects Evaluation of safety on the operation of the project in the light of other projects
	Trans-boundary impacts or climate change	B-	B+/-	Construction machinery which discharges greenhouse gas on the construction activities Estimation of greenhouse gas reduction by the implementation of the project	Confirmation of the reduction measures on the construction plan Evaluation of reduction effects of greenhouse gas on the project
Others	Risk of flood	C	C	Review of existing materials relevant to flood around the project site Review of the project plan	Confirmation of appropriate measures in case that there is food risk

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)

D: No impact is expected

* Impact Items refer to “JICA Guidelines for Environmental and Social Considerations April 2010”

Source: JICA Study Team

5.6 The Results of the EIA Survey

5.6.1 Results of the Survey of Each Items

Regarding the raised items on the TOR of EIA, the results of the EIA survey are shown below.

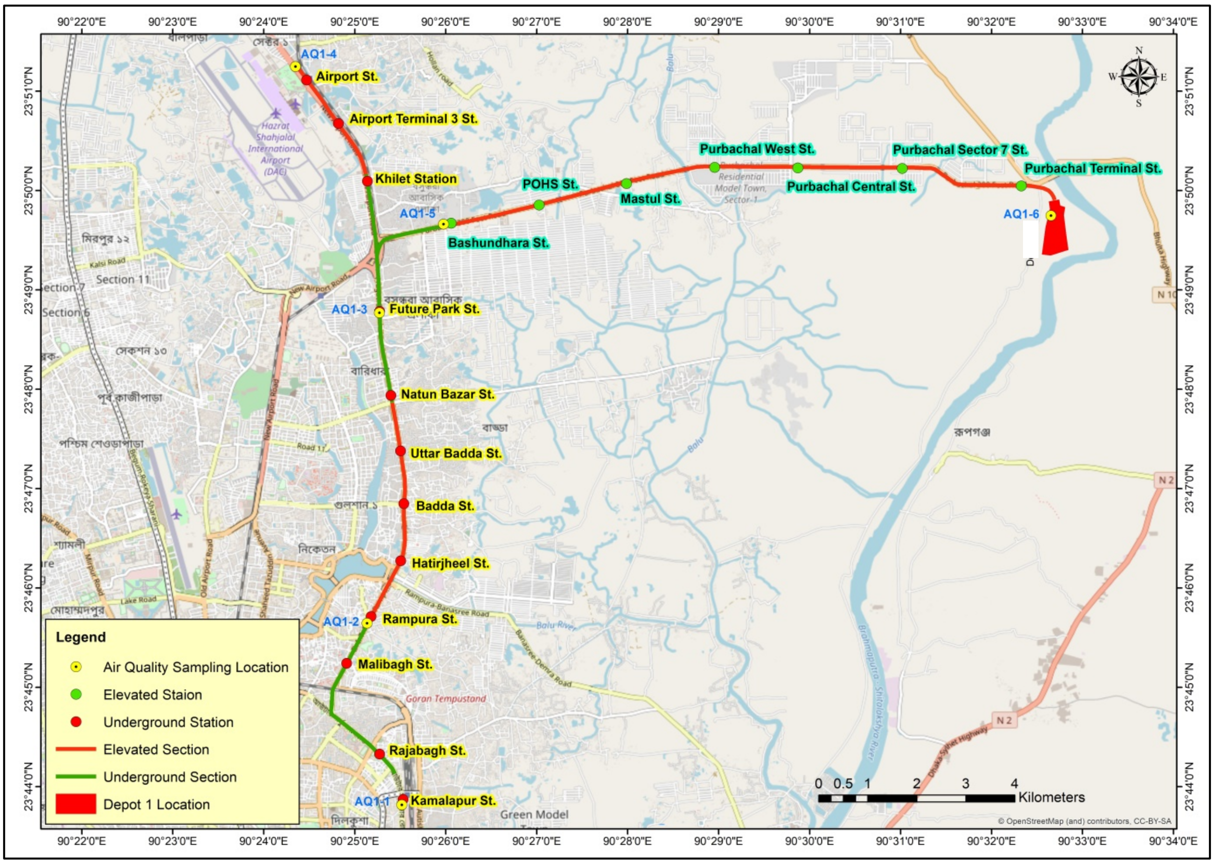
1) Air Pollution

Air quality survey was conducted on the locations along the MRT Line 1. Five survey points were allocated along the MRT Line 1 alignment. Table 5.6.1 and Figure 5.6.1 show the survey points.

Table 5.6.1 Air Quality Sampling Location of MRT Line 1

No.	Location	Geographic Coordinate
AQ1-1	Kamlapur Station	23°43'48.99"N 90°25'31.01"E
AQ 1-2	Rampura Station	23°45'38.70"N 90°25'8.10"E
AQ 1-3	Jamuna Future Park Station	23°48'46.1"N 90°25'16.2"E
AQ 1-4	Airport Station	23°51'14.9"N 90°24'20.9"E
AQ 1-5	Bashundhara Station	23°49'39.7"N 90°25'58.5"E
AQ 1-6	Depot Site of Line 1	23°49'44.8"N 90°32'39.2"E

Source: JICA Study TeamEQMS



Source: EQMS

Figure 5.6.1 Air Quality Sampling Location of MRT Line 1

The subjects of survey are seven parameters (PM10, PM2.5, SO_2, NO_2, CO, Pb and O_3) including national ambient air quality standards (NAAQS) of Bangladesh.

Results of the survey are illustrated in Table 5.6.2. To summarize, concentration of the particulate matters are high in the project area. The value of PM10 and PM2.5 on the airport line including Kamalapur, Rampura, Jamuna Future Park and Airport station are higher than the NAAQS. NO_2 of Kamlapur, Rampura and Jamuna future park stations are also higher than the NAAQS.

Air pollutions of survey points are dominated by PM10 and PM2.5. Because on major roads in Dhaka city, a lot of construction work is being conducting, even paved roads are very muddy. Considering low concentrations of other pollutants, the high concentration of PMs is estimated to be derived from road dust.

WHO Guidelines recommends lower concentration of contaminants. Comparing the WHO Guidelines, concentrations of PM10 and PM2.5 highly exceed on the whole locations.

Table 5.6.2 Ambient Air Quality of MRT 1

Location	Present Concentration in µg/m³						CO (ppm)
	PM10	PM2.5	NO_2	SO_2	O_3	Pb	
Kamlapur Station	310.7	125.4	112.6	21.2	20.6	0.07	4.9
Rampura Station	286.5	108.5	107.1	22.8	15.6	0.05	1.7
Jamuna Future Park Station	231.2	95.7	103.4	17.0	13.4	0.03	0.8
Airport Station	275.6	103.6	98.4	17.6	10.2	0.04	0.6
Bashundhara Station	123.4	58.4	43.2	11.3	6.6	BDL	0.1
Depot Site of Line 1	92.3	52.2	30.6	9.8	4.5	BDL	0.1
NAAQS (ECR1997)	150	65	100	365	157	0.5	9
WHO Guideline	50	25	40	20	100	0.5	10

Source: EQMS Laboratory, Sampling Date: 28th February, 2017 to 5th March, 2017, Analysis date: 1st-15th March, 2017

Note: BDL- Below Detection Limit

🟧 Exceeding Standard Level

As the results of the baseline survey show, concentrations of PM2.5 and PM10 along the project area are high comparing the national standard of Bangladesh. Main cause of the air pollution can be dust of road surface. Some construction works including earth work may cause dust. However, mitigation measures against the dust such as water spray on the construction works should be introduced.

(1) Negative Impact of Dust caused by Construction Work

As mentioned above, main factor of air pollution in Dhaka is dust. On stakeholder meetings, some concerns about dust of construction work were raised. On the project, operation of construction machinery will generate dust. Based on simple prediction method of dust generation, study team examined negative impacts of dust falling around the project sites. As a prediction method, the prediction method by National Institute for Land and Infrastructure Management (NILIM), Japan was referred. On some typical construction work, volume of falling dust is estimated as table and meets criteria. The criteria is to secure living environment against spike tire dust in Japan.

Table 5.6.3 Estimated falling dust on typical construction work

Construction Work	Unit of falling dust near construction work (t/km2/8h)	Working day per month	Falling dust per month (t/km2/month)	Criteria (t/km2/month)
Embankment	0.04	30	1.2	20
Slope forming	0.07	30	2.1	
Piling (Earth Drill)	0.02	30	0.6	

Note: criteria: guideline on spike tire dust (NILIM)

Because estimated volume of falling dust is comparatively low, it is estimated that negative impacts are not significant. However, estimation of dust caused by construction work has uncertainty. Therefore, appropriate mitigation measures are essential.

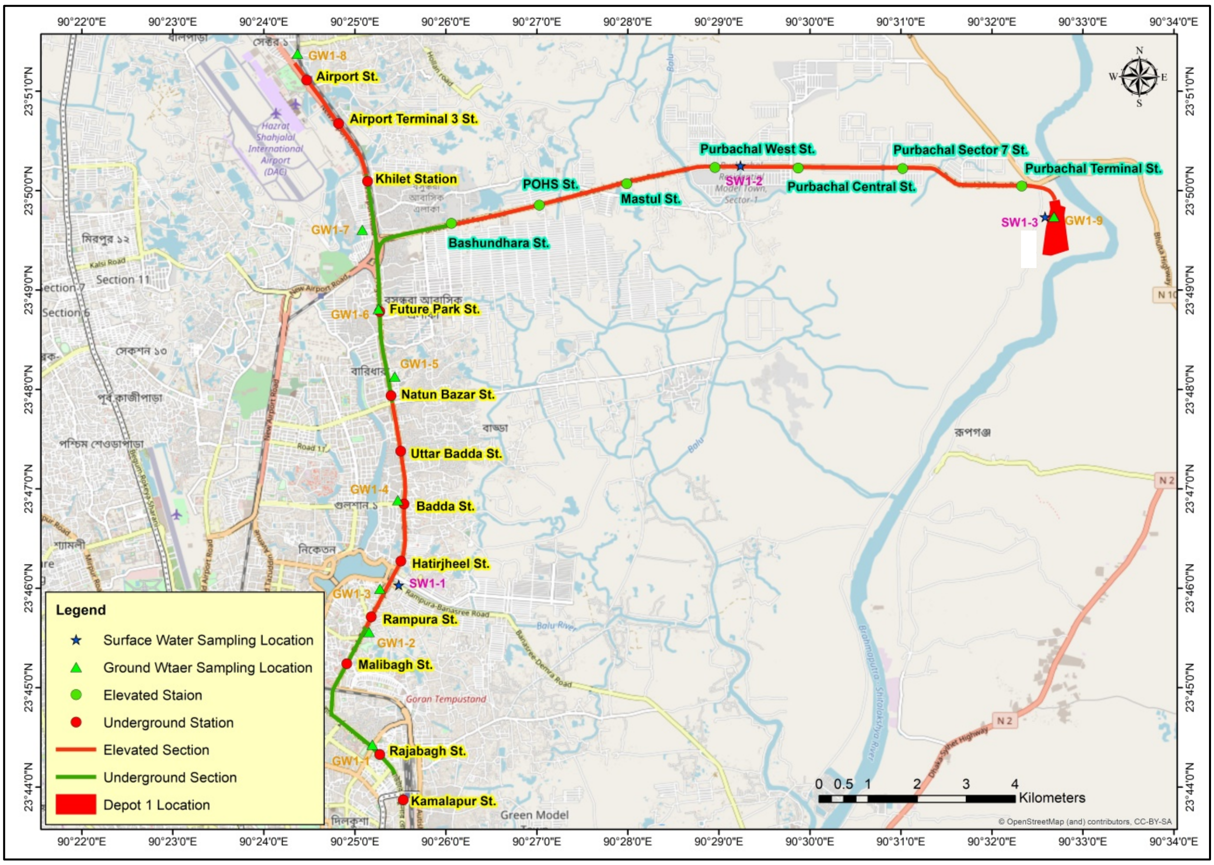
2) Water Pollution

To understand current conditions of surface water quality along the MRT Line 1, water quality survey was conducted. Surface water samples were taken from 3 different locations for river and pond along the MRT line 1. Surface water sample were collected on 19th to 22nd March 2017, 4th March 2018 (SW1-3). Detail Sampling Locations are provided in the following Table 5.6.4 and depicted in Figure 5.6.2.

Table 5.6.4 Surface water Sampling Location of MRT Line 1

No.	Location	Geographic Coordinate
SW1-1	Hatirjheel Canal	23° 46.033'N 90° 25.481'E
SW1-2	Balu River	23° 50.251'N 90° 29.235'E
SW1-3	Depot Site of Line 1	23°49'44.1"N 90°32'34.9"E

Source: JICA Study Team



Source: JICA Study Team

Figure 5.6.2 Surface and Ground Water Sampling Location of MRT Line 1

Results of the survey are shown on Table 5.6.5. To summarize, surface water quality are nearly same as “water usable by fisheries, various process and cooling industries” or “Water usable for irrigation“ of Bangladesh standard. The Bangladesh standards have no criteria of COD and TSS (SS). Comparing the Japanese standard of water quality, it is nearly same as Category D (industrial or agricultural use) or Category E (industrial use). Among 3 locations, water quality of Hatirjheel Canal is worst. Even SW1-2 which is designated as ECA is same as f category. Since concentration of DO is very low, it is crucial condition for aquatic organism.

Table 5.6.5 Surface Water Quality Analysis Result

Parameter	Unit	SW 1-1	SW 1-2	SW 1-3	Standard for Inland Surface Water*					
					a	b	c	d	e	f
Colour	Hazen	1.1	1.3	3.2	-	-	-	-	-	-
Temperature	˚C	26.9	28.7	28.5	-	-	-	-	-	-
pH	-	7.37	8.43	7.42	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
DO	mg/l	1.5	3.2	2.4	6 or above	5 or more	6 or more	5 or more	5 or more	5 or more
BOD	mg/l	24	12	7	2 or less	3 or less	6 or less	6 or less	10 or less	10 or less

Parameter	Unit	SW	SW	SW	Standard for Inland Surface Water*					
		1-1	1-2	1-3	a	b	c	d	e	f
COD	mg/l	88	44	32	-	-	-	-	-	-
TSS	mg/l	46	31	15	-	-	-	-	-	-
Coliform (Faecal)	N/100ml	1080	996	33	50 or less	200 or less	5000 or less	---	5000 or less	1000 or less

*Note: a- Source of drinking water for supply only after disinfecting
b- Water usable for recreational activity
c- Source of drinking water for supply after conventional treatment
d- Water usable by fisheries
e- Water usable by various process and cooling industries
f- Water usable for irrigation

Source: JICA Study Team, EQMS laboratory and Department of Public Health and Engineering Lab; Analysis date: 22/03/2017- 30/04/2017 and 30/04/2017-22/05/2017

The alignment of the project passes through some water bodies including ECA (Balu river, Turag river). Water quality of the water bodies are level to meet industrial use. The alignment passes through the water bodies by underground or bridge. There will be no pier in river. Therefore, the project will not directly affect the water bodies.

However, in case that structures including viaduct are constructed near the water bodies, influx of turbid water is expected. According to review of detail design, appropriate mitigation measures and monitoring should be taken as needed.

On the operation phase, the operation of the depot generates drainage water. Discharge of untreated drainage water may deteriorate water bodies. In this project, wastewater of toilet and cleaning of stations is treated by septic tank, and discharged water bodies.(4.4.2 3)) On the depot, wastewater including cleaner and oil is generated. The wastewater is collected in the depot, treated to meet the standards of water quality of Bangladesh, and discharged. Moreover, the drainage water is monitored regularly. Therefore, the drainage water will cause no deterioration of water quality around the depot.

3) Soil Pollution

On construction work of the project, some construction machinery will operate. Bad maintenance machinery has a possibility of oil leak. The machinery should be maintained appropriately. Since the structure of the project is almost underground, the project will generate a lot of excavation soil. Because there is no facility discharging pollutants such as factory in the project site, there is few possibilities to spread highly polluted soil to other areas. The depot construction of the project needs a lot of soil to form embankment. In case that the filling soil is contaminated, contaminants can scatter around the depot site. Therefore, when the project receives the soil, no contamination of the soil should be confirmed.

4) Waste

(1). Excavation Soil

Since the structure of the project is almost underground, the project will generate a lot of excavation soil (approximately 2.4 million cubic meters). There are no acts and regulations on soil disposal in Bangladesh. Although Dhaka City also has no regulation of disposal of excavation soil, disposal and reuse are promoted as followings.

(1). Applicants dealing soils register to Dhaka city (with desirable spec of soil).

(2). Dhaka city selects receivers of soil from the registered applicants, and informs soil owners of it.

(3). Soil owners disposes spoiled soils to designated dumping sites.

The study team interviewed RAJUK[2] about procedures of soil dumping. They mentioned that RAJUK does not secure soil dumping site, and the project proponents should consult with National Housing Authority, brick factory's owners[3] and developers. Moreover they informed that there is a development plan of filling soil on the east of Dhaka city to prevent flood disaster.

Regarding soil disposal, the project will require disposal to approved site by the government to contractors. Moreover, following policies are taken to reuse the excavation soil as possible. Tangible measures will be examined on construction plan of detail design.

(1). Excavation soil that is good conditions is stocked temporarily, and reused on the project as filling soil.

(2). Reuse for other projects or Use as pre-load material of extension of the depot site.

(2) Waste

Regarding waste disposal, to use disposal sites which are managed by Dhaka city[4], project proponents acquire a permit from Dhaka city and pay for disposal. Private disposal sites[5] also are available under an agreement.

Construction work of the project generates wastes: the operation of the project generates wastes from stations and the depot site. Hazardous waste must not be generated. Trash box will be installed at the stations. The waste of the project is disposed and reused appropriately under consultation with Dhaka city and a permit.

5) Noise and Vibration

For the purpose of understanding noise environment along the MRT Line1, an ambient noise survey was conducted. Nine survey points were allocated along the MRT Line 1 alignment. Table 5.6.6 and Figure 5.6.3 show the survey points.

The survey points are chosen in such a way that a representative data could be recorded all over locations.

Table 5.6.6 Noise Level Sampling Location of MRT Line 1

No.	Location	Geographic Coordinate
NL1-1	Kamlapur Station	23°43'49.48"N 90°25'30.93"E
NL1-2	Rajarbagh Station	23°44'21.0"N 90°25'15.0"E
NL1-3	Rampura Station	23°45'38.6"N 90°25'08.0"E
NL1-4	Badda Station	23°46'52.1"N 90°25'31.9"E
NL1-5	Notun Bazar Station	23°48'00.6"N 90°25'23.8"E
NL1-6	Jamuna Future Park Station	23°48'47.21"N 90°25'15.77"E
NL1-7	Airport Station	23°51'12.7"N 90°24'23.2"E
NL1-8	Bashundhara Station	23°49'39.2"N 90°25'56.1"E
NL1-9	Depot Site of Line 1	23°49'43.2"N 90°32'41.1"E

Source: JICA Study Team

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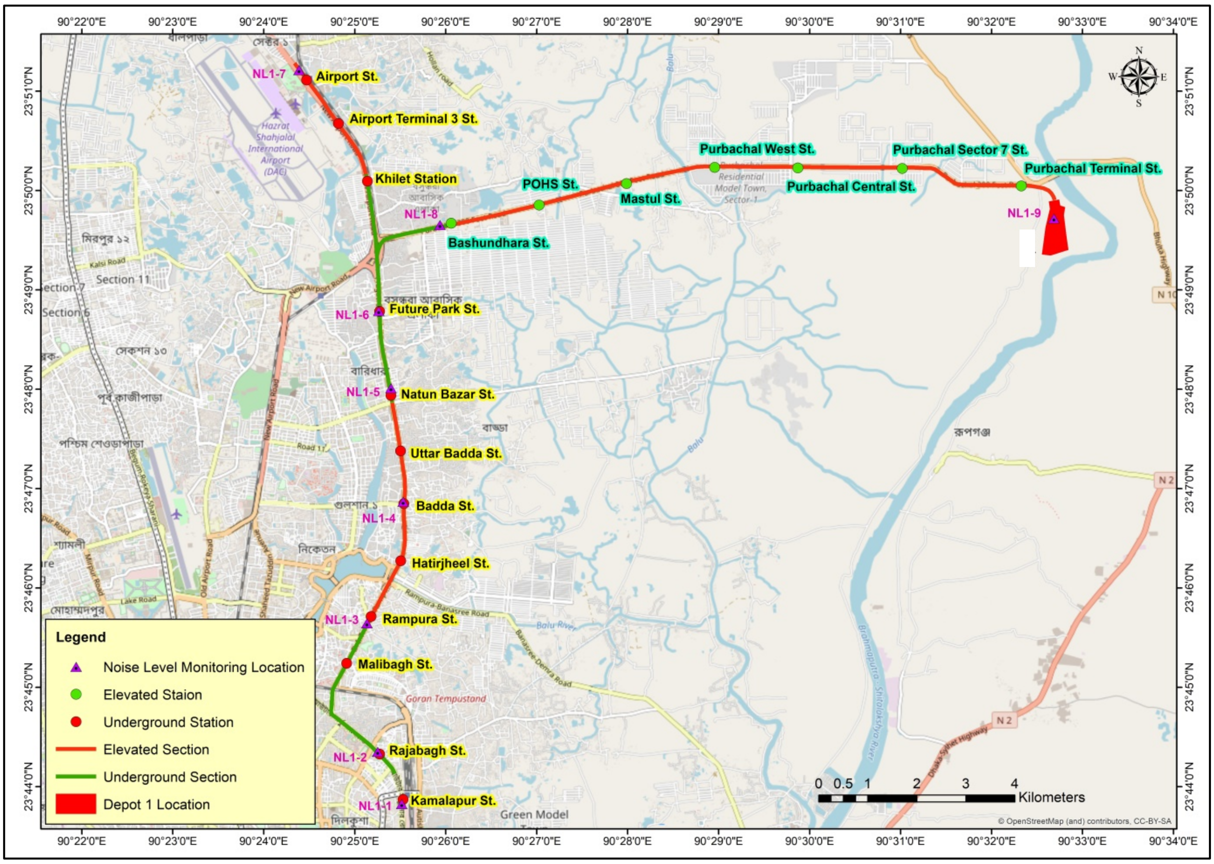
[2] Ashraf Islam, Project Director, Detailed Area Plan, RAJUK

[3] It is estimated that they supposed reuse as materials of brick.

[4] Matuali (south of Dhaka city), Amin Bazar (west of Dhaka)

[5] It depends on a land use plan.



Source: JICA Study Team

Figure 5.6.3 Noise Level Monitoring Location of MRT Line 1

Results of the ambient noise survey are shown on Table 5.6.7.

Table 5.6.7 Noise Level Analysis of the MRT Line 1

Code	Lmax	Lmin	Leq$_{day}$	Leq$_{night}$	L90	L50	L10	Area Setting*	Standard**	
									Day	Night
NL1-1	92.9	57.4	70.8	66.8	62.5	65.5	71.1	Commercial	70	60
NL1-2	83.2	42.6	68.3	63.0	59.4	63.7	69.9	Commercial	70	60
NL1-3	91.8	60.1	70.5	65.2	63.3	66.6	71.4	Commercial	70	60
NL1-4	84.8	61.2	71.7	65.9	62.4	66.8	72.5	Commercial	70	60
NL1-5	86.0	58.4	70.8	63.5	61.2	64.1	71.3	Commercial	70	60
NL1-6	87.3	63.1	70.4	64.7	60.2	63.8	70.2	Commercial	70	60
NL1-7	83.7	61.8	69.7	67.6	60.4	64.6	70.1	Commercial	70	60
NL1-8	79.4	49.3	65.7	56.4	56.9	59.4	66.3	Commercial	70	60
NL1-9	65.8	39.4	53.7	44.7	42.8	48.2	54.7	Residential	55	45

Source: JICA Study Team (Monitoring Date: 28th February, 2017 – 10th March, 2017)

* Area setting (according to the ECR, 1997)

**Standard according to the ECR, 1997 and subsequent amendment in 2006

▨ Exceeding Standard Level

Generally, ambient noise levels along the Airport Line are high and exceed standards of the ECR. It is estimated due to the urban activity including huge number of vehicle operation because the area is located along major roads.

Since the area along the project is almost commercial zone, ambient noise level is comparatively high.

On construction stage, some construction machinery will be operated. On the centre of

Dhaka, the structure is underground, alone the locations of the station have construction work above ground. Because basically the construction work will be conducted at the centre of road, noise damping by distance will be kept. Moreover, mitigation measures such as installation of noise barrier are hoped.

In this survey, no tangible construction plan is examined. On detail design stage, construction noise should be examined again.

On operation stage, railway noise will be expected on viaduct sections. There are no regulations or guidelines of railway noise in Bangladesh. Considering the railway noise guideline of Japan, the installation of noise barrier will reduce the noise, meet the criteria of the guidelines.

Depot site and station facilities such as ventilator may generate noise. Because tangible design has not examined yet, it should be examined on the detail design stage.

Regarding vibration, it is estimated that there are no negative impacts around the project site because there is no factory generating significant vibration. Construction work of the project, especially pile driving and earth work, may cause negative impacts of vibration around the project site. MRT Line 6 project which is going in advance is examining compensation for vibration grievance around the project site. The project adopts low vibration methods on pile driving and earth work as possible, and carry out monitoring of vibration.

On the operation stage, negative impacts of tunnel vibration are expected. However, instances of Japan show that observed vibration is below the threshold (55 dB). Therefore it is expected that negative impacts is negligible.

(1) Construction Noise

Noise level along the project site will increase due to construction activities. Most of the noise will be contributed by operation of heavy equipment and machineries. On the underground sections where are dense areas, construction work of alignment is carried out underground. Therefore, there is no noise problem on the construction work of alignment. On the other hand, because construction work of station and viaduct section are carried out on ground, there are concerns of negative impacts of noise. Study team shows an estimation of construction noise below.

- Prediction model: distance damping model of sound
- Condition of prediction: Noise source locates on the centre of road. Observed point is set on a road side. (Distance between noise source and observed point is 10m.) Installation of temporally wall (h=3m) is assumed as mitigation measures.
- Noise source: Expected typical construction activities are set. (NILIM)

Results of the prediction are shown on Table 5.6.8.

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Table 5.6.8 Results of Prediction of Construction Noise

Construction Work		Distance from the Edge of the ROW to Receiving Point (m)				Noise standard of Bangladesh Day time 6:00-21:00 Night: 21:00-6:00 (Leq: dBA)
Type	Power Level (dB)	0	5	10	15	
Without temporary wall						
D-wall	107	79.0	75.5	73.0	71.0	Residential area: 50/40 Mixed area: 60/50 Commercial area: 70/60
Pile drivers (earth drill)	106	78.0	74.5	72.0	70.0	
Pile drivers (hydraulic pile hammer)	135	107.0	103.5	101.0	99.0	
Excavation	119	91.0	87.5	85.0	83.0	
Asphalt pavement	108	80.0	76.5	74.0	72.0	
With temporary wall (3.0m)						
D-wall	107	60.0	57.5	55.0	53.0	Residential area: 50/40 Mixed area: 60/50 Commercial area: 70/60
Pile drivers (earth drill)	106	59.0	56.5	54.0	52.0	
Pile drivers (hydraulic pile hammer)	135	88.0	85.5	83.0	81.0	
Excavation	119	72.0	69.5	67.0	65.0	
Asphalt pavement	108	61.0	58.5	56.0	54.0	

Source: JICA Study Team

On the condition without temporary wall, generally noise levels are expected to be high. Temporary wall installed near the noise source has remarkable effect to reduce the construction noise. The temporary wall should be introduced as noise mitigation measures. It cannot be compared the prediction and the standards directly because the noise standard of Bangladesh evaluates by Leq. Leq depends on level and duration of noise. In case that the machinery operates 8 hours per day, the noise level is deducted approximately 3 dB, in case of 1 hour per day, approximately 12dB from the figure of Table 5.6.8.

Therefore operation hour of machinery should be shorten as possible by rational construction management. Since the standards of night time is 10 dB lower than daytime, the impacts at night are more. On the residential area such as Purbachal area, night time construction work on the ground should be avoided.

(2) Railway Noise

The Purbachal Line of MRT Line 1 takes viaduct structure. The operation of railway may cause noise impacts along the project site. Study team examined prediction of railway noise, evaluated and proposes noise mitigation measures based on a result of the prediction.

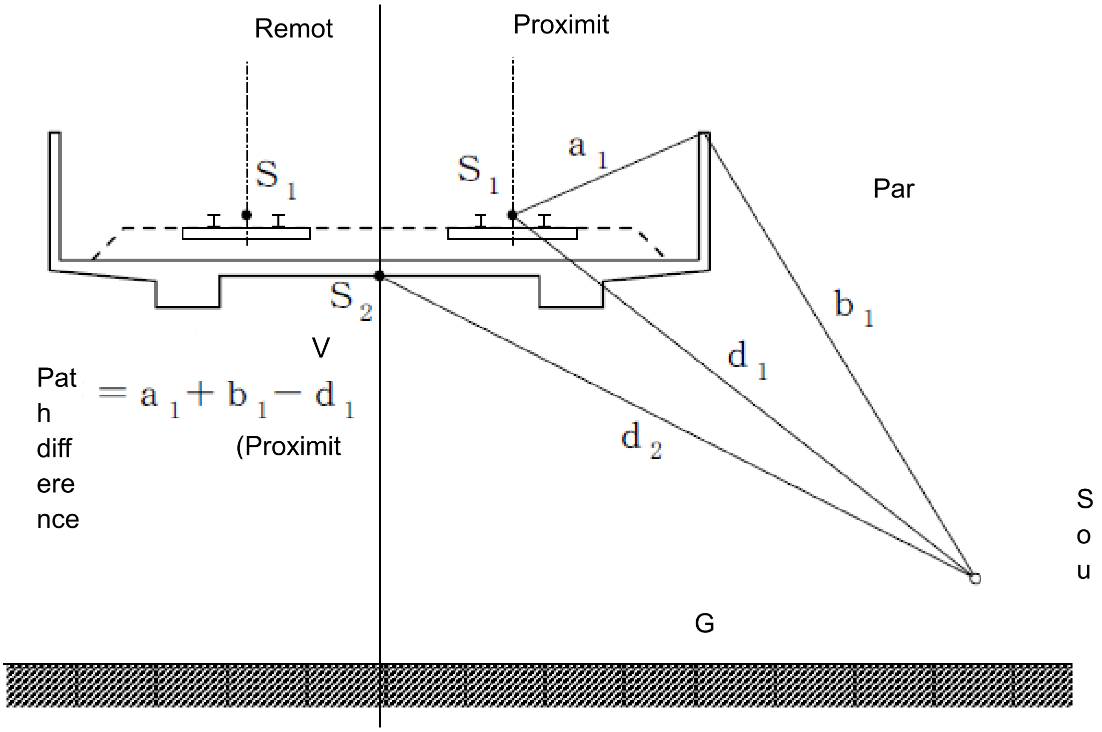
Based on section structure and train velocity, the maximum of the noise level at the time of the run of 1 train (L_{Amax}) is estimated firstly. Moreover single event sound exposure level (L_{AE}) is estimated from train transit time. Finally equivalent continuous sound pressure level (L_{Aeq}) by train number every train type of time zone is calculated.

- Prediction model

The prediction model by Japanese formula is applied. The noise by train operation compounds 3 main sound sources such as rolling noise of running train, structure sound from vibration of slab on concrete viaduct, and railway vehicle sound. The formula is calculated by combining these sound sources.

- Estimation of maximum value of noise level (L_{Amax})

The prediction formula for train length l m and train velocity V km/h indicates Formula 1 - 4 by definition of each variable shown in Figure 5.6.4.



S_1: Location of sound sources such as rolling noise, sound from motor fan etc

Source: Proposal of a Prediction Model for Noise of Conventional Railway, Noise Control Engineering 20(3), 1996, Institute of Noise Control Engineering, Japan

Figure 5.6.4 Arrangement of Sound Source, Sound Receiving Point and Explanation of Path Difference

(a.1) Rolling noise

$$L_{Amax}(R) = PWL_R - 5 - 10log_{10}d_1 + 10log_{10}\left(\frac{\left(\frac{l}{2d_1}\right)}{1+\left(\frac{l}{2d_1}\right)^2} + \tan^{-1}\left(\frac{l}{2d_1}\right)\right) + \alpha_1 \quad --- \text{Fomula 1}$$

Where, $L_{Amax}(R)$: maximum value of noise level (decibel)

PWL_R : Sound source power level (decibel)

$PWL_R = 30.0 \log_{10}(V) + 42.6$

D_1 : Distance between center of run orbit and sound receiving point (m)

L : Train length (m)

V : Train velocity (km/h)

α_1 : damping effect by balustrade (decibel)

(a.2) Structure sound

$$L_{Amax}(C) = PWL_C - 5 - 10log_{10}d_2 + 10log_{10}\left(\frac{\left(\frac{l}{2d_2}\right)}{1+\left(\frac{l}{2d_2}\right)^2} + \tan^{-1}\left(\frac{l}{2d_2}\right)\right) + \varDelta L_C \ --- \text{Formula 2}$$

Where, $L_{Amax}(C)$: Maximum value of noise level (decibel)

PWL_C : Sound power level of structure sound (decibel)

$PWL_C = 72$

d_2 : Distance between center of structure underside and sound receiving point (m)

$\varDelta L_C$: Correction value

$r < 4h$: $\varDelta L_C = 0$

$r > 4h$: $\varDelta L_C = - 10 \log_{10}(r/4h)$

r: Horizontal distance between center of viaduct and sound receiving point (m)

h: Height of viaduct underside from ground (m)

(a.3) Maximum value of noise level (L_{Amax})

The maximum value of noise level for one (1) train formation is calculated by combining noise levels calculated by Formula 1 - 2.

$$L_{Amax} = 10log_{10}\left(10^{\frac{L_{Amax}(R)}{10}} + 10^{\frac{L_{Amax}(C)}{10}}\right) --- \text{Formula 3}$$

b. *Relation between estimation of maximum value of noise level (L_{Amax}) and single event sound exposure level (L_{AE})*

The relation between estimation of maximum value of noise level (L_{Amax}) and single event sound exposure level (L_{AE}) is calculated by using Formula 4.

$$L_{AE} = L_{Amax} + 10log_{10}(l/(1000V/3600)) --- \text{Formula 4}$$

c. *Calculation of equivalent continuous sound pressure level (L_{Aeq})*

$$L_{Aeq} = 10log_{10}\left(\frac{1}{T}\sum_{i=1}^{n} 10^{L_{AEi}/10}\right) --- \text{Formula 5}$$

Where, L_{AEi}: Single event sound exposure level by direction and train type (decibel)

N : Number of trains

T : Time for L_{Aeq} (second)

- Condition of prediction:

Section		Purbachal Line
Prediction year		2035
Train length		20m x 8 cars
Maximum operation speed		100km/h
Total number of operated train(on-way)		131 Day time(7:00~22:00) 110 Night time (22:00~7:00) 21
Structure	Width of viaduct	3m+4m+3m
	Height of rail	8m
	Truck	Slab
	Rail type	Long rail
	Mitigation measures	Noise barrier H=1.0m, 1.5m

Criteria: Noise guideline values for the new project and large-scale modification of the conventional railway in Japan (Environmental Agency, 1995)

Results of the prediction are shown on Table 5.6.9.

Table 5.6.9 Prediction of Noise Level during Train Operation after

		Day time (7:00~22:00)	Night time (22:00~7:00)
Mitigation measures (Noise barrier)	No mitigation measures	68.2	63.2
	1.0m	55.9	51.0
	1.5m	55.4	50.4
Guideline values Noise guideline values for the new project and large-scale modification of the conventional railway in Japan (Environmental Agency, 1995)		60	55

Source: JICA Study Team

Without the mitigation measures, railway noise will exceed the guideline. With installation of noise barrier, railway noise is expected to meet the guideline. Since noise barrier is very common measures for noise mitigation, the installation of noise barrier is proposed as noise mitigation measures of the project.

6) Ground Subsidence

Based on geological survey, study team is examining suitable structure and construction method to secure ground stability. This F/S proposes shield tunnel boring for the alignment of underground, and open-cut method by D-wall for station structure. Details of structure and construction plan will be developed on D/D (detail design) study. Safety against ground subsidence should be continuously monitored on D/D study. On the construction, neighboring structures will be monitored to avoid negative impacts.

7) Bottom Sediment

As mentioned in “Water Quality”, the alignment passes through the water bodies by underground structure or bridge. Therefore the project will not directly cause negative impacts to bottom sediment.

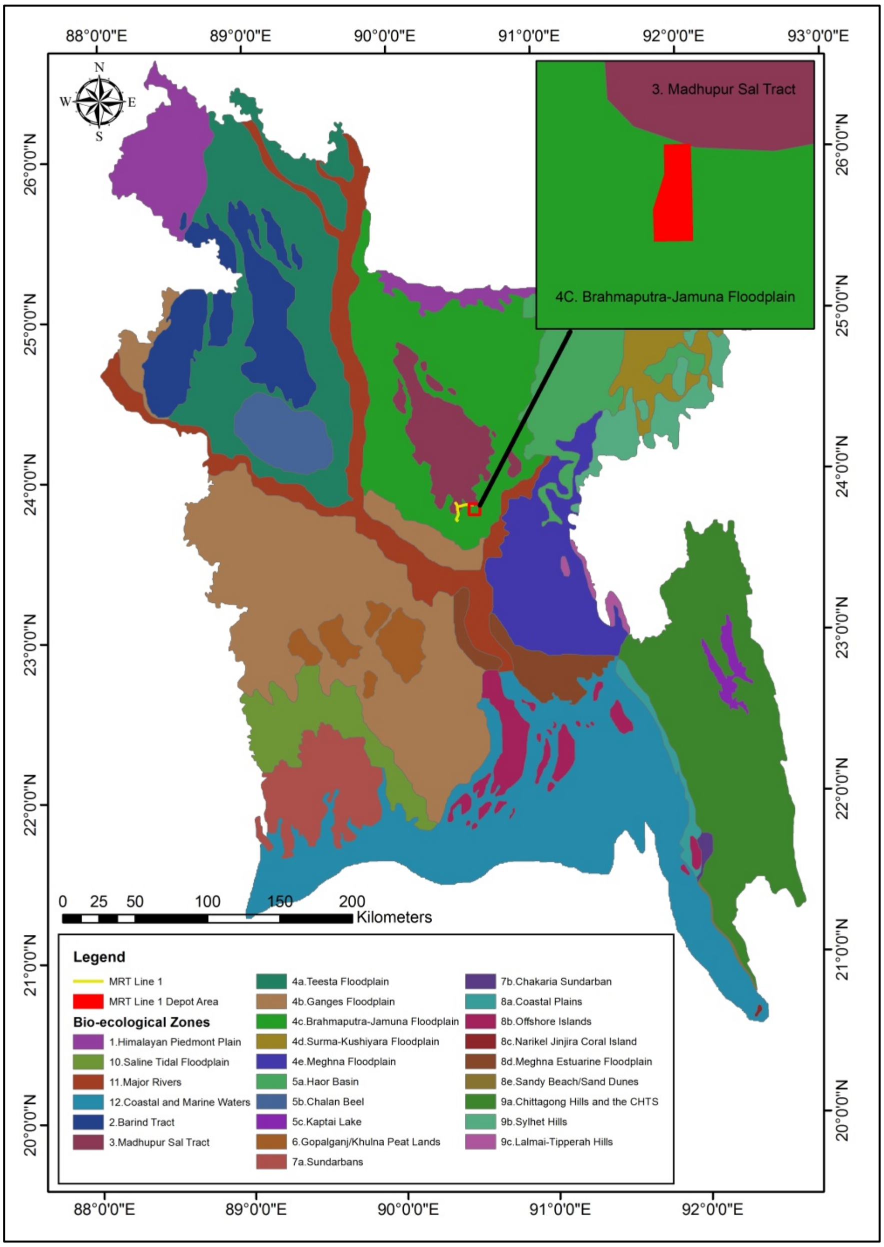
8) Ecosystem

(1) Ecosystem

In the project sites which are urbanized, the only Agro-ecosystem, Homestead ecosystem and wetland ecosystem are still existed in Purbachal area of Line1.

(2) Bio-Ecological Zone

Twenty-five bio-ecological zones have been delineated within Bangladesh by the IUCN. Six parameters were used to determine the areas including: physiography, soil, rainfall and temperature, floral distribution, faunal distribution and flood depth (IUCN 2002). The depot site falls in Brahmaputra-Jamuna Floodplain bio-ecological zone (Figure 5.6.5).



Source: IUCN, 2002

Figure 5.6.5 Depot Location in Bio-ecological Zones of Bangladesh

(3) Floral Component

Tree Species

In the depot site, a total of 59 species of plant were found under 34 families. Among all Mimosaceae family has been found highest (five times) and Verbenaceae (one time) has been counted lowest. Myrtaceae and Rutaceae found 4 time each and Fabaceae, Anacardiaceae, Arecaceae and Moraceae have been found 3 times among the families.

Among the tree species 46% are fruits bearing, 15% medicinal, 13% timber, 10% flower and firewood bearing and 4% are fruit bearing. Mango (Magnifera indica), Bamboo (Bambusa balcooa), Jackfruit (Artocarpus heterophyllus), Banana (Musa acuminata) are the dominant species in the depot area. The checklist of tree species has been provided in Table 5.6.10.

Table 5.6.10 Tree Species in Deport Area

Sl#	Common Namer	*Scientific Name*	Family	Uses	Red Data Book of Bangladesh (National Herbarium Bangladesh 2001)
	Mango	*Mangifera indica*	Anacardiaceae	Fruit	NE
	Coconut	*Cocos nucifera*	Arecaceae	Fruit, Fiber	NE
	Bengal currant	*Carissa carandas*	Apocynaceae	Fruit	NE
	Sugar-apples	*Annona squamosal*	Annonaceae	Fruit	NE
	Indian date	*Phoenix sylvestris.*	Arecaceae	Fruit & Juice	NE
	Indian ash tree	*Lannea coromandelica*	Anacardiaceae	Firewood	NE
	Pinwheel flower	*Tabernaemontana divaricata*	Apocynaceae	Flower	NE
	Date palm	*Phoenix dactylifera*	Arecaceae	Fruit	NE
	Hog plum	*Spondias mombin*	Anacardiaceae	Fruit	NE
	Tree turmeric	*Berberis aristata*	Berberidaceae	Medicinal	NE
	Papaya	*Carica papaya*	Caricaceae	Fruit	NE
	Muskmelon	*Cucumis melo*	Cucurbitaceae	Fruit	NE
	Arjun tree	*Terminalia arjuna*	Combretaceae	Medicinal	NE
	Country-almond	*Terminalia catappa*	Combretaceae	Fruit	NE
	Elephant apple	*Dillenia indica.*	Dilleniaceae	Fruit	NE
	Velvet apple	*Diospyros discolor*	Ebenaceae	Fruit	NE
	Jolphai	*Elaeocarpus serratus*	Elaeocarpaceae	Fruit	NE
	Tamarind	*Tamarindus indica*	Fabaceae	Fruit	NE
	Asian pigeonwings	*Clitoria ternatea*	Fabaceae	Flower	NE
	Flame tree	*Delonix regia*	Fabaceae	Timber	NE
	Meda	*Litsea monopetala.*	Lauraceae	Medicinal	NE
	Itchytree	*Barringtonia acutangula*	Lecythidaceae	Timber	NE
	Giant crepe-myrtle	*Lagerstroemia speciosa*	Lythraceae	Timber	NE
	Teak	*Tectona grandis*	Lamiaceae	Timber	NE
	Henna tree	*Lawsonia inermis*	Lythraceae	Medicinal	NE
	Indian bay leaf	*Cinnamomum tamala*	Lauraceae	Medicinal	NE
	Tulasi	*Ocimum sanctum*	Lamiaceae	Medicinal	NE
	Pomegranate	*Punica granatum*	Lythraceae	Fruit	NE
	Jackfruit	*Artocarpus heterophyllus.*	Moraceae	Fruit, timber	NE
	Ear leaf acacia	*Acacia auriculiformis.*	Mimosaceae	Timber	NE
	West-indian mahogany	*Swietenia mahagoni*	Meliaceae	Timber	NE
	Neem	*Azadirachta indica.*	Meliaceae	Medicinal	NE
	Blackberry	*Syzygium cumini.*	Myrtaceae	Fruit, firewood	NE
	Areca palm	*Areca catechu.*	Mimosaceae	Timber	NE
	Water rose apple	*Syzygium samarangense*	Myrtaceae	Fruit	NE
	Banana	*Musa paradisiac.*	Mussaceae	Fruit	NE

Sl#	Common Namer	*Scientific Name*	Family	Uses	Red Data Book of Bangladesh (National Herbarium Bangladesh 2001)
	Weeping paperbark	*Melaleuca leucadendron.*	Mimosaceae	Timber	NE
	Guava	*Psidium guajava.*	Myrtaceae	Fruit	NE
	Raintree	*Samanea saman.*	Mimosaceae	Timber	NE
	White siris	*Albizia procera.*	Mimosaceae	Timber	NE
	Cool mat	*Schumannianthus dichotomus*	Marantaceae	Fiber	NE
	Cluster fig tree	*Ficus racemosa*	Moraceae	Fruit	NE
	Bodhi tree	*Ficus religiosa.*	Moraceae	Wild	NE
	Night-flowering jasmine	*Nyctanthes arbor-tristis*	Oleaceae	Flower	NE
	Otaheite gooseberry	*Phyllanthus acidus*	Phyllanthaceae	Fruit	NE
	Asian palmyra palm	*Borassus flabellifer*	Palmae	Fruit	NE
	Bamboo	*Bambusa balcooa*	Poaceae	Household	NE
	Burmese grape	*Baccaurea ramiflora*	Phyllanthaceae	Fruit	NE
	Sugarcane	*Saccharum officinarum*	Poaceae	Fruit	NE
	Pomelo	*Citrus maxima*	Rutaceae	Fruit	NE
	Lemon	*Citrus limon*	Rutaceae	Fruit	NE
	Bael	*Aegle marmelos*	Rutaceae	Fruit	NE
	Elephant-apple	*Limonia acidissima*	Rutaceae	Fruit	NE
	Indian plum	*Ziziphus mauritiana*	Rhamnaceae	Fruit	NE
	Bur flower-tree	*Neolamarckia cadamba*	Rubiaceae	Flower	NE
	Sapodilla	*Manilkara zapota*	Sapotaceae	Fruit	NE
	Eggplant	*Solanum melongena*	Solanaceae	Vegetable	NE
	Litchi	*Litchi chinensis*	Sapindaceae	Fruit	NE
	Golden dewdrop	*Duranta erecta*	Verbenaceae	Flower	NE

Note: NE: Not evaluated

Source: JICA Study Team

Fallow Land Vegetation

Fallow lands were dominated by herb species of Durba Grass (Cynodon dactylon), Taro (Colocasia esculenta) Shame plant (Mimusa pudica), Scutchgrass (cynodon dactylon), Black nightshade (Solanum nigrum), Spiny amaranth (Amaranthus spinos), Goma flower (Leucas indica), Hill glory bower (Aleroden dronviscosum), Native Gooseberry (Physalis minima), Nut Grass (Cyperus rotundus), Ironweed (Vernonia cinerea), Yellow fruit nightshade (Solanum xanthocarpum), Caesarweed (Eurena lobata), Rattlebox Plant (Crotalaria pallida), Diamond burbark (Triumfetta rhomboidea), Rough cocklebur (Xanthium indicum), Indian heliotrope (Heliotropium indicum).

Grass Land Vegetation

7 families have been recorded with 12 different species and Cyperraceae family has been found maximum three times among those species. The second dominating family was Poaceae which was found twice during the survey tenure. Among the common grasses species Cyperus rotundus, Cynodon doctylon, Amaranthus philoveroides, Alternanthera sessilis, Alerodendron viscosum and Eurena loba were notable.

Aquatic Vegetation

During the survey time different water bodies were found around the project area. The aquatic vegetation survey has been conducted by visual observation and consultation with local people as well as secondary information sources.

It has been found different aquatic plants in the study area. The ecology team has been considered these for aquatic vegetation survey. Direct counting method by visual observation has been applied for the aquatic vegetation survey of this area.

A total number of nine aquatic plant species belonging to 8 families have found at the study area. Among them Convolvulaceae family have found maximum two times. But the population of Common water hyacinth was highest in and everywhere in the aquatic bodies of the study site. The checklist aquatic vegetation has been shown in the Table 5.6.11.

Table 5.6.11 Aquatic Flora in the Study Area

Sl	Scientific Name	Family	Common name	Local visual status
	Azolla sp	Salviniaceae	Mosquito fern	C
	Eichornia crassipes	Pontederiaceae	Common water hyacinth	VC
	Ipomea alba	Convolvulaceae	Tropical white morning-glory	R
	Ipomoea aquatica	Convolvulaceae	River spinach	C
	Hydrilla verticillata	Hydrocharitaceae	Esthwaite waterweed	C
	Calocasia esculenta	Araceae	Taro	VC
	Oxalis corniculata	Oxalidaceae	Procumbent yellow-sorrel	C
	Marselia sp	Marsileaceae	Four-leaf clover	R
	Enhydra fluctuans	Asteraceae	Marsh herb	C

Note: Local Visual Status: C- Common, VC- Very Common, R- Rare
Source: JICA Study Team

(4) Faunal Component

Birds (Avifauna)

A total of 31 species of birds were identified belongings to 11 families at the study area.

The highest number of birds dominated in the study area belonging to the family Corvidae. However, the birds belong to the family Accipitaridae, Ardidae has found as second dominated family among all. Homestead forest, grassland and bush, and some aquatic habitat of this area have supported the wild birds for feeding and roosting ground. All of the bird species found in this are least concern (LC) both locally and globally according to IUCN Red List 2015. A detail of bird's species checklist is shown in Table 5.6.12.

Table 5.6.12 Bird Species in the Depot Area

Sl. No	Common Name	Local Name	Scientific Name	Family	IUCN Global Status	IUCN BD Status
	Black kite	Bhubon chil	*Milvus migrans govinda*	Accipitridae	LC	LC
	Brahminy Kite	Shonkho Chil	*Haliastur Indus*	Accipitridae	LC	LC
	Indian pond heron	Kani Bok	*Ardeola grayii*	Ardeidae	LC	LC
	Cattle Egret	Goo Boga	*Bubulcus ibis*	Ardeidae	LC	LC
	Common King fisher	Chhoto Maachranga	*Alcedo atthis*	Alcedinidae	LC	LC
	White-throated kingfisher	Dhola gola Machranga	*Halcyon smyrnensis*	Alcedinidae	LC	LC
	Asian palm swift	Ashio Talbatashi	*Cypsiurus balasiensis*	Apodidea	LC	LC
	Ashy woodswallow	Metey Bonababil	*Artamus fuscus*	Artamidae	LC	LC
	Common Iora	Fotikjol	*Aegithina tiphia*	Aegithinidae	LC	LC
	Spotted dove	Tila Ghughu	*Streptopelia chinensis*	Columbidae	LC	LC
	House Crow	Patikak	*Corvus splendens*	Corvidae	LC	LC
	Large-billed crow	Dar kak	*Corvus macrorhynchos*	Corvidae	LC	LC
	Rufous treepie	Harichacha,	*Dendrocitta vagabunda*	Corvidae	LC	LC
	Black Drongo	Kala Fingey	*Dicrurus macrocercus*	Dicruridiae	LC	LC

Sl. No	Common Name	Local Name	Scientific Name	Family	IUCN Global Status	IUCN BD Status
	Bronze-winged Jacana	Jol Pipi	*Metopidius indicus*	Jacanidae	LC	LC
	Black hooded oriole	Halde Pakhi	*Oriolus xanthornus*	Oriolidae	LC	LC
	Oriental magpie robin	Doel	*Copsychus saularis*	Muscicapidae	LC	LC
	Asian Paradise Flycatcher	Dudhraaj	*Terpsiphone paradisi*	Monarchidae	LC	LC
	Purple sunbird	Moutushi	*Nectarinia asiatica*	Nectariniidae	LC	LC
	House sparrow	Pati choroi	*Passer domesticus*	Passeridae	LC	LC
	Black-rumped Flameback	Sonali kaththokra	*Dinopium benghalense*	Picidae	LC	LC
	Fulvous-breasted woodpecker	Batabi Kathkurali	*Dendrocopos macei*	Picidae	LC	LC
	Baya weaver	Babui	*Ploceus philippinus*	Ploceidae	LC	LC
	Red-vented Bulbul	Bangla bulbul	*Pycnonotus cafer*	Ptcnonotidae	LC	LC
	Rose ringed parakeet	Sobuj Tia	*Psittacula krameri*	Psittacidae	LC	LC
	Common myna	Salik/BhatSalik	*Acridotheres tristis*	Sturnidae	LC	LC
	Asian Pied Starling	Gobrey shalik	*Sturnus contra*	Sturnidae	LC	LC
	Chestnut-tailed Starling	Kath Shalik	*Sturnus malabaricus*	Sturnidae	LC	LC
	Jungle Myna	Jhunti Shalik	*Acridotheres fuscus*	Sturnidae	LC	LC
	Common Tailor Bird	Tuntuni	*Orthotomus sutorius*	Sylviidae	LC	LC
	Oriental White eye	Shetakkhi	*Zosterops palpebrosus*	Zosteropidae	LC	LC

Note: LC-Least Concern
Source: JICA Study Team

Amphibians and Reptiles

Two reptile species Bengal Monitor (*Varanus bengalensis*) and Spotted flapshell turtle (*Lissemys punctat)* were recorded by direct observation of the ecological team. But Focus Group Discussion (FGD) with local people provides some additional information about the availability of some other species. A total number of seven species of reptiles and three species of amphibians were recorded in the project area and among them Bengal Monitor is categorized as Near Threatened all rest of all are Least Concern according to the IUCN, 2015.

Table 5.6.13 List of Amphibians and Reptiles in Depot Area

Sl.#	Common Name	Local Name	Scientific Name	IUCN Bangladesh Status
Reptiles				
	House gecko	Tiktiki	*Hemidactylus frenatus*	LC
	Garden lizard	Roktochosa	*Calotes versicolor*	LC
	Checkered keel back	Dora shaap	*Xenochrophis piscator*	LC
	Common vine snake	Laudoga, sutanoli	*Ahaetulla nasuta*	LC
	Bengal Monitor	Gui Shap	*Varanus bengalensis*	NT
	Spotted flapshell turtle	Sundhi Kachim	*Lissemys punctat*	LC
	Indian Roofed turtle	Kori kaitta	*Pangshura Tecta*	LC
Amphibians				
	Asian Common Toad	Kuno bang	*Duttaphrynus melanostictus*	LC
	Indian Bull Frog	Kola bang, Sona bang	*Hoplobatrachus tigerinus*	LC
	Skipper frog	Katkati bang, Vensa bang	*Euphlyctis cyanophlyctis*	LC
Note: LC-Least Concern, NT-Near Threatened				

Source: JICA Study Team

Mammals

As like as the herpetofaunal investigation the presence of Asiatic Golden jacked and Irrawadi squirrel has been confirmed by observing their nest and sign. Furthermore, Focus Group Discussion (FGD) with local people allows to get some more information about other species. As a result it has been recorded total six mammalian species at the study area. Mammals that has found were Common mongoose (Herpestes edwardsii), Common Indian field mouse (Mus booduga) and Indian Fruit Bat (Pteropus giganteus), Indian pipistrelle (Pipistrellus coromandra). All of them are least Concern according to the IUCN, 2015.

Fishes

Two fish ponds has found in the depot area. After consultation with the owner of the pond and fish cultivator some fish species has recorded to be found at the study area. Furthermore, A total of 14 fish species under different families have been reported. The list of fish species is provided in the Table 5.6.14 .

Table 5.6.14 List of Fish in Depot Area

SL	Local Name	Common Name	Scientific Name	Family	IUCN Status
	Koi	Climbing perch	*Anabus testudines*	Anabantidae	LC
	Potka	Ocellated Pufferfsh	*Tetraodon cutcutia*	Ambassidae	LC
	Gulsha Tengra	Bleeker's Mystus	*Mystus bleekeri*	Bagridae	LC
	Choto Tengra	Tengara Catfsh	*Mystus tengara*	Bagridae	LC
	Tengra	Striped Dwarf Catfsh	*Mystus vittaus*	Bagridae	LC
	Kakila	Silver Needle Fish	*Xenentodon cancila*	Belonidae	LC
	Jat Punti	Spotfn Swamp Barb	*Puntius sophore*	Cyprinidae	LC
	Rui	Ruhu	*Labeo rohita*	Cyprinidae	LC
	Katol	Catla	*Catla catla*	Cyprinidae	LC
	Shol	Snakehead Murre	*Channa striatas*	Channidae	LC
	Taki	Spotted Snakehead	*Channa punctata*	Channidae	LC
	Shing	Stinging Catfsh	*Heteropneustes fossilis*	Heteropneustidae	LC
	Khailsha	Banded Gouram	*Trichogaster fasciata*	Osphronemidae	LC
	Sucker Fish	Suckermouth catfish	*Hypostomus plecostomus*	Loricariidae	LC

Source: JICA Study Team

Most of the project area is developed area. On the other hand, the depot location is still undeveloped. As results of field survey on the depot location, various species were observed. However, no rare species such as "threatened" of IUCN Red List were observed.

Although the vicinity of the depot site is going to be developed, some natural environment may be still remained. Monitoring of the natural environment around the project site should be conducted continuously.

9) Hydrology

As mentioned in "Water Quality", the alignment passes through the water bodies by underground structure or bridge. Therefore, the project will not directly cause negative impacts to hydrology.

10) Groundwater

To understand current conditions of groundwater quality along the MRT Line 1, water quality survey was conducted. Ground water samples were taken from 9 existing wells along the MRT line 1. The ground water samples were collected on 19th to 22nd March 2017. Detail Sampling Locations are provided in the following Table 5.6.15 and shown in the Figure 5.6.2.

Table 5.6.15 Ground water Sampling Location of MRT Line 1

SL#	Location	Sampling ID	Geographic Coordinate
	Near the Rajarbagh ST (Navana Circular Heights)	GW1-1	23°44'25.60"N 90°25'11.40"E
	Near the Rampura ST. (Health Care Pharmaceutical)	GW1-2	23°45'33.60"N 90°25'9.30"E
	Near the Hatirjeel St	GW1-3	23°45'59.60"N 90°25'16.50"E
	Middle Badda Pump House	GW1-4	23°46'53.20"N 90°25'28.20"E
	Car Selection (Car House) near Notun Bazar Station	GW1-5	23°48'7.83"N 90°25'26.22"E
	Ground Water Sample Collected from Development and Properties limited	GW1-6	23°48'48.60"N 90°25'15.50"E
	Khilkhet Pump House	GW1-7	23°49'36.30"N 90°25'4.80"E
	Armed Police Battalion Water Pump, Zone-9.	GW1-8	23°51'22.6"N 90°24'22.1"E
	Depot site of line 1	GW1-9	23°49'44.3"N 90°32'40.8"E

Source: JICA Study Team

Results of the survey are shown on Table 5.6.16. In Bangladesh, there is no standard for groundwater. Whole parameter of whole locations meets the permissible limit in accordance with the Environmental Conservation Rules, 1997 (Standards for drinking water). As drinking water, the underground water keeps good condition.

In Bangladesh, arsenic contamination of groundwater is crucial problem. Fortunately, concentration of arsenic is very low comparing the standards. Even comparing Japan standards on underground water quality (0.01mg/l: MoE, J), it is still low.

Table 5.6.16 Ground Water Quality of MRT Line 1

Parameter	Unit	GW1-1	GW1-2	GW1-3	GW1-4	GW1-5	GW1-6	GW1-7	GW1-8	GW1-9	ECR, 1997 Standard
Water Level	m	487	365	183	300	215	245	487	243	50	-
Colour	Hazen	0.9	1.4	1.0	1.6	1.2	0.8	1.3	1.1	1.0	15
Temperature	˚C	30	28.3	27.1	27.7	6.60	27.0	25.2	27.3	23.6	-
pH	-	6.20	6.81	7.0	6.62	6.43	6.43	6.36	7.3	7.6	6.5-8.5
Sodium	mg/l	29	32	39	19	15	39	15	14	26	200
Potassium	mg/l	1	3	1	2	2	2	2	2	4	12
Calcium	mg/l	18	35	2	7	4	10	7	7	18	75
Bicarbonate	mg/l	<LOQ	175	150	110	90	105	70	95	130	-
Chloride	mg/l	45	70	17	12	15	16	13	18	31	150-600
Sulfate	mg/l	1.0	24	1.0	1.0	1.0	1.0	1.0	3.0	2.0	400
Nitrate	mg/l	3.29	3.04	0.84	2.73	0.38	0.63	2.46	0.33	2.1	10
Nitrite	mg/l	0.08	0.15	<LOQ	<LOQ	<LOQ	0.07	<LOQ	<LOQ	0.02	<1.0
Arsenic	mg/l	0.002	0.002	0.001	0.004	0.001	0.001	0.001	0.001	0.001	0.05
Fecal Coliforms	N/ 100ml	0	0	0	0	0	0	0	0	0	0

Source: JICA Study Team, EQMS Laboratory and Department of Public Health and Engineering Lab; Analysis date: 22/03/2017- 30/04/2017 and 30/04/2017-22/05/2017, 30/04/2017-22/05/2017(Depot)

Note: LOQ- Limit of Quantitation

Dhaka city depends on groundwater for water supply. The underground structure may cause negative impacts to the ground water.

Groundwater level along the project site is approximately -67~57m[6]. Water extraction in Dhaka is conducted below 100m of ground level. (see “Water Level” of Table 5.6.16) The railway level of the underground structure is about -10m to -30m. Therefore, the underground structure will not cause negative impacts to the groundwater.

11) Geographical Features

(See “6) Ground Subsidence”)

12) Resettlement and Land Acquisition

The project will have direct impact on 115 PAUs including 32 title holders from the station areas. The PAUs cover 12 residential households (HHs), 101 CBEs and one residential cum CBEs and 02 households losing other properties. In addition to the PAUs 23 CPRs are going to be affected.

All these losses will be compensated, and it is expected that the APs will find their own place or means to resettle and rehabilitate them. Certainly the project will extend additional support to the vulnerable APs. Without RAP, restoration oh livelihood would be very difficult for them.

A total of 18.78 ha land will be required to be acquired for the depot area to implement the project. However, it is estimated that additional 0.23 ha of land will be required in different pockets along the route, mainly in the station areas.

13) Poor People

It is defined that annual income less than Tk 60,000 is hard core poor in Bangladesh. Considering the economic condition of the project area, these 23% affected households may be considered as hard core poor. The hard core poor and poor households will get special assistance under the policy of RAP. Special assistance will be paid to those who are women headed, old aged and physically handicapped and supported income generation activities under LIRP.

14) Ethnic Minorities and Indigenous Peoples

More than 98% of the affected HHs are Muslim and rest are Hindu by religious believe. No other religious group of people was identified among the affected people in the project area.

In Bangladesh, the term “indigenous people” is a generic term that includes many different cultural categories including ethnic minorities, tribals, upajati, paharis and jhumias. However, the most commonly used and preferred term today is adibasi, or ethnic minority which encompasses all of the above under one “identity” as indigenous people who have distinct social origins and cultural lives. They constitute nearly 1.1% of the total population of Bangladesh, with a major concentration in the Chittagong Hill Tracts (CHT) area. Among the project affected people no ethnic minority people have been identified in the project area.

15) Local Economies, such as Employment, Livelihood, etc.

Many of the stations under this project are located nearer to the business center where people usually gather. This is why people who are living around the area have established business and some small shops by some arrangement or are just encroachers on

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[6] Bangladesh Water Development Board

government land, where they got the opportunity. It is found that more than 87% household heads are involved in business. The study identified 146 people to be affected by losing their income for displacement of commercial and business premises. They are the principal bread earner of their families. Majority of them (76%) are engaged in business, 1.7% in service, 2.6% in household work, 7% are aged/retired and 1.7% household heads are involved in other type of occupation.

16) Land Use and Utilization of Local Resources

Almost total acquired area is rural in nature covering three types of land. Majority of the land is agriculture land followed by vita/homestead and rest is for khal (water body). However, majority of the land area where MRT routes would pass above and under the ground and the stations above and under the ground is owned by the government and mostly being used as road network in the city. Along these routes and station area most of the project affected units are business and commercial premises. People are having their livelihood and operating business by utilizing the road network facilities.

There are some green areas or some tree covered area in the project area. This area is again mostly around the depot area in Purbachal. The project will also require removal of approximately 126 thousand trees of various sizes and categories from the surveyed area. Majority are fruit bearing trees.

17) Water Usage

As mentioned on “Groundwater”, the project will not cause negative impacts the groundwater which is origin of water supply in Dhaka. Therefore, the project will not cause negative impacts to water usage.

18) Existing Social Infrastructures and Services

The project area covers both the DNCC and DSCC of Dhaka district and Rupganj Upazila of Narayanganj district and administered by Mayors and Chairmen/Councilors as part of local government. However, for administration the project area is within Dhaka and Narayanganj Districts. In addition to Dhaka district administration many other agencies are involved like RAJUK, DWASA, PDB, RHD and others.

The alignment of MRT will cross existing power cable, drinking water pipe, and water drainage etc., further study aims to specify those utilities and to take actions to protect or divert them.

19) Social Structure such as Social Capital and Local Decision-Making Institutions

The society in Bangladesh in general is a traditional society. However, the city society has some unique characteristics like any other city dwellers with diversified social back ground of the migrant people coming from different areas of the country.

The identified 23 Common Property Resources (CPR) as social institutions or resources which are going to be affected by the project. The CPRs include mosque, madrasa, school/college, graveyard, offices etc.

20) Misdistribution of Benefits and Damages

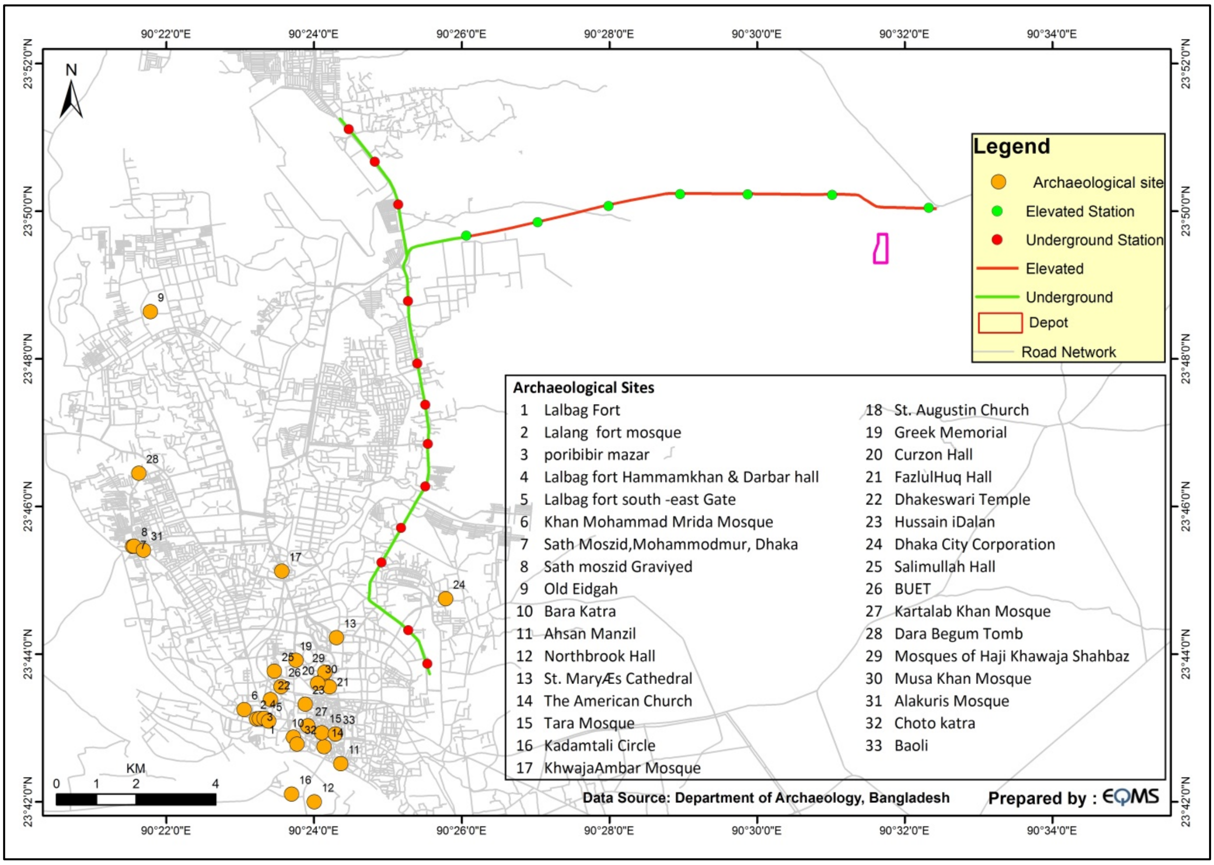
It is envisaged that the benefit of the MRT line will not be distributed evenly to all the people along the line equally. Certainly the people near the station area in general will be benefitted more. However, only the affected people will have to bear the burden of damages like loss of assets and livelihood. It is speculated that the economically solvent affected people will be able to recover their damages through receiving compensation and utilizing the locational opportunity of the new infrastructure provided by the project. But the vulnerable and marginal APs will be difficult without assistance and they need support on income generation activities under LIRP.

21) Local Conflicts of Interest

Local conflicts are mainly generated through abuse of power by some group of people or by some individuals. Local problems and conflicts are mainly resolved through local informal and formal groups with the help of representatives from local government and when necessary other respective agencies get involved.

22) Cultural Heritage

Dhaka has a lot of cultural heritage. However, the cultural heritages concentrated on the Old Dhaka area. As a result of the survey of secondary materials such as an official information (List of Monuments: Department of Archaeology), there is no cultural heritage around the project. The project will cause negative impacts to cultural heritages.



Source: Department of Archaeology, Bangladesh

Figure 5.6.6 Archaeological Heritage in Dhaka city

23) Landscape

On the section of Purbachal Line, viaduct structure is adopted. Since the area is still undeveloped but developing area, viaduct may affect landscape.

On stakeholder meetings (second stage), the attendants of the meetings were asked about issues of landscape. However, there are no response. Because tangible design cannot be proposed on the F/S stage, landscape and design of the viaduct should be continuously consulted with stakeholders on D/D stage.

24) Gender

As a result of focus group discussion which targeted women group, their needs were specified as follows.

Design of Station

- Separate ticket booths for male and female passengers
- Separate washrooms for male and female passengers
- Separate prayer rooms (space) for male and female passengers
- Adequate lighting facilities
- Clean waiting room (space) and platform
- Installation of escalator/lift
- Installation of drinking water facility
- Allocation of vendor (small business) area (space) for women

Design of Rolling Stock

- Separate compartments for male and female passengers
- Reserved/priority seats for pregnant women, women with young children, children, elderly people and physically challenged passengers
- Adequate lighting

Construction

- Employment of women for construction work
- Equal pay/work/opportunities for male/female workers
- Employment of women for construction project related work (e.g.: supporting staff, cooking, cleaning, laundry, catering, etc.)
- Separate prayer rooms (space), washroom, changing rooms, dining space (different timing between male/female for lunch break) for male/female workers/staff
- Provision of training to raise awareness on gender
- Provision of training on prevention of HIV/AIDS

Operation

- Deployment of female staff for both ground operation and on board
- Setting affordable fares
- Setting time schedule to meet women's needs
- Keep clean (station, platform, train, etc.)
- Responding to gender issues, measures on sexual harassment and implementation of those

Others

- Concerning the resettlement plan, consideration should be given to the women so that they will also be able to obtain financial compensation

- In relation with the above, not only the financial compensation but provision of employment opportunities should be also considered
- During the planning stage, women's opinions should be heard as well as women's participation of decision making should be secured

25) Children's Rights

As a result of the survey of maps, it was confirmed that some universities scattered around the project site. Because the structures of the project are viaduct and underground, school-commuting roads will not be divided. However, on the construction stage, appropriate considerations to secure the school-commuting roads will be required on construction plan.

26) Infectious Diseases such as HIV/AIDS

HIV prevalence rate is less than 0.1% and it is still low in Bangladesh. However, the sufferers are sometimes found among sex workers in Mongra and Chittagong. It is reported that that risk due to the turn used needles is much higher than sexual intercourse.

Influx of construction workers by the project may trigger the prevalence of the HIV/AIDS. To avoid the prevalence of the HIV/AIDS, Appropriate education and enlightenment for the construction workers should be introduced on construction sites.

27) Working Conditions (including Occupational Safety)

It is necessary to secure the safety of workers, pedestrians and vehicular traffics in both in construction and operation phases. Many temporary shops and vendors are found in crowded streets. There might be a possibility that those shops have tendency the lack of consideration on occupational safety. The construction sites have to pay attention to those small shop workers.

28) Trans-Boundary Impacts or Climate Change

Construction machinery will temporarily increase greenhouse gas. Reducing the emission of greenhouse gas, the machinery needs to well maintain. And/or the introduction of energy saving machinery is desirable.

On the depot site, it is expected that approximately 126 thousand trees are logged. Tree cutting losses absorption of greenhouse gas. Because annual CO2 absorption of a tree is roughly 80kg, totally CO2 absorption of roughly 10 thousand ton is lost. It is equivalent to CNG of roughly 3.7 thousand ton. As mitigation measures, the study team proposes replanting for tree cutting.

Train operation generates modal shift from vehicle traffic to mass transit system. The operation of the railway can increase greenhouse gasses by power consumption generated by thermal power plants. However, because train operation is remarkably energy saving measures comparing vehicle traffic, the project will contribute to reduce the emission of greenhouse gas. The implementation of the project will decrease 63,421t of CO2 emission a year.

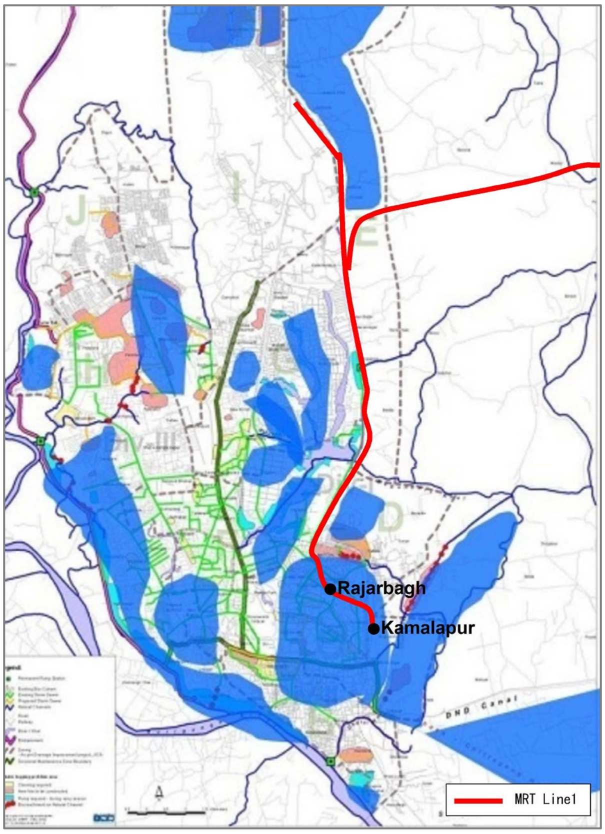
Table 5.6.17 Reduction Volume of CO2 Emission by MRT Line 1

		Value	Unit
Emission reduction		63421	tCO_2/year
Baseline emission		141648	tCO_2/year
Number of passenger of the project activity in year y		371,205,000	passenger/year
Average trip distance of the passenger of the project activity in year y		9.8	km
CO_2 emission factor per passenger kilometer for transport mode i	Auto Tempo	3.41945E-05	tCO_2/passenger-km
	Microbus	0.000117188	tCO_2/passenger-km
	Standard Bus	2.35647E-05	tCO_2/passenger-km
	Other1	0	tCO_2/passenger-km
	Other1	0	tCO_2/passenger-km
	Other1	0	tCO_2/passenger-km
Share of passengers by transport mode i in the baseline scenario in year y	Auto Tempo	7.289	%
	Microbus	15.729	%
	Standard Bus	76.982	%
	Other1	0	%
	Other1	0	%
	Other1	0	%
Project emission		78227	tCO_2/y
Annual electricity consumption associated with the operation of the project activity in year y		171550	MWh/year
CO_2 emission factor of the grid electricity		0.456	tCO_2/MWh

Source: JICA Study Team

29) Risk of Flood

Dhaka city is flood prone area. (see 2.3.2 Hazards) On the past major inundations, a part of the project such as Kamalapur, Rajarbagh has been inundated. (Figure 5.6.7)



Sourve: RSTP, Figure6.28 The inundation map of Greater Dhaka, 2004, location of MRT Line5 is added.

Figure 5.6.7 Inundation Risk around MRT Line1 (location of inundation on September, 2004)

Flood disaster may cause inundation to underground structure of the project. And the project may also encourage flood disaster. Against the negative impacts of flood and inundation, the project proposes the following mitigation measures.

(1). Mitigation measures on the project

Against potential risk of flood hazard, the project will introduce the anti-inundation measures taken in subway projects in Japan such as the followings.

- Provision of waterproof door at entrance of tunnel
- Vent and ventilation shaft are closed automatically by water sensor. Vent is installed on high place.
- Provision of drain pump

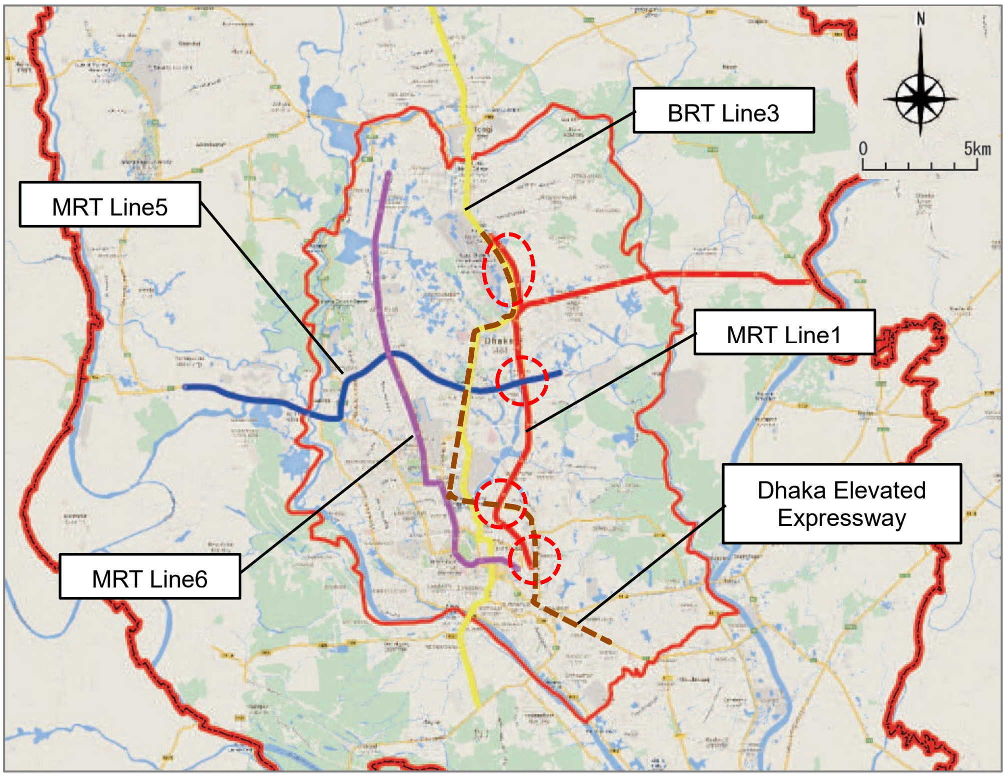
(2). Negative impacts by the project

Because of underground and viaduct structures, the alignment of the project does not hamper draining and flow of inundation, and does not encourage the flood disaster.

RSTP which is a basic plan of the project proposes the decentralization of urban areas. Backbone which supports the scenario is MRTs. The project is expected to connect suburb and urban areas effectively, and promote dispersion from inundation areas to suburb areas which is anti-disastrous.

5.6.2 Accumulated Impacts by other Projects

There are some major projects in Dhaka city. Due to overlapping with construction of other projects, it is expected that negative impacts increase. Particularly, it should be noted that negative impacts increase at crossing points or parallel sections especially on construction period. Therefore construction period of both projects needs to be confirmed. MRT Line 1 will cross Dhaka Elevated Expressway BRT Line3, LRT Line 5. (see Figure 5.6.8)



Source: JICA Study Team

Figure 5.6.8 Major Projects in Dhaka

1) Dhaka Elevated Express

Dhaka Elevated Express (DEE) is an elevated road project which connects Shahjalal International Airport, Mohakhali, Kamalapur and Dhaka Chittagong Highway. DEE crosses MRT Line 1 at Malibagh station, and parallels around International Airport.

DEE project is ongoing, and is going to reach the completion at December 2020. Since commencement of the construction work of MRT Line 1 is from the middle of 2021, construction work of both projects will not overlap. Therefore, accumulated impacts are not expected.

2) BRT Line 3

The route of BRT Line 3 is divided to North and South section. North section which ADB has sponsored connects Gazipur and Uttara. South section which WB has been sponsored connects Uttara (Airport) -Mohakhali – Ramna- Gulisthan -Keranigonj. A part of the south section of BRT Line 3 shares DEE route and MRT Line 1. Regarding BRT Line 3, some assessments on project feasibility are being conducted by project proponents and donors. Because BRT Line 3 will run existing road or proposed road, accumulated negative impacts will not significant even if construction works of the both projects overlap.

3) MRT Line 5

MRT Line 5 is an urban railway which connects the east and the west area in Dhaka city. MRT Line 5 crosses the project at the intersection at Natun Bazar. Natun Bazar station is a junction station with MRT Line 1 station. Stations of both projects adopt underground structure.

At present, Construction period of MRT Line 5 is from 2022 to 2027 to aim at the operation in 2028. Since the construction period of MRT Line 1 is from 2021, construction work of both projects may overlap. Natun Bazar is remarkably congested area. In case that construction work of both projects overlaps, negative impacts including deterioration of traffic congestion, air pollution and traffic noise are expected. To avoid accumulated negative impacts, construction schedule of both projects should be sufficiently managed.

4) Cumulative impacts on the Operation Phase

The project connects MRT Line 5 at Natun Bazar Station. The junctions will make more liveliness. On the other hand, it is expected that traffic concentration to the junctions causes more congestion. On development around the junctions, considerations to avoid the congestion is required.

5.6.3 Traffic Management in Construction and Expected Negative Impacts

Construction of the alignment is almost carried out at underground. However, because underground stations are constructed by open-cut method, road traffic will be affected by restriction of lanes. During the construction of stations, traffic management will be conducted to minimize restriction of lanes and a part of construction work will be conducted at night to avoid road congestion. (see) As negative impacts by lane control, traffic congestion and pollution caused by the traffic congestion are assumed.

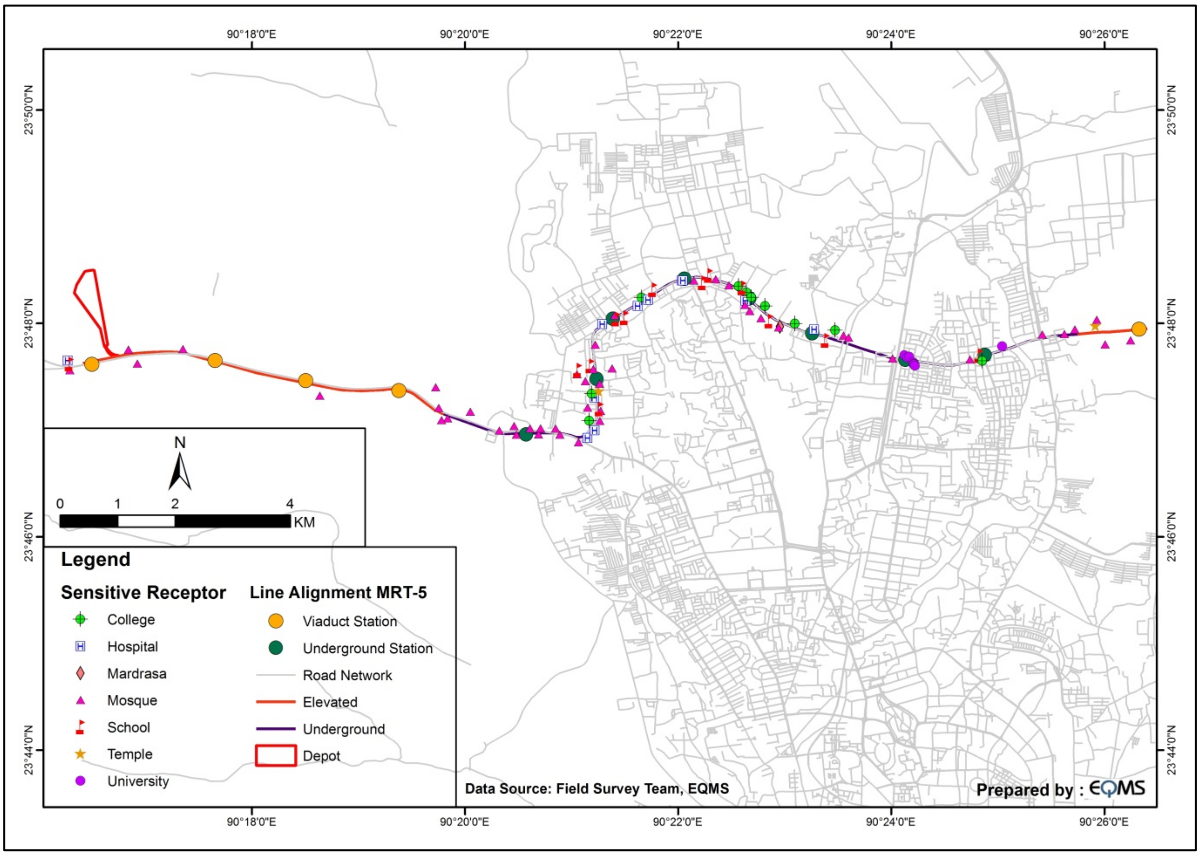
Regarding air pollution, because cause of the air pollution in Dhaka is thought of as dust, road congestion will not directly cause increase of dust. Regarding traffic noise, because it depends on traffic volume, traffic noise will not increase without increase of traffic volume.

5.6.4 Concentration of Vehicle Traffic around Stations

Because the project runs parallel to major roads, it is expected that the traffic volume of the major roads is reduced. On the other hand, it is also expected that vehicle traffic concentrates the new stations. In case that, noise and air pollution may be worsen. To handle the vehicle traffic smoothly and mitigate the negative impacts, appropriate developments around the stations are needed. In this study, suitable developments in front of / around the stations are studied.

5.6.5 Sensitive Facilities

The alignment of the project passes the urban area, and there is a lot of sensitive facilities along the alignment. Figure 5.6.9 shows locations of sensitive facilities such as educational, religious and medical institutes around the alignment of the project. Along the Airport line, Mosques are evenly scattering on the whole section. Comparing the religious facility, Educational and medical institutes are relatively few. Since the structure of the project is underground and viaduct, there is no possibility that the structure cuts access path to these facilities.



Source: JICA Study Team

Figure 5.6.9 Sensitive Facilities along MRT Line1

5.6.6 Considerations on Procurement of Materials

The project requires to procure general materials used on construction work. The quantity of concrete which is a main material is expected to approximately 180 thousand m3 (except pile work). Because aggregate which is raw materials of concrete is gathered from quarry sites, mass gathering of aggregate may cause negative impacts around quarry sites.

On the other hand, because Bangladesh is no mountainous, it is difficult to gather the aggregate, and depends on import from neighboring countries. The project also similar to other projects. (On the advance work of MRT Line 6 project, aggregate is imported from Thailand.) Because of import, it is out of object of EIA system of Bangladesh. (ECC for quarry site)

Regarding the considerations for material procurements including aggregate, the study team is consulting with the counterpart about the considerations including green procurements. On the consultation which is held on September 2017, this issue was discussed, and the counterparts mentioned that bidding documents can take the considerations on the material procurement. The study team proposes procurement from quarry sites which acquire environmental permit on each country as essential conditions on procurement. About more considerations including the green procurement, consultation is continued with the counterpart.

Construction of the depot site needs filling soil of approximately 720 thousand m3. Because specifications of the filling soil are fixed by detail design, so far location of procurement is not able to be fixed. The counterpart describes this based on the detail design. MRT Line 6 procures filling soil for the depot site from Megna river and Sylheti (north east of Bangladesh). it is expected that the project also follows it.

5.6.7 Issues on Projects assisted by other Donors

Around Dhaka city, BRT Line 3 (north section: Gazipur – Airport) assisted by ADB is being implemented. As results of interview to the person in charge of environmental and social matters[7], the following issues and problems were raised:

(Social Considerations)

(1). In Dhaka city, land rights are very complicate. It is very difficult to find out true owners of lands.

(2). It is difficult to acquire lands of apartments and commercial buildings. Power of land owners is very strong, and compensation cost is rocketing up.

(3). Identification of squatters and hawkers is difficult because they are wandering.

(Environmental considerations)

There is no problem on environmental matters.

As above, BRT Line 3 project has mainly land acquisition and social issues.

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[7] Md. Momenul Islam Mridha, Project Manager, Greater Dhaka Sustainable Urban Transport Project

5.7 The Assessment of Impacts

Draft scoping and results of the survey are shown on Table 5.7.1.

Table 5.7.1 Draft Scoping (MRT Line1)

No	Items	Evaluation				Reason of evaluation
		Scoping		After survey		
		Before/ under construction	Operation	Before/ under construction	Operation	
Pollution Control						
1	Air Pollution	B-	B+	B-	B+	Construction Phase: ･Construction works and operation of construction equipment will generate dust and exhaust gas. Convergence with construction work of MRT Line5 will cause more negative impacts. Operation Phase: ･Air pollution will be mitigated by reducing traffic congestion.
2	Water pollution	B-	B-	D	B-	･The project crosses the major water bodies by underground or viaduct structures. Therefore, there are few significant impacts of water pollution. However, to correspond uncertainty of construction plan, monitoring of the water pollution should be introduced. Operation Phase: ･Waste water from the depot and stations is treated to meet the standards of Bangladesh, and discharged. No mitigation measures may cause water pollution to water bodies.
3	Soil pollution	B-	B-	B-	B-	Construction Phase: ･Bad maintenance construction machinery and vehicles may cause soil contamination by leak of oil. In case that filling soil for embankment is contaminated, the vicinity of the depot site may be contaminated. In case that excavation soil is contaminated, there is a possibility of a spread of hazardous materials. Operation Phase: ･Maintenance facility of depot may cause soil contamination by leak of oil.
4	Waste	B-	B-	A-	B-	Construction Phase: ･Construction work will vast quantity of excavation soil. About suitable measure of the excavation soil should be proposed on D/D stage. Operation Phase: ･Illegal dumping from stations and depot may cause negative impacts on the environment.

No	Items	Evaluation				Reason of evaluation
		Scoping		After survey		
		Before/ under construction	Operation	Before/ under construction	Operation	
5	Noise and Vibration	B-	B-	B-	B-	Construction Phase: ・Without mitigation measures, construction works will cause noise and vibration. Operation Phase: ・Without mitigation measures, operation of trains may cause noise around viaduct sections.
6	Ground subsidence	C	C	B-	D	Construction /Operation Phase: ・Because appropriate methods will be adopted to avoid ground subsidence, there will be few negative impacts to ground subsidence.
8	Bottom sediment	B-	D	D	D	Construction Phase: ・The project crosses the major water bodies by underground structure. Therefore, there are few significant impacts of water pollution.
Natural Environment						
10	Ecosystem	B-	B-	B-	B-	Construction / Operation Phase: ・There are no negative impacts to rare species. However, monitoring survey is recommended to minimize negative impacts to the ecosystem including Near Threaten species around the depot site. In case that some impacts are found, appropriate mitigation measures are examined and implemented. For logged trees found on the detail design phase, replanting is implemented and monitoring.
11	Hydrology	C	C	D	D	Construction / Operation Phase: ・The project crosses the major water bodies by underground structure. Therefore, there are few significant impacts of water pollution.
12	Groundwater	B-	D	D	D	Construction / Operation Phase: ・Because extraction level of groundwater in Dhaka city is below underground structure of the project, there will be few impacts to groundwater. However, to correspond uncertainty of forecast, monitoring of the groundwater is proposed.
13	Geographical features	B-	D	D	D	Construction Phase: ・Because appropriate methods will be adopted to avoid ground subsidence, there will be few negative impacts to ground subsidence.
Social Environment						

No	Items	Evaluation				Reason of evaluation
		Scoping		After survey		
		Before/ under construction	Operation	Before/ under construction	Operation	
14	Resettlement/ Land Acquisition	A-	D	A-	A-	Pre-Construction Phase: ・A 19.01 ha of large scale land acquisition and 525 PAPs are assumed. Operation Phase: Impact will remain if RAP is not carried out appropriately. ・Impact will be small when the prepared RAP is applied.
15	Poor people	A-	A-	A-	A-	Construction Phase: ・Poor whose income is less than 60,000 BDT are living in the project sites are affected. Operation Phase: ・Further impact will be mitigated by the prepared RAP.
16	Ethnic minorities and indigenous peoples	C	C	D	D	Construction / Operation Phase: ・No ethnic minority or indigenous people is found, therefore Impacts is nil.
17	Local economies, such as employment, livelihood, etc.	B-/B+	C	D	D	Construction / Operation Phase: ・Some extent of negative impacts are assumed, however those will be small because of the new business opportunity created by MRT.
18	Land use and utilization of local resources	B-/B+	B+	B+	B+	Construction / Operation Phase: ・Some extent of negative impacts were assumed, however those will be very small.
19	Water usage	C	C	D	D	Construction / Operation Phase: ・Because extraction level of groundwater in Dhaka city is below underground structure of the project, there will be few impacts to groundwater.
20	Existing social infrastructures and services	C	C	B-	B-	Construction / Operation Phase: ・Gates and fence will be affected with some extent.
21	Social structure such as social capital and local decision-making institutions	C	C	D	D	Construction / Operation Phase: ・Negative impacts to local administrations will be assumed very small.
22	Misdistribution of benefits and damages	B-	B-	B-	B-	Construction / Operation Phase: ・Since the benefits will be not distributed evenly, misdistribution will arise among them.
23	Local conflicts of interest	B-	B-	D	D	Construction / Operation Phase: ・Local conflict will be solved with the help of respective local agency, therefore impact will be very small.
24	Cultural heritage	C	C	D	D	Construction / Operation Phase: ・There is no cultural heritage in/around the project site.

No	Items	Evaluation				Reason of evaluation
		Scoping		After survey		
		Before/ under construction	Operation	Before/ under construction	Operation	
25	Landscape	B-	B-	B-	B-	Before Construction / Construction Phase: ･So far there is no concerns of stakeholders. However considerations on viaduct design is needed.
26	Gender	C	C	D	D	Construction / Operation Phase: Following measures will be taken in accordance with the Gender Action Plan. In construction phase: ・ Equal pay/work/opportunities for male/female workers. ・Provision of separate toilet ・Resettlement planning which consider gender issue. In operation phase: ・Deployment of female staff ・Separate compartment, reserved/priority seat for women ・ Equal pay/work/opportunities for male/female workers
27	Children's rights	C	C	D	D	Construction / Operation Phase: ･There is a lot of educational facility. The structures of the project are underground and viaduct. Therefore school-commuting road will be divided by the project. However, on the construction period, considerations to secure the school-commuting road is required.
28	Infectious diseases such as HIV/AIDS	B-	D	B-	D	Construction Phase: ･Infection risks of HIV/AIDS may be increased among construction workers. Operation Phase: ･Since the Project aims improvement of urban traffic, the project will not directly concern spread of infection risks of HIV/AIDS.
29	Working conditions (including occupational safety)	B-	B-	B-	B-	Construction Phase: ･Inappropriate safety measures of contractor will deteriorate occupational safety. Operation Phase: ･Inappropriate safety measures of railway operator will deteriorate occupational safety.
Others						
30	Trans-boundary impacts or climate change	B-	B+/-	B-	B+	Construction Phase: ･Operation of construction machinery and vehicles will occur greenhouse gas (CO2). Tree cutting loses absorption of CO2. By replanting, the loss is avoidable. Operation Phase: ･Modal shift to from vehicles to railway will reduce greenhouse gas.

No	Items	Evaluation				Reason of evaluation
		Scoping		After survey		
		Before/ under construction	Operation	Before/ under construction	Operation	
31	Accidents	B-	B-	B-	B-	Construction Phase: ･There is a risk of accident on construction activity. Operation Phase: ･Collision of vehicle and viaduct, and accident in depot are expected.
32	Risk of flood	C	C	B-	B-	Construction / Operation Phase: ･Because the project site has a risk of flood, detail of mitigation measures is examined on detail design phase.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected
* Impact Items refer to "JICA Guidelines for Environmental and Social Considerations April 2010"
Source: JICA Study Team

5.8 Mitigation Measures and Costs

Regarding the items which were evaluated as A-, B-, or C on the scoping matrix (Table 5.7.1), mitigation measures are shown on Table 5.8.1 and Table 5.8.2.

Table 5.8.1 Mitigation Plan and Cost on Construction Phase

No	Items	Mitigation Measures	Cost	Responsibilities of implementation
1	Air Pollution	･ Water spray on construction site to prevent dust generation ･ Suitable and continuous maintenance of construction machinery to control exhaust gasses ･ Installation of temporary walls on the construction sites ･ Formulation of rational construction plan to reduce operation hours of construction machinery	To be included in service fee of construction	Contractor (supervised by DMTC)
2	Water pollution	･ Suitable and continuous maintenance of construction machinery to prevent oil leak ･ Periodic monitoring water quality of crossing rivers	To be included in service fee of construction Monitoring cost is shown on Table6.9.1.	Contractor (supervised by DMTC)
3	Soil pollution	･ Suitable and continuous maintenance of construction machinery to prevent oil leak ･ Check contamination of soil for the depot embankment ･ Check contamination of excavation soil	To be included in service fee of construction	Contractor (supervised by DMTC)
4	Waste	･ Regarding disposal of the excavation soil, less negative impact measure will be studied and taken.	To be including service fee of consultation	Contractor (supervised by DMTC)

No	Items	Mitigation Measures	Cost	Responsibilities of implementation
5	Noise and Vibration	· Suitable and continuous maintenance of construction machinery to control noise emission · Installation of temporary walls on the construction sites to prevent noise propagation · Formulation of rational construction plan to reduce operation hours of construction machinery · Monitoring of construction noise	To be included in service fee of construction Monitoring cost is shown on Table6.9.1.	Contractor (supervised by DMTC)
6	Ground subsidence	· Appropriate planning of construction plan on detail design phase · Confirmation houses along the project site before construction work · Monitoring of shoring on construction work	To be included in detail design fee To be included in construction cost	Contractor (supervised by DMTC)
10	Ecosystem	· Monitoring of ecosystem around the depot site · Tree planting to mitigate tree cutting	Tree planting cost: 63 million BDT Monitoring cost is shown on Table6.9.1.	Contractor (supervised by DMTC)
12	Groundwater	· Monitoring of ground water level and quality during construction period and until one year after completion	Monitoring cost is shown on Table6.9.1.	Contractor (supervised by DMTC)
13	Geographical features	· Same as No.6 Ground subsidence		
14	Resettlement/ Land Acquisition	· Appropriate implementation of land acquisition and resettlement based on RAP	To be shown on RAP	DMTC,
15	Poor people	Ditto	Ditto	DMTC
22	Misdistribution of benefits and damages	Ditto	Ditto	DMTC
25	Landscape	· Information disclosure and continuous discussion with residents, and adoption of opinions of residence to secure landscape	To be included in service fee of construction	DMTC, Contractor
27	Children's rights	· Information disclosure and continuous discussion with residents · Preparation of construction plan to secure school-commuting roads	To be included in service fee of construction	Contractor (supervised by DMTC)
28	Infectious diseases such as HIV/AIDS	· Education and enlightenment for construction workers to prevent prevalence of HIV/AIDS	To be included in service fee of construction	Contractor (supervised by DMTC)
29	Working conditions (including occupational safety)	· Preparation of work safety plan and implementation	To be included in service fee of construction	Contractor (supervised by DMTC)
30	Trans-boundary impacts or climate change	· Suitable and continuous maintenance of construction machinery to reduce fuel consumption · Introduction of energy saving construction machinery	To be included in service fee of construction	Contractor (supervised by DMTC)
31	Accidents	· Installation of suitable safety facility on construction site · Suitable use of personal safety equipment to secure safety of workers · Education and enlightenment for construction workers to prevent accidents	To be included in service fee of construction	Contractor (supervised by DMTC)

No	Items	Mitigation Measures	Cost	Responsibilities of implementation
32	Risk of flood	・ Preparation of hazard management plan to avoid flood damage on construction period	To be included in service fee of construction	Contractor (supervised by DMTC)

Source: JICA Study Team

Table 5.8.2 Mitigation Plan and Cost on Operation Phase

No	Items	Mitigation Measures	Cost	Institutional Responsibilities
2	Water pollution	・ Check of waste water from stations and maintenance facilities	To be included in routine operation	DMTC (Operator)
3	Soil pollution	・ Suitable and continuous maintenance of maintenance facility of depot to prevent leak of oil and other chemicals	To be included in routine operation	DMTC (Operator)
4	Waste	・ Enlightenment for users to prevent illegal dumping from stations ・ Preparation of waste management plan including depot operation	To be included in routine operation	DMTC (Operator)
5	Noise and Vibration	・ Introduction of noise mitigation measures such as noise barrier on viaduct sections ・ Suitable and continuous maintenance of rail structure to reduce noise generation	To be included in the project cost to be finalized during D/D	DMTC (Operator)
10	Ecosystem	・ Monitoring of ecosystem around the depot site ・ Tree planting to mitigate tree cutting (4 trees per a logged tree)	Replanting cost: To be shown on table6.9.1.	DMTC (Operator)
15	Poor people	・ Confirm APs if displacement is carried out appropriately in accordance with RAP. ・ Confirm the present situation of APs	DMTC will hire outsourced monitoring firm.	DMTC
23	Misdistribution of benefits and damages	・ Confirm APs if displacement is carried out appropriately in accordance with RAP. ・ Confirm the conducted compensation and LIRP are appropriate or not.	DMTC will hire outsourced monitoring firm.	DMTC
25	Landscape	・ Information disclosure and continuous public consultation, ・ Mitigation plan to secure landscape to incorporate public opinions (on detail design phase)	To be included in detail design fee	DMTC
29	Working conditions (including occupational safety)	・ Preparation of operation plan to secure occupational safety	To be included in routine operation	DMTC (Operator)
31	Accidents	・ Preparation of operation plan to secure occupational safety	To be included in routine operation	DMTC (Operator)
32	Risk of flood	・ Development of safety management plan ・ Maintenance of anti-flood facilities of alignment and stations	To be included in routine operation	DMTC (Operator)

Source: JICA Study Team

5.9 Monitoring Plan

5.9.1 Monitoring plan

In Bangladesh, there is no system of environmental monitoring and inspection. To prevent deterioration of environment and social situation, monitoring of environment and social items which were evaluated as possible negative impacts should be monitored, reported and inspected. Monitoring plans are shown on Table 5.9.1 and Table 5.9.2.

Table 5.9.1 Monitoring Plan and Cost on Construction Phase

No	Items	Method of monitoring	Locations	Frequency	Cost	Responsibilities of implementation
1	Air Pollution	Confirmation of mitigation measures on a construction plan	-	One time before commencement of construction work	To be included in consulting fee	Consultant（DMTC）
		Confirmation of implementation of mitigation measures on field	Construction sites	During construction period	To be included in consulting fee	Consultant (DMTC)
		Sample collection and laboratory analysis PM10, PM2.5, NOx	6 locations	Two times a year 24 hours	4,500,000BDT a year	Contractor (supervised by DMTC)
2	Water pollution	Confirmation of mitigation measures on a construction plan	-	One time before commencement of construction work	To be included in consulting fee	Consultant（DMTC）
		Confirmation of implementation of mitigation measures on field	Construction sites	During construction period	To be included in consulting fee	Consultant（DMTC）
		Sample collection and laboratory analysis DO, COD, PH, TSS oil grease, and total coliform index.	3 locations	Two times a year	1,200,000BDT a year	Contractor (supervised by DMTC)
3	Soil pollution	Confirmation of records of construction activities (regular maintenance of construction machinery)	Construction sites	During construction period	To be included in construction cost	Contractor (supervised by DMTC)
		Referred to 6.9.2				
4	Waste	Confirmation of records of construction activities	Construction sites	During construction period	To be included in construction cost	Contractor (supervised by DMTC)
5	Noise and Vibration	Confirmation of mitigation measures on a construction plan	-	One time before commencement of construction work	To be included in consulting fee	Consultant（DMTC）

No	Items	Method of monitoring	Locations	Frequency	Cost	Responsibilities of implementation
		Confirmation of implementation of mitigation measures on field	Construction sites	During construction period	To be included in consulting fee	Consultant（DMTC）
		Noise measurements Vibration measurements	9 locations	One time a month 24 hours	5,000,000BDT a year	Contractor (supervised by DMTC)
6	Ground subsidence	Confirmation of mitigation measures on a construction plan	-	One time before commencement of construction work	To be included in consulting fee	Consultant（DMTC）
		Confirmation of implementation of mitigation measures on field	Construction sites	During construction period	To be included in consulting fee	Consultant（DMTC）
		Confirmation of records of construction activities	Construction sites	During construction period	To be included in construction cost	Contractor (supervised by DMTC)
10	Ecosystem	Survey of fauna and flora	Depot site	One time a year	1,000,000BDT a year	Contractor (supervised by DMTC)
12	Groundwater	Sample collection and laboratory analysis Groundwater level and quality Colour, Temperature, pH, Sodium, Potassium, Calcium, Bicarbonate, Chloride, Sulfate, Nitrate, Nitrite, Arsenic, Fecal Coliforms	5 locations	One time a year 4 time a year for groundwater level	1,650,000BDT a year	Contractor (supervised by DMTC)
13	Geographical features	Same as “6 Ground subsidence”				
14	Involuntary resettlement	Implementation record on land acquisition/resettlement	Implemented sites	During land acquisition and resettlement	Included in Consultant fee	I-NGO
15	Poor people	Yearly income of APs	Vulnerable people	Before and after resettlement	Included in Consultant fee	I-NGO
22	Misdistribution of benefits and damages	Yearly income of APs	Implemented sites	Before and after resettlement	Included in Consultant fee	I-NGO
25	Landscape	Confirmation of records of public consultations	Along viaduct sections	During detail design	To be included in detail design fee	DMTC

No	Items	Method of monitoring	Locations	Frequency	Cost	Responsibilities of implementation
28	Infectious diseases such as HIV/AIDS	Confirmation of records of construction activities	Construction sites	During construction period	To be included in construction cost	Contractor (supervised by DMTC)
29	Working conditions (including occupational safety)	Confirmation of safety plan of construction work	-	One time before commencement of construction work	To be included in consulting fee	Consultant（DMTC）
		Confirmation of records of construction activities	Construction sites	During construction period	To be included in consulting fee	Consultant（DMTC）
30	Trans-boundary impacts or climate change	(Maintenance of construction machinery) Confirmation of construction records	Construction sites	During construction period	To be included in consulting fee	Consultant（DMTC）
		(Replanting) Confirmation of records of construction activities and field reconnaissance	Subject fields	After completion of replanting	To be included in consulting fee	Consultant（DMTC）
31	Accidents	Confirmation of safety plan of construction work	-	One time before commencement of construction work	To be included in consulting fee	Consultant（DMTC）
		(Implementation of safety plan) Confirmation of records of construction activities	Construction sites	During construction period	To be included in consulting fee	Consultant（DMTC）
32	Risk of flood	Confirmation of safety plan	-	One time before commencement of construction work	To be included in consulting fee	Consultant（DMTC）
		(Implementation of safety plan) Confirmation of records of construction activities	Construction sites	During construction period	To be included in consulting fee	Consultant（DMTC）

Source: JICA Study Team

Table 5.9.2 Monitoring Plan and Cost on Operation Phase

No	Items	Monitoring Methods	Locations	Frequency	Cost	Responsibilities of Implementation
2	Water pollution	Sample collection and laboratory analysis DO, COD, PH, TSS oil grease, and total coliform index.	1 location around the drainage of the depot site	Two times a year	400,000BDT a year	DMTC (Operator)
3	Soil pollution	(Depot site) Confirmation of maintenance records of maintenance facilities	Depot site	Every month	To be included in a project cost	DMTC (Operator)
4	Waste	(Stations and depot site) Confirmation of operation records	Stations and depot site	Every month	To be included in a project cost	DMTC (Operator)
5	Noise and Vibration	Noise measurements Vibration measurements	3 locations along the viaduct section	Yearly	150,000BDT a year	DMTC (Operator)
10	Ecosystem	Survey of fauna and flora	Depot site	Yearly during two years after launching operation	1,000,000BDT a year	DMTC (Operator)
12	Groundwater	Sample collection and laboratory analysis Groundwater level and quality Colour, Temperature, pH, Sodium, Potassium, Calcium, Bicarbonate, Chloride, Sulfate, Nitrate, Nitrite, Arsenic, Fecal Coliforms	5 locations	Yearly Quarterly for groundwater level)	1,650,000BDT a year	DMTC (Operator)
15	Poor people	Yearly income of APs	Vulnerable people	Once	DMTC	Out-sourced monitoring firm
22	Misdistribution of benefits and damages	Yearly income of APs	Implemented sites	Once	DMTC	Out-sourced monitoring firm

No	Items	Monitoring Methods	Locations	Frequency	Cost	Responsibilities of Implementation
29	Working conditions (including occupational safety)	Confirmation of occupation safety plan	-	Before implementation of operation	To be included in a project cost	DMTC
		Confirmation of operation records	-	During operation	To be included in a project cost	DMTC
32	Risk of flood	Confirmation of safety management plan	-	Before implementation of operation	To be included in the project cost	DMTC
		Maintenance for anti-flood facilities of the alignment and stations	-	During operation	To be included in the project cost	DMTC

Source: JICA Study Team

5.9.2 Monitoring of Soil Contamination

Because the structure of the project is mostly underground structure, construction of the project generates vast quantity of excavation soil. In case that the excavation soil is contaminated, contaminants may scatter to other places. On the contrary, depot site needs vast quantity of soil for forming embankment. In case that the embankment soil is contaminated, the vicinity of the depot site may be contaminated. To prevent spread of contaminants, monitoring of soil contaminant should be conducted on carrying soil in and out,

1) Carrying out of Excavation Soil

(1) Soil Contamination Monitoring on Whole Section

On the whole construction section, excavation soils are sampled and analysed. Status of soil contamination is confirmed. (Frequency of sampling: roughly 1 sample / 200 thousand m3)

(2) Monitoring of Unnatural Soil Contamination

Sources of contaminants in ROW (such as factory) are found by map reading and field reconnaissance. For the source of contaminants, possible contaminants are identified by hearing survey from the land owners and residents around the site. In case that there is high probability of discharge of contaminants, soil contamination is monitored by sampling survey. (Frequency of sampling: roughly 1 sample / 1,000m2)

(3) Management of Contamination Soil

In case that results of monitoring show significant high concentration comparing standards, management and mitigation measures for disposal of contamination (such as containment, purification, elimination and etc.) is examined.

(4). Implementation and Management

Regarding soil contamination survey, DMTC (consultant committed by DMTC) instructs sampling locations considering the conditions of construction sites, and contractors carries out the survey. From the results of the survey, DMTC assesses existence or nonexistence of soil contamination. In case that the site is contaminated, DMTC and the contractor consult with Dhaka city and carry out it to appropriate sites.

2) Carrying in of Embankment Soil

(1) Identification of Origin of Soil

On borrow pits of filling soil, information such as location, status of land use, existence of contaminant source and land history are found by map reading, field reconnaissance and hearing survey.

(2) Confirmation of Soil Contamination

In case that no discharge of contaminants is confirmed as results of (1), natural soil contamination is confirmed by sampling survey. (Frequency of sampling: 1 sample / every site) In case that discharge of contaminants is confirmed, soil contamination is confirmed around the source of contaminants by sampling survey. (Frequency of sampling: roughly 1 sample / 1,000m2) If concentration of contaminants is remarkably high, no filling soil is acquired from the site.

(3) Implementation and Management

Regarding soil contamination survey of filling soil, DMTC (consultant committed by DMTC) confirms sites of filling soil materials, and assesses necessity of soil contamination survey. In case of necessity, the contractors carry out the soil contamination survey. DMTC confirms the result of the survey, and assessed procurement from the site.

3) Contaminants and Standards

Soil contaminants which affect human health by intake are shown on Table 5.9.3. As criteria, soil contamination standards of Japan or other countries are referred.

Table 5.9.3 Example of Soil Contaminants

Category	Contaminants	
Volatile Organic Compounds (VOCs)	chloroethylene carbon tetrachlorid 1,2-dichloroethene 1,1-dichloroethylene sys-1,2- dichloroethylene 1,3- dichloropropene	dichloromethane tetrachloroethylene 1,1,1-trichloroethane 1,1,2- trichloroethane trichloroethylene benzene
Heavy Metal	cadmium and compounds hexavalent chrome cyanogen compound mercury and compounds selenium and compounds	lead and compounds arsenic and compounds fluorine and compounds boron and compounds
Pesticide/PCB	simazine benthiocarb thiuram	PCB organic phosphorus

Source: Law of Soil Contamination Protect (Japan), Annex

5.9.3 Reporting and Inspection

Results of the monitoring survey need to be reported, and reflected to conservation of environment and social condition.

On the construction phase, most of the monitoring are implemented by contractors. The contractors compile monitoring reports from the results of the monitoring, and submit the reports to DMTC. DMTC submits the monitoring reports to JICA and relating donors. Moreover, DMTC should share the reports with DoE. Although there is no legal basis of

DoE's involvement to the monitoring, DoE's involvement is recommended to be inspected from specialist point.

On the operation phase, DMTC (operator) has a responsibility of the implementation of the monitoring. DMTC compiles monitoring reports from the results of the monitoring, and submit the reports to JICA and relating donors. As same as construction phase, DMTC should share the reports with DoE.

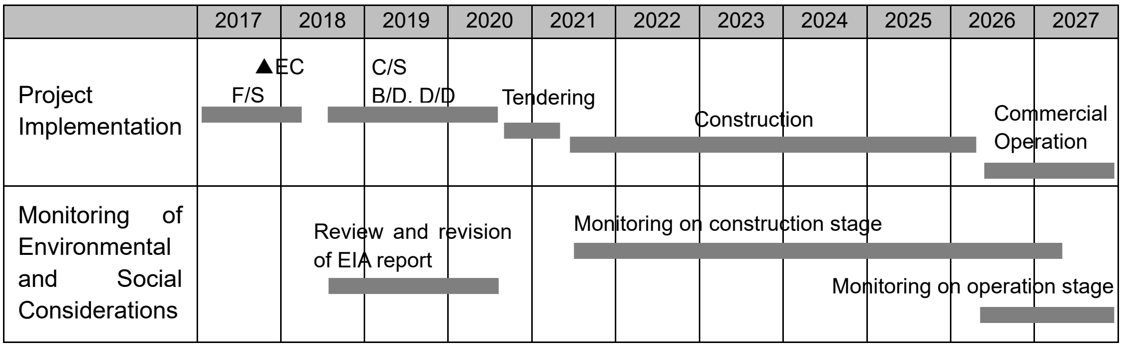
Table 5.9.4 Monitoring report

	Construction Phase	Operation Phase
Preparation	By contractors	By DMTC (operator)
Contents of report	Progress of construction works Results of monitoring Implementation status of mitigation measures Issues to be solved, and etc.	Progress of operation works Results of monitoring Implementation status of mitigation measures Issues to be solved, and etc.
Frequency	quarter during construction period	Half-yearly
Submission	To DMTC DMTC submits to JICA and relating donors, and shares with DoE	To JICA and relating donors DMTC shares with DoE

Source: JICA Study Team

Monitoring schedule is shown on Table 5.9.5.

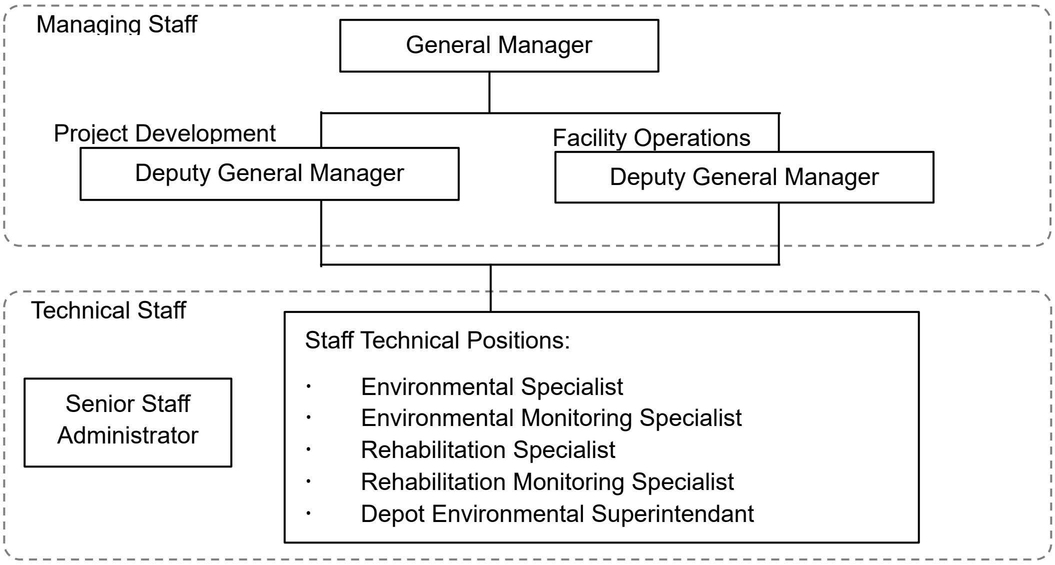
Table 5.9.5 Monitoring Schedule



Project schedule is based on 4.10.3, Figure4.10.2.

5.9.4 Implementation Structure

Implementation structure of the environmental and social considerations for the project follows the operation of MRT Line 6. MRT Line6 organizes an operation section (referred to 4.11.1) in DMTCL (Dhaka Mass Transit Company Limited). ERD（Environment and Rehabilitation Division） prepared in this section handles the management of environmental matters except land acquisition and resettlement. Organization of ERD is shown on Figure 5.9.1. ERD conducts; instruction and supervision for environmental management of contractors; monitoring; and report to JICA. MRT Line 6 proposes procurement of environmental survey equipment for environmental management. However because an environmental survey requires special knowledge and technical skill, the study team recommends commission to consultants.



Source: Environmental Impact Assessmnet Main Report of Consultancy Services for Design, Construction Supservision, Procurement support and Managemnet of Dhaka Mass Rapid Transit Development Project (January 2016, DMTCL)

Figure 5.9.1 Organization Chart of ERD

5.10 Stakeholder Meetings (EIA)

To collect opinions of the stakeholders including residents near the project site and reflect the opinions to the project, stakeholder meetings were held on 4 venues along the MRT Line 1 route. the stakeholder meetings have two stages. The first stage is meetings to explain the outlines of the project and EIA study. The second stage is meetings to explain the outlines of expected impacts by the project and mitigation measures.

5.10.1 First Stage Stakeholder meetings

Date/Venue/Number of participants	March 19, 2017 / Shahjadpur Bazar, Shahjadpur /48 persons March 20, 2017 / Yusufganj high School and College, Purbachal / 30 persons March 29. 2017 / Bangamata Shekh Fazilatunnesa Mujib Government Secondary School, Uttara, Dhaka / 41 persons March 30, 2017 / Purba Rampura High School, Rampura / 56 persons
Contents	Explanation of project outlines Project outlines, alignment, location of stations (explained by Google Earth) Explanation of EIA, scoping and potential environmental impacts Gathering of public opinions
Methods of inform of meetings	Informed through local politician, local governments, leader of women, NGO (disable, gender, minority and others), publicity on the street, visit to houses on the vicinity

Table 5.10.1 Opinions on Stakeholder Meetings (First round)

Category	Comment/Question	Answer and Policy of Countermeasure
Planning	Shahjadpur is a densely populated place. A lot of people move everyday here. So we demand a station at our place shahjadpur bazaar.	We will recommend this issue to design team. They will consider it accordingly.
	It will be tough to mobilize from road to stations because of its higher depth and height.	We will recommend this issue to design team. They will consider it accordingly.
	Is there any plan of separate toilet/washroom for women in the metro rail and station?	Yes. We will recommend it in our EIA report.
	How many days will it take to start and complete?	It will take almost 4-5 years from beginning.
	Direction label/sign should be in Bengali so that people can easily understand how to travel.	Yes. We will recommend it in our EIA report.

Category	Comment/Question	Answer and Policy of Countermeasure
	We need a station at our bazaar. (Purbachal)	It will be reviewed by the design consultant.
	How many days it will take to be completed?	It will take approximately 4-5 years to complete the total project from beginning.
	The total number of station need to be increased in metro rail line-1.	We will recommend it to the design team.
	I also demand a MRT from airport to kaliganj.	Design team will consider the alignment accordingly.
	Bangladesh is developed day by day and such kind of mega projects are the proof.	Yes, thank you for your complement.
	Want to know the process of Oxygen supply and Emanation of Carbon dioxide gas at the underground station.	Design team will be considered this issue during design the underground station
	I am interested to know about the financial issues like total budget, who will fund it, percentage of interest etc.	JICA will fund for the project. Total budget not yet finalized
	What kind of fuel will be used to run the Metro Rail? If the electricity supply turned off or failed then what will be the alternative plan?	Metro rail will be powered by electricity. There will be a backup plan to run the Metro rail to run the Metro Rail.
	How much earthquake resistance capacity has been considered to design the metro rail	Metro rail design not yet started. Now the feasibility study is going on. Earthquake resistance capacity will be considered during the details design stage.
	Is there any disaster management plan? Is there any coordination among the different roads, flyover, and metro rail projects?	Yes, a detail disaster management plan will be prepared and followed accordingly The metro rail will be constructed after getting consent from different authorities related to the proposed alignment.
	Is there any chance of confliction with the existing flyovers?	No there is no chance of confliction with existing flyovers. Authority will design the project in collaboration with different agencies
Construction	Excessive dust might be generated during construction phase. So it should be a major concern for authorities. And I hope our road side area will be beautified like Hatirjheel by this project.	Yes, we will recommend it in our EIA report.
	During the construction period huge traffic congestion will be taken place so alternative traffic route need to be find out. Is there any possibility of ground water pollution?	Yes. We will recommend it in EIA report. There is no possibility of ground water pollution. Advanced technology will be used. All types of mitigation measures related to the environmental pollution will be recommended in EIA report
	What will happen if the place be flooded during tunnel construction?	It will cover in the Disaster Management Plan.
Environment	Is there any possibility of damage of nature in our area?	No. There are no possibilities of damage any properties in this area. All types of mitigation measures will recommend.
	Bangladesh needs information technology based educated society. So that people can easily take all types of advanced technology. About 0.5 million people live here (Daskhin Khan) and dust pollution will make a hazardous situation for this people. So authorities should take step like water spray or any other to mitigate dust pollution.	Yes, authority will take step to mitigate all types of pollution. We will recommend suggestion in EIA report to control the dust and other pollution
	Due to different types of environmental or other impact metro rail track need to be planned underground. How authority will mitigate the negative impact during the construction period of elevated section?	Mitigation measures for environmental impact will be recommended in the EIA report and authority will be followed strictly during the construction as well as operation period
Land Acquisition and Resettlement	If there will any damages or loss then authority should give proper compensation to the land and property loser.	Yes it will be compensated if there will any damages or loss. Updated technology will be used in this project so that no loss or damages expected.

Category	Comment/Question	Answer and Policy of Countermeasure
	As far I understood almost 60 percent line will be constructed as a flyover in metro rail line 1. So I am scared about the land acquisition process.	Land acquisition team will clarify this issue.

5.10.2 Second Stage Stakeholder meetings

Date/Venue/Number of participants	July 23, 2017 / Ichapura Bazar, Purbachal / 28 persons July 27, 2017 / Kawlar, Hazicamp, Airport / 37 persons July 29, 2017 / 18 No ward, DNCC, Kalachadpur / 27 persons July 30, 2017 / N23 No ward, DNCC, Khilgaon / 32 persons
Contents	Explanation of project outlines Project outlines, alignment, location of stations (explained by Google Earth) Explanation of EIA, scoping and potential environmental impacts Gathering of public opinions
Methods of inform of meetings	Informed through local politician, local governments, leader of women, NGO (disable, gender, minority and others), publicity on the street, visit to houses on the vicinity

Table 5.10.2 Opinions on Stakeholder Meetings (Second round)

Category	Comment/Question	Answer and Policy of Countermeasure
Planning	What kinds of fuel will be used for running the metro rail?	Metro rail will be run by electricity.
	Is there any possibility to crisis of Oxygen at the underground?	There will be ventilation system in the metro rail system which will maintain the oxygen supply.
	What will be the depth of underground tunnel of metro rail?	The average depths of the metro rail will 30 m. It might depend so much upon the control point. It will be finalized during the detail design stage.
	What will be the underground metro rail depth and its viaduct height?	The underground depth will be average 30 m. The viaduct section height will vary from 13-20m. It will be finalized during detail design stage.
	What is the main difference between elevated and underground sections?	For the elevated section traffic congestion will be a major concern and the width of present road will be reduced. No traffic congestion will occur for the underground section and no need to take land acquisition.
	Have any possibility to increase traffic congestion at the station section?	Overall traffic congestion will be reduced due to run of metro rail. Citizen of the city will move from one place to another within a short time. Traffic management plan will be followed to reduce the traffic congestion in the station area.
	Metro rail should be constructed as early as possible to reduce the huge traffic congestion in the city.	Thank you for your valuable comments.
	Development of communication system is the prerequisite for a country development. It's a great step to make metro rail in the city. Need more station for more benefit to the local people.	Thank you for your compliments.
	As early possible need to end the construction of the metro rail.	Thank you for your comments.
	How much earthquake resistance capacity has been considered to design the metro rail?	Earthquake resistance capacity will be considered in the final design of the metro rail.
	If flood occur in the underground section what will happen?	Flood management provision will keep in the design.
	If there is an accident in the underground	An emergency management will be provided in the EIA report.

Category	Comment/Question	Answer and Policy of Countermeasure
	section what step will be taken to manage?	Emergency exit point will be included in the final design.
	If there any alternative of electricity during the emergency case of metro rail operation?	Yes, alternative electricity source will be kept at the metro rail.
	To reduce the huge traffic congestion at Dhaka city, Metro rail will be the best option.	Thank you for your positive comment.
	Govt. should be taken earlier to construct the Metro rail. It is one of the best ways to move fast from one side to other side of the Dhaka city. As the communication system increase, business will be increased, living standard will be changed. It will reduce the sufferings of people.	Thank you for your comments.
Construction	Need proper monitoring at the construction phase to reduce traffic congestion	Traffic management plan will be prepared and followed accordingly.
Environment	What types of steps will be taken against air pollution?	Water will spray in the high dust generation area and details mitigation plan has been incorporated in the EIA report.
	What will be the major environmental pollution due to the metro rail construction	As the MRT 1 Line will be mostly underground so minimum environmental impact will be taken place. During construction, main environmental impacts will be dust pollution, noise pollution & vibration, traffic congestion. A comprehensive mitigation plan has been recommended in the EIA report to minimize the environmental impact.
Land Acquisition and Resettlement	Is there any possibility to acquire the land?	Total 18.78 ha of land need to be acquired for depot area
	Is there any possibility to acquire the land except the depot area?	No, there is no possibility of land acquisition except the depot area.
	How much land will be acquired for this project?	Total 18.78 ha of land need to be acquired for the depot area.
	How much land will be acquired for this project?	Total 18.78 hectares of land need to acquire for MRT line-1.

5.10.3 Summary of Opinions of Stakeholders

Opinions of the stakeholders are classified into: planning, construction, environment, land acquisition and resettlement.

About the planning issues, there are questions on structure such as depth of underground, schedule of operation opening, disaster mitigation plan including earthquake and flood. Some participants proposed introduction of separate toilet for women and language of sign board. Since these are general matters adopted in other railway projects, opinions on the planning will be adopted (except installation of a new station).

A lot of participants raised concerns on construction phase including environmental issues. The concerns include pollution, especially dust control and groundwater pollution, construction management such as traffic control.

About the environmental issues, outline of negative impacts, impacts by construction and impacts on rivers were asked. The mitigation measures which are proposed must be implemented definitely.

About the land acquisition and resettlement, expected size of land acquisition and a level of compensation were asked. And appropriate and prompt compensation were requested. Based on RAP prepared on this study, land acquisition and resettlement must be implemented appropriately.

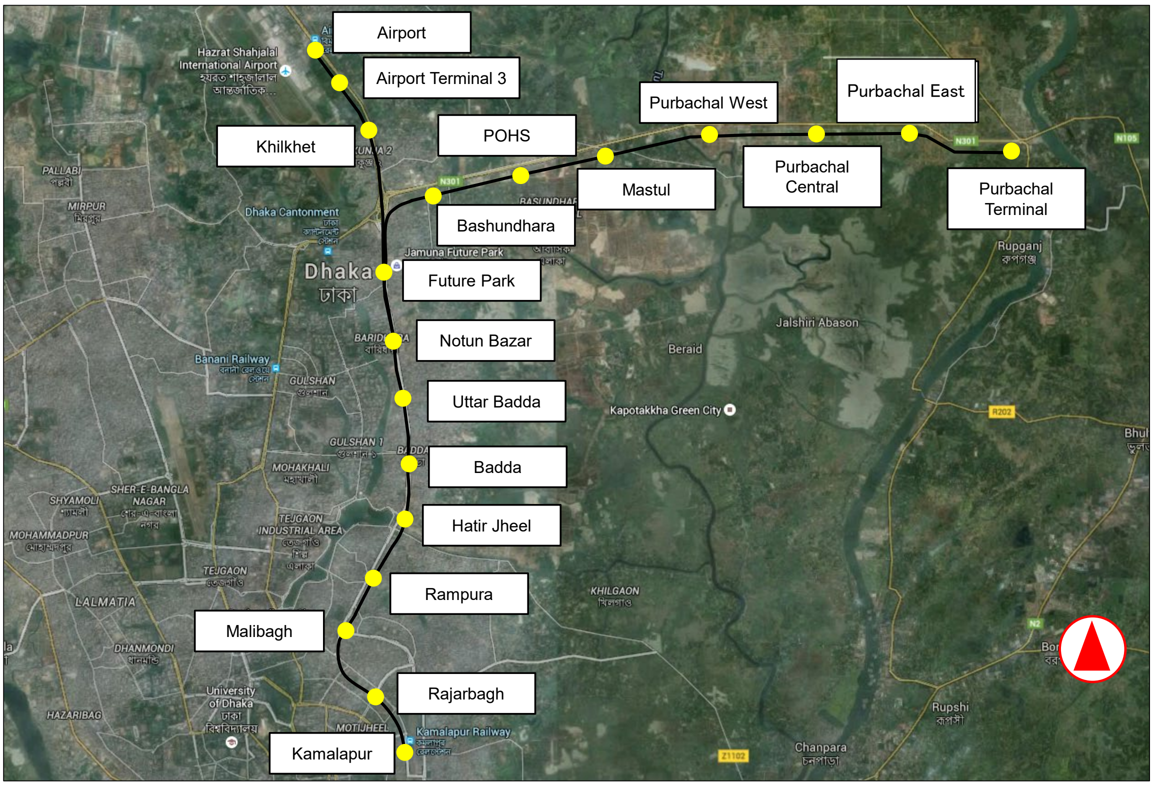
Among 8 stakeholder meetings, there are no clear objection. However some concerns about compensation for land acquisition and resettlement were raised.

Regarding the latest option of depot plan (Option 4), DMTCL held a stakeholder meeting for PAPs, and asked PAPs for understanding.

On the detail design phase, stakeholder consultation should be continued about more tangible project design. For example, although the project has a viaduct section, information on evaluation for “landscape” has not presented this study. On the detail design phase, based on more tangible design, agreement should be gotten.

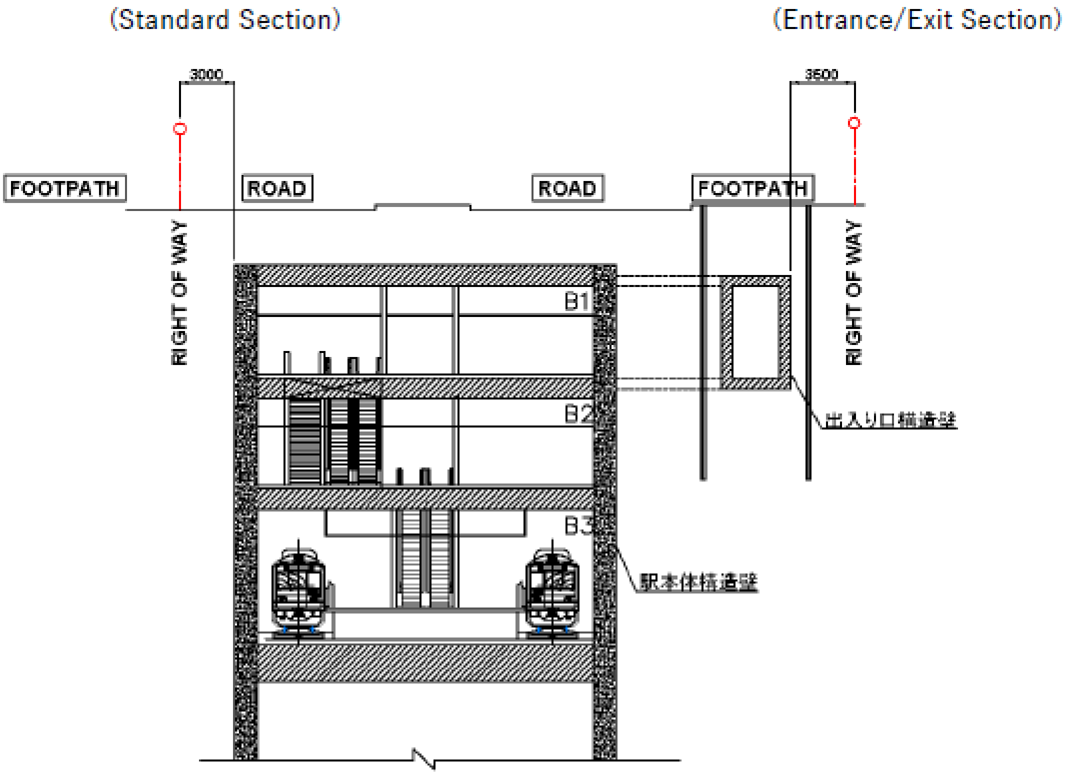
5.11 Necessity of Land Acquisition and Resettlement

MRT Line 1 is consisted of 14.8 km long which connects from Kamalapur to Airport: southern and northern part of Dhaka City with 9 stations and Purbachal Line of 13.4 km long which connects from Future Park to Purbachal with 7 stations as subsidiary. (Total length including overlapping section and supplement track is 31.2km.) Whole Main Line will be underground and all stations of subsidiary line will be above ground. A total of 38.993 ha will be required for depot and ancillary facilities. The stations for both Main and Purbachal line will be built within right of way (ROW) and land acquisition is not required in principle, however, due to the construction of entrances/exits, cooling tower and ventilation duct a total of 0.23ha of private land is required, hence, displacement occurs. As a result, 1,119 PAHs (513 of them are residential PAHs) and 4,632 PAPs will be affected.



Source: Google Map is manipulated by JICA Study Team

Figure 5.11.1 MRT Line 1 Map



Source: JICA Study Team

Figure 5.11.2 Typical Cross Section of Underground Station

The number of affected PAPs might be more than 200; therefore the project will fall in **category A**: displaced population is more than 200 people and significant impacts are assumed, therefore, Resettlement Action Plan (RAP) is prepared in line with JICA's Guidelines.

The attached annexures are consisted of Annex-1: Form of Census and Inventory of Losses, Annex-2: Form of Questionnaire for Property Valuation and Others, Annex-3: List of PAHs, Land Owners, CPRs, Vulnerable and Wage Workers, Annex-5: TOR for RAP Implementing Agency, Annex-6: Minutes of SHM, Annex-7: TOR for External Monitoring Consultant and Annex-8: Gender, in the Report.

5.12 Legal Framework of Land Acquisition and Resettlement

5.12.1 Current Legislation on Land Acquisition and Resettlement

The current legislations governing land acquisition for Bangladesh are the Acquisition and Requisition of Immovable Property Ordinance 1982 and subsequent amendments during 1993 - 1994. The Ordinance requires that compensation be paid for (i) land and assets permanently acquired (including standing crops, fisheries, trees, houses); and (ii) any other damages caused by such acquisition. The Deputy Commissioner (DC) determines the market price of assets based on an approved procedure and in addition to that pays an additional 50 percent (as premium) on the assessed value as the market price established by the Land Acquisition Officer (LAO) which still remains much below the replacement value. The 1994 amendment made provisions for payment of compensation for crops to tenant cultivators. The Ordinance, however, does not cover project-affected persons without titles or ownership records, such as informal settlers/squatters, occupiers, and informal tenants and lease-holders (without documents) and does not ensure replacement value of the property acquired. The act has no provision for resettlement assistance or transitional allowances for restoration of livelihoods of the non-titled affected persons. The Acquisition and Requisition of Immovable Property Ordinance (ARIPO, 1982) with its subsequent amendments will be applied for this project.

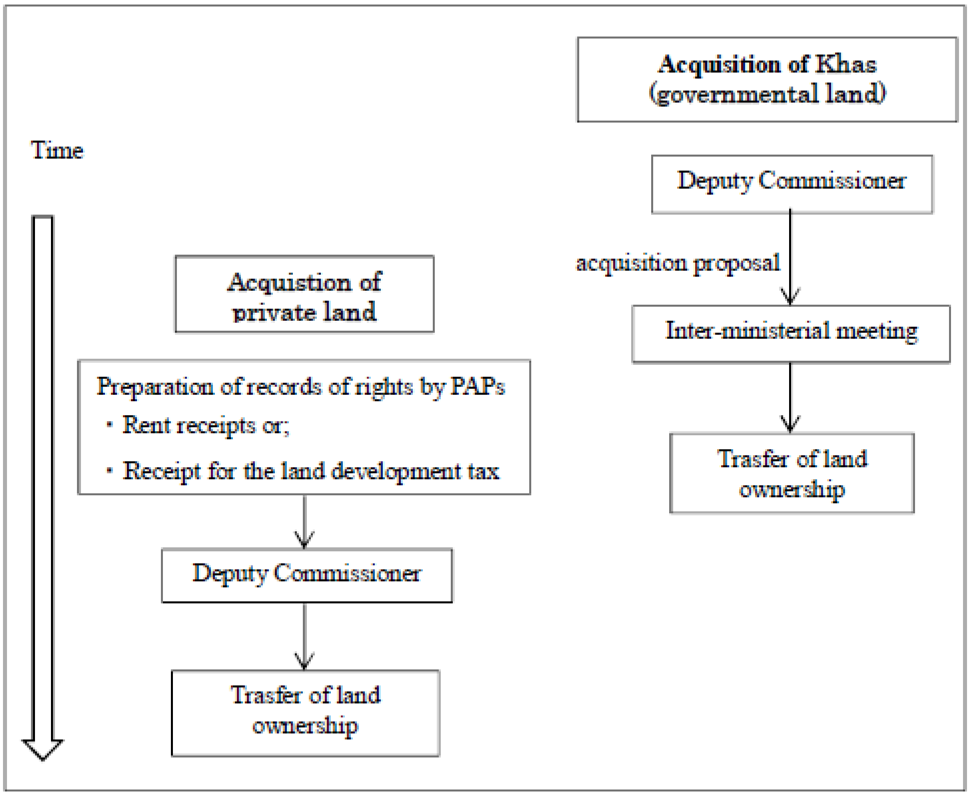
However, the ARIPO (1982) does not give any direction to compensate the subsurface property for imposing restriction in use. Though sub-surface easement had discussed in this Study it has concluded to deal it as examination issue in future due to the lack of relative legislation. The appropriate design measures would be taken in order may not to affect the structure above ground, however, when affects are confirmed due to the tunneling DMTC will compensate in accordance with present law same as other domestic project.

1) Land Acquisition

The DC processes land acquisition under the Ordinance and pays compensation to the legal owners of the acquired land. The Ministry of Lands (MOL) is authorized to deal with land acquisition through the DCs. Khas (government owned) lands should be acquired first when a project acquires both khas and private land. If a project acquires only khas, the land will be transferred through an inter-ministerial meeting following the preparation of an acquisition proposal submitted to DC/MOL.

2) Land Ownership

The land owner has to establish ownership by producing a record-of-rights in order to be eligible for compensation under the law. The record of rights prepared under Section 143 or 144 of the State Acquisition and Tenancy Act 1950 (revised 1994) are not always updated and as a result legal land owners have to face difficulties in trying to “prove” ownership. The APs must also produce rent receipts or receipt for the land development tax, but this does not assist in some situations as a person is exempted from payment of rent if the area of land is less than 25 bighas (3.37 ha).



Source: JICA Study Team

Figure 5.12.1 Flow of Land Acquisition

3) Draft National Policy on Involuntary Resettlement

The Government of Bangladesh, funded by ADB, has prepared a draft national policy on involuntary resettlement that is consistent with the general policy of the Government that the rights of those displaced by a development project shall be fully respected, and persons being displaced shall be treated with dignity and assisted in such a way that safeguards their welfare and livelihoods irrespective of title, gender, or ethnicity, but it is yet to be enacted.

The draft Policy was submitted to the Government in November 2007. It was approved by the Ministry of Land on 1 January 2008 and was placed before the Cabinet later in February 2008. After cabinet approval, the draft Policy is going to be enacted as legislative resettlement rights by law in 2017, however, it is not enacted yet.

5.13 Gap between JICA's Guidelines and Related Ordinances in Bangladesh

5.13.1 Gap between JICA's Guidelines and related Ordinances in Bangladesh

The land acquisition law of Bangladesh, the Acquisition and Requisition of Immovable Property Ordinance (ARIPO) 1982 with subsequent amendments during 1993 – 1994 is followed for acquisition and requisition of properties required for the development project in Bangladesh, which is not consistent with the Government's commitment to reducing poverty. There are some gaps in the land acquisition law of Bangladesh and the JICA Guidelines for Environmental and Social Considerations (GESC, April 2010). Below is the comparative analysis between the GoB laws (ARIPO) related to land acquisition, compensation and involuntary resettlement and JICA's requirements as prescribed in the

GESC 2010. The Table 5.13.1 describes the details.

Table 5.13.1 Gap and Gap Filling Measure

No.	JICA's Guidelines (2010)	GOB's Acquisition and Requisition of Immovable Property Ordinance (ARIPO) of 1982	Gaps Between JICA's Guidelines and ARIPO	Proposed Gap Filling Measures
1	Involuntary resettlement should be avoided wherever possible.	Not specified	The 1982 ordinance legislated nothing in this regard, while the JICA Guidelines require to avoid/minimize resettlement/loss of livelihood	Like other donor funded projects in Bangladesh, the approach of avoiding involuntary resettlement had already been taken by this project. The measure will be developed in design and implementation stages, furthermore.
2	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken.	Not specified for non-titled people	There are no provisions for compensation for non-titled residents in the Bangladesh ordinance, while JICA's Guidelines acknowledges all affected persons whether legally residing or not, are eligible for compensation.	Compensations are proposed even for non-titled people as follows. - Compensation for structures, trees - Structure transfer assistance - Structure reconstruction assistance - Moving assistance for residential house owner - Tenant moving allowance
3	People who must be settled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.	Not specified for maintaining living standard of affected people at the same or above of pre-project levels.	There is no provision for maintaining living standard of affected people at the same or above pre-project levels in Bangladesh ordinance, while JICA's Guidelines require that no one is worse off as a result of resettlement and would maintain their living level at least at original levels	Assistances were proposed in the form of: - Grant for business loss - Compensation for loss of plant and fish-stock - Grant for loss of wage employment - Rental fee loss for displaced rented house owner - One time moving assistance for tenant business owner - Introduction of micro-credit - Provision of job training Provision of priority employment etc.
4	Compensation must be based on the full replacement cost as much as possible	Compensation is made based on the pre-determined government prices which are usually much lower than full replacement cost.	There are no related provisions in the Bangladesh ordinance, while JICA's Guidelines require that the replacement cost plus tax and remittance charge shall be included in compensation.	The resettlement plan addresses all these issues and spells out a mechanism to fix the full replacement costs as follows. District Commissioner: Pay compensation for PAPs based on ARIPO. DTCA: Pay compensation for PAPs the difference between full replacement cost and determined by DC.

No.	JICA's Guidelines (2010)	GOB's Acquisition and Requisition of Immovable Property Ordinance (ARIPO) of 1982	Gaps Between JICA's Guidelines and ARIPO	Proposed Gap Filling Measures
5	Compensation and other kinds of assistance must be provided prior to displacement	Payment is made at a predetermined time, regardless of whether it is before or after the construction starts	Compensation and other assistance are made regardless of whether it is before or after construction, while JICA Guidelines requires to pay compensation prior to relocation	The resettlement plan addresses all these issues and spells out a mechanism for all the compensation to be paid prior to possession of the acquired land and prior to displacement
6	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public.	There is no provision for the formulation of RAP or public hearings. The Deputy Commissioner contacts the land owner through the land Acquisition Officer (LO), and if the landowner has no objection, confirms the compensation amount etc. and proceeds.	There is no provision for the resettlement plan that describes all features of resettlement requirements should be disclosed to the public.	The Resettlement Action Plan (RAP) prepared for this project with all features of resettlement requirements and mechanism of disclosure to the public is an integral part of F/S. DTCA is requested to disclose the RAP with their consensus.
7	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance.	The 1982 Ordinance has provisions to notify only the owners of property to be acquired	There is no provision in the law for consulting the stakeholders, but the land allocation committees at district, division and central government level are all involved.	The RAP for the project has been prepared by consultation process which involves all stakeholders (affected persons, government department/line agencies, local community, NGO, etc.), and the consultation will be conducted in continuous process at all stages of the project development, such as project formulation, feasibility study, design, implementation, and post-implementation, including the monitoring phase.
8	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people	There are no provisions	Requirements of JICA Guidelines are not specifically mentioned in the Bangladesh laws and rules	The RAP has been prepared based on the consultation process in local language. And participatory process involves questions and explanations on the components of RAP. The consultation will be a continuous process at all stages of the project development, such as project formulation, feasibility study, design, implementation, and post-implementation, including the monitoring phase.
9	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans	There is no provision for the monitoring related activities with the participation of affected people	There is no provisions in Bangladesh ordinances, while JICA Guidelines recommend participation of affected people in planning, implementation and monitoring of the RAP	The RAP has been prepared by following a consultation process with all stakeholders. The consultation will be a continuous process at all stages of the project development, such as project formulation, feasibility study, design, implementation, and post-implementation, including the monitoring phase.

No.	JICA's Guidelines (2010)	GOB's Acquisition and Requisition of Immovable Property Ordinance (ARIPO) of 1982	Gaps Between JICA's Guidelines and ARIPO	Proposed Gap Filling Measures
10	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities	If PAPs have objection regarding the compensation amount, he should protest and entrust the matter to an Arbitrator. If he has to appeal against the Arbitrator's decision, then he should file a law suit and wait for the decision.	The law of Bangladesh states it should be settled through Arbitrator as court case, while JICA's Guidelines recommend to establishing an appropriate grievance redress mechanism for amicable settlement to minimize the legal confrontation.	The RAP for this project has made a provision for setting up a grievance redress mechanism accessible for all the affected people including non-titled affected people.
11	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socio-economic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers or others who wish to take advantage of such benefit.	No such an activity is required	There is no provision in Bangladesh ordinances, while JICA Guidelines recommend identification of affected people in the least possible time preferably at the project identification stage.	This RAP has been prepared based on the data collected through conducting a census, socioeconomic survey for the displaced persons and making an inventory of losses. Video filming has also been recorded to the affected properties.
12	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who do not have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying	There is no provision.	Requirement of JICA's Guidelines is not specifically mentioned in the Bangladesh laws and rules.	The RAP ensures compensation and assistance to all affected persons, whether physically displaced or economically displaced, irrespective of their legal status. Eligibility depends on the cut-off date, and affected persons listed before the cut-off date will be eligible for assistance.
13	Preference should be given to land–based resettlement strategies for displaced persons whose livelihoods are land-based.	There is no provision.	Requirement of JICA Guidelines is not specifically mentioned in the Bangladesh laws and rules.	Though this option may be a difficult proposition given the lack of government lands and the difficulties associated with the acquisition of private lands, the resettlement plan proposes land-for-land compensation as its priority, if feasible. Attempts will be made to find alternate land for the loss of land, in case it is available and if it is feasible, looking at the concurrence of the host community and land value.

No.	JICA's Guidelines (2010)	GOB's Acquisition and Requisition of Immovable Property Ordinance (ARIPO) of 1982	Gaps Between JICA's Guidelines and ARIPO	Proposed Gap Filling Measures
14	Provide support for the transition period (between displacement and livelihood restoration)	There is no provision for support for the transition period.	There is no provision in Bangladesh ordinances, while JICA Guidelines require providing support for the transition period.	The following are provided in the RAP: Transfer assistance for residential house owners Tenant moving allowance
15	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.	There is no provision either acknowledgment of or compensation to vulnerable groups	There is no provision in Bangladesh ordinances, while JICA Guidelines require providing special attention to vulnerable people and groups.	Vulnerable allowances were proposed to widowed, old, disabled and poor house head families such as : Special Assistance for Vulnerable households. Focus group discussion was held to cope with gender.
16	For a project that entails land acquisition or involuntary resettlement of more than 200 people, a resettlement action plan is to be prepared	There is no provision	Requirement of JICA Guidelines is not specifically mentioned in the Bangladesh laws and rules	The RAP has been prepared since the displaced people in Line 5 are estimated to be more than 200.

Source: JICA Study Team

5.14 Census and Socio-economic Survey

5.14.1 Eligibility Criteria

The census and a socio-economic survey was carried out in March through April 2017, June 2018 for the depot site to provide requisite details on the Project Affected Units (PAUs) of MRT line 5 to further assess the magnitude of likely impacts and to identify measures for mitigation of adverse impacts. The survey included (i) full census and socioeconomic survey with structured questionnaire and inventory of losses (Annex-1), (ii) surveys for property valuation and other assets through structured questionnaire (Annex-2); (iii) Video filming of the affected properties and (iv) community based public consultation etc. The survey identified the households, commercial and business enterprises, land owners, sharecroppers, squatters, tenants and community properties on project right of way.

The census questionnaire incorporated the basic questions for identification of the affected unit, its owner/user, and types and extent of losses and other relevant data. These data are collected to prepare the Inventory of Losses (IOL) generated by the project.

The socioeconomic survey collected a wide range of data, for example, demography, age/sex distribution, education, occupation, income/poverty data, types of businesses, types and ownership status of affected structures and other assets.

5.14.2 The Project Area

The project area extends in both Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC) and Savar Upazila starting from Dhaka Airport, extended towards south and ended at Kamalapur. One branch has extended towards west and ended in East Purbachal in Rupganj Upaziila of Narayanganj District. Total length of the MRT Line 1 is 31.2 Km with 1 depot in Purbachal (tentative one). There are 19 stations which consist of elevated 7 and underground 12.

5.14.3 Profile of Affected Households

1) Population

A total of 4,632 people have been identified as affected by losing residential structure, commercial structure, trees, ponds and other minor infrastructures. Community properties (42) have not been considered in calculating population. A total of 513 households will be displaced from their residence. On the other hand 404 households will lose their commercial structure, 21 households will lose both homestead and CBE, 181 households will lose their trees or other minor structures like gates, drains, walls etc. Among the CBEs 272 are vendors or temporary shop owners will have to be displaced for the intervention of this project.

Out of the total affected population, 2,512 (54 %) are male and 2,120 (46 %) are female. Location wise number of affected male and female population is shown in Table 6.14.1.

Table 5.14.1 Number of Male and Female Population by Location

Location	Total HH	Population		
		Male	Female	Total Population
Airport	215	542	434	976
Airport Terminal-3	00	00	00	00
Khilkhet	01	03	02	05
Basundhara	04	11	11	22
POHS	00	00	00	00
Mastul	00	00	00	00
Purabachal West	00	00	00	00
Purbachal Central	17	36	26	62
Purbachal East	00	00	00	00
Purbachal Terminal	14	39	30	69
Depot Area	698	1503	1267	2770
Jamuna Future Park	07	18	12	30
Nuton Bazar	30	59	66	125
Uttar Badda	03	08	06	14
Badda	09	22	24	46
Hatir Jheel	05	13	13	26
Rampura	24	56	51	107
Malibag	12	28	33	61
Rajarbag	05	12	12	24
Kamlapur	75	162	133	295
Total	1119	2512	2120	4632

Source: Census & Socioeconomic survey, April 2017, and June 2018 for Depot area

2) Ethnicity and Religion

Based on findings of the survey, the Project will affect 1,119 households. Out of total 1,119 households 1,020 are Muslim and 99 are Hindu. No ethnic minority is found in the proposed project locations. Detail of households in terms of religion is shown in Table 5.14.2.

Table 5.14.2 Affected Households by Location and Religion

Location	Religion				Total (No)
	Muslim (No)	%	Hindu (No)	%	
Airport	202	93.95	13	6.05	215
Airport Terminal-3	0	0.0	0	00.0	0
Khilkhet	1	100.0	0	00.0	1
Basundhara	3	75.0	1	25.0	4
POHS	0	0.0	0	00.0	0
Mastul	0	0.0	0	00.0	0
Purbachal West	0	0.0	0	00.0	0
Purbachal Central	17	100.0	0	00.0	17
Purbachal East	0	0.0	0	00.0	0
Purbachal Terminal	14	100.0	0	00.0	14
Depot Area	621	88.97	77	11.03	698
Jamuna Future Park	7	100.0	0	00.0	7
Notun Bazar	30	100.0	0	00.0	30
Uttar badda	3	100.0	0	00.0	3
Badda	9	100.0	0	00.0	9
Hatir Jheel	3	60.0	2	40.0	5
Rampura	24	100.0	0	00.0	24
Malibag	12	100.0	0	00.0	12
Rajarbag	5	100.0	0	00.0	5
Kamalpur	69	92	6	8	75
Total	1020	91.15	99	8.85	1119

Source: Census & Socioeconomic survey, April 2017, and June 2018 for Depot area

3) Level of Education

The numbers of school going children are increasing. Today, almost all the young children are going to school, girl children are more advanced in this regard as the GOB is providing additional facilities to them. This is an urban area with good opportunity to go to school. Young generations irrespective of sex have much higher level of education than compared to the head (older members) of the household.

Table 5.14.3 Level of Education of the Head of the Households

Location	Level of Education						Total
	Illiterate	Class-I-V	Class VI-X `	SSC & HSC	Graduate	Above Graduate	
Airport	1.86	33.95	50.23	11.16	1.86	0.93	100
Airport Terminal-3	0	0.0	0	00.0	0	00.0	0.00
Khilkhet	0.0	100.0	0.0	0.0	0.0	0.0	100.0
Basundhara	25.0	25.0	0.0	25.0	0.0	25.0	100.0
POHS	0	0.0	0	00.0	0	00.0	0.00
Mastul	0	0.0	0	00.0	0	00.0	0.00
Purbachal West	0	0.0	0	00.0	0	00.0	0.00
Purbachal Central	0.0	58.8	23.5	11.7	5.8	0.0	100.0
Purbachal East	0	0.0	0	00.0	0	00.0	0.00
Purbachal Terminal	7.1	64.2	28.5	0.0	0.0	0.0	100.0
Depot Area	4.15	46.85	30.66	8.31	3.87	6.16	100
Jamuna Future Park	14.2	28.5	14.2	42.8	0.0	0.0	100.0
Notun Bazar	3.33	20.0	30.0	13.33	0.0	33.3	100.0
Uttar badda	0.0	66.6	0.0	0.0	0.0	33.3	100.0
Badda	0.0	33.3	11.1	33.3	0.0	22.2	100.0
Hatir Jheel	0.0	40.0	20.0	20.0	0.0	20.0	100.0
Rampura	4.1	41.6	8.3	20.8	8.3	16.7	100.0

Malibag	0.0	25.0	33.3	33.3	0.0	08.3	100.0
Rajarbag	0.0	20.0	0.0	40.0	0.0	40.0	100.0
Kamalpur	24.0	46.67	20.0	4.4	1.33	4.0	100.0
Total	5.0 (56)	43.34(485)	32.44(363)	9.83(110)	3.13(35)	6.26(70)	100.00(1,119)

Source: Census & Socioeconomic survey, April 2017, and June 2018 for Depot area

4) Age and Occupation

The largest proportion of population is in age group of 15-29 (26.34 %) followed by age group of 30-44 (23.29 %) and up to 14 (24.44 %) irrespective of male and female population in all the locations. Population within the age group 45-59 is more than 16.08 % and above 60 is about 9.84 %. Table 5.14.4 shows in detail.

Table 5.14.4 Age Distribution of Affected Population by Location

Location	Age Group										Total	
	Up to -14		15-29		30-44		45-59		60 & Above			
	No	%	No	%	No	%	No	%	No	%	No	%
Airport	239	24.49	255	26.13	184	18.85	180	18.44	118	12.09	976	100
Airport Terminal-3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.00
Khilkhet	3	60.0	0	0.0	2	40.0	0	0.0	0	0.0	5	100.0
Basundhara	2	9.0	12	54.5	2	9.0	4	18.1	2	9.0	22	100.0
POHS	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.00
Mastul	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.00
Purbachal West	0	0.0	0	00.0	0	00.0	0.0	0.0	0	0.0	0	0.00
Purbachal Central	14	22.5	18	29.0	17	27.4	12	19.3	1	1.6	62	100.0
Purbachal East	0	0.0	0	0.0	0	0.0	0.0	0.0	0	0.0	0	0.00
Purbachal Terminal	14	20.3	20	28.9	13	18.8	14	20.2	8	11.5	69	100.0
Depot Area	695	25.09	733	26.46	708	25.56	393	14.19	241	8.7	2770	100
Jamuna Future Park	9	30.0	7	23.3	8	26.6	5	16.6	1	3.3	30	100.0
Notun Bazar	33	26.4	27	21.6	27	21.6	26	20.8	12	9.6	125	100.0
Uttar badda	3	21.4	5	35.7	2	14.2	2	14.2	2	14.2	14	100.0
Badda	12	26.0	13	28.2	11	23.9	6	13.0	4	8.7	46	100.0
Hatir Jheel	7	26.9	8	30.7	4	15.3	4	15.3	3	11.5	26	100.0
Rampura	13	12.1	28	26.1	19	17.7	25	23.3	22	20.5	107	100.0
Malibag	13	21.3	17	27.8	12	19.6	12	19.6	7	11.4	61	100.0
Rajarbag	6	25.0	4	16.6	6	25.0	3	12.5	5	20.8	24	100.0
Kamalpur	69	23.39	73	24.75	64	21.69	59	20	30	10.17	295	100.0
Total	1132	24.44	1220	26.34	1079	23.29	745	16.08	456	9.84	4632	100.00

Source: Census & Socioeconomic survey, April 2017, and June 2018 for Depot area

5) Income and Poverty Dimensions

Poverty in Bangladesh is measured through per capita income or through Direct Calorie Intake (DCI) where persons having DCI of less than 2,122 kcal are considered to be living in poverty while a person having DCI of less than 1,805 kcal is considered to be in 'hard core poverty'. As per Statistical Year Book of Bangladesh 2010 average household size is 4.50 and 40.94% households earn maximum BDT 108,000 per year. Based on the census socioeconomic survey (March-April 2017 and June 2018) indicating yearly income and expenditure of the project affected households, it is found that about 10.9 % households earn less than Tk 108,000 per year (Table 5.14.5).

Table 5.14.5 Poverty Level and Annual Income (BDT) of Head of the Households

Location	Annual Income (BDT)					
	Up to 100,000	108,001-200,000	2,00,001-3,00,000	3,00,001-5,00,000	500,001-700,000	Above 7,00,000
Airport	14.88	15.35	49.3	5.12	3.72	11.63
Airport Terminal-3	00.0	00.0	00.0	00.0	00.0	00.0
Khilkhet	100.0	00.0	00.0	00.0	00.0	00.0
Basundhara	00.0	00.0	00.0	00.0	25.0	75.0
POHS	00.0	00.0	00.0	00.0	00.0	00.0
Mastul	00.0	00.0	00.0	00.0	00.0	00.0
Purbachal West	00.0	00.0	00.0	00.0	00.0	00.0
Purbachal Central	5.88	5.88	00.0	47.0	29.4	11.8
Purbachal East	00.0	00.0	00.0	00.0	00.0	00.0
Purbachal Terminal	7.14	21.4	21.4	21.4	21.4	07.1
Depot Area	6.59	21.92	38.25	10.74	9.17	13.3
Jamuna Future Park	28.57	28.57	28.5	14.2	00.0	00.0
Notun Bazar	6.67	00.0	36.67	3.3	6.7	46.7
Uttar badda	33.3	00.0	0.0	66.6	00.0	00.0
Badda	66.6	00.0	0.0	11.1	00.0	22.2
Hatir Jheel	20.0	00.0	0.0	20.0	20.0	40.0
Rampura	54.2	4.17	08.3	08.3	0.00	25.0
Malibag	25.0	8.33	08.3	25.0	08.33	25.0
Rajarbag	40.0	00.0	00.0	40.0	0.00	20.0
Kamalpur	14.67	33.3	34.7	2.67	8.0	6.7
Total	10.9(122)	19.57(219)	37.35(418)	10.0(112)	8.13(91)	14.0(157)

Source: Census & Socioeconomic survey, April 2017, and June 2018 for Depot area

The survey identified 395 vulnerable households in the project area. These are almost all the project affected female headed households, households headed by elderly persons, disable persons, male headed household but under the poverty line. The vulnerable households of different locations are shown in the Table 5.14.6**.**

Table 5.14.6 Vulnerable Households in Percentage and by Location

Location	Vulnerability				Total
	Female Headed HHs	Elderly (<60yr,)	Disabled Male HHHs	Male Headed Households under poverty line	
Airport	2.17	10.87	6.52	00.0	00.0
Airport Terminal-3	00.0	00.0	00.0	00.0	00.0
Khilkhet	00.0	00.0	00.0	100.0	100.0
Basundhara	100.0	00.0	00.0	00.0	100.0
POHS	00.0	00.0	00.0	00.0	00.0
Mastul	00.0	00.0	00.0	00.0	00.0
Purbachal West	00.0	00.0	00.0	00.0	00.0
Purbachal Central	00.0	00.0	00.0	100.0	100.0
Purbachal East	00.0	00.0	00.0	00.0	00.0
Purbachal Terminal	00.0	66.6	00.0	33.3	100.0
Depot Area	61.3	19.54	0.77	00.0	00.0
Jamuna Future Park	33.3	0.0	00.0	66.6	100.0
Notun Bazar	28.57	7.14	00.0	7.14	100.0
Uttar badda	00.0	50.0	00.0	50.0	100.0
Badda	00.0	16.6	00.0	83.3	100.0
Hatir Jheel	00.0	00.0	00.0	00.0	00.0
Rampura	6.6	33.3	00.0	60.0	100.0

Location	Vulnerability				Total
	Female Headed HHs	Elderly (<60yr,)	Disabled Male HHHs	Male Headed Households under poverty line	
Malibag	00.0	57.1	14.2	28.5	100.0
Rajarbag	00.0	33.3	00.0	66.6	100.0
Kamalpur	38.71	9.68	6.45	9.68	100.0
Total	45.32(179)	17.72(70)	2.03(8)	8.61(34)	100.0(395)

Source: Census & Socioeconomic survey, April 2017, and June 2018 for Depot area

5.14.4 Scope of Land Acquisition

A total of 38.993 ha and 0.23 ha land will be required to be acquired for depot and pockets along the RoW to implement the project. The land for the depot area in Pitolganj, Rupganj are privately owned. This area is rural in nature. This patch of land is from two mouzas namely Brhamonkhali and Pitolgonj covering two types of land. Majority of the land is agriculture land followed by vita/homestead. Out of the total land 17.23 ha is agricultural land and 21.763 ha in being used as vita or some kind of high land. In addition to this acquired land some government owned land will be used to construct the MRT - 1 line and its components. However, the distribution and ownership of the pockets of land is yet to be finalized. Mouza wise type of land use of total land to be acquired is shown in Table 5.14.7.

Table 5.14.7 Land Acquisition of the Project by Mouza and Type of Land

Name of Mouza	Type of Land (ha)		Total (ha)
	Agriculture	Vita	
Brhamonkhali	0.396	1.188	1.584
Pitalgonj	16.834	20.575	37.409
Total	17.23	21.763	38.993

Source: Census & Socioeconomic survey, April 2017, and June 2018 for Depot area

5.14.5 Displacement and Other Impacts

In addition to land acquisition, the project will have direct impact on 1,119 Project Affected Units (PAUs). These PAUs are from stations areas. It is to be mentioned here that there will not be any affected people in six proposed stations namely Airport Terminal-3, Bashundhara, POHS, Mastul, Purbachal West and Purbachal East and the depot area. The project work will affect 513 residential households, 404 Commercial & Business enterprises (CBEs) and 21 residential cum CBE and 181 household are going to lose varieties of assets and minor structures like wall, trees, drains etc. with a total population of 4,632. Out of 513 households 471 will be displaced due to loss of residential structure, 42 will be displaced from rented residential structure. The list of PAHs, land owners, CPRs, vulnerable and wage workers is attached in Annex-3. The location wise impact is presented in Table 5.14.8.

Table 5.14.8 Displacement of PAHs and Impacts by Location

Location	Location wise Number of PAHs						Total PAHs	Total Population
	Loss of Residence	Loss of Business	Loss of Business and Residence	Loss of Residence by Rented	Vendors on Govt. land	Others		
Airport	0	18	0	1	196	0	215	976
Airport Terminal-3	0	0	0	0	0	0	00	00
Khilkhet	0	0	0	0	1	0	01	05
Basundhara	0	4	0	0	0	0	04	22
POHS	0	0	0	0	0	0	00	00

Mastul	0	0	0	0	0	0	00	00
Purbachal West	0	0	0	0	0	0	00	00
Purbachal Central	0	1	0	0	16	0	17	62
Purbachal East	0	0	0	0	0	0	00	00
Purbachal Terminal	0	14	0	0	0	0	14	69
Depot Area	463	27	20	4	5	179	698	2770
Jamuna Future Park	1	2	0	1	3	0	07	30
Notun Bazar	0	14	0	0	16	0	30	125
Uttar badda	1	2	0	0	0	0	03	14
Badda	0	5	0	2	1	1	09	46
Hatir Jheel	0	4	0	0	0	1	05	26
Rampura	4	18	1	0	1	0	24	107
Malibag	1	10	0	0	1	0	12	61
Rajarbag	1	2	0	0	2	0	05	24
Kamalpur	0	11	0	34	30	0	75	295
Total	471	132	21	42	272	181	1119	4632

Source: Census & Socioeconomic survey, April 2017, and June 2018 for Depot area

Among the Affected Units only 711 are title holders i.e. Owns the land and rest 408 are on government land. Total affected persons are 4,632. The affected households by legal status, type of loss and by location is shown in Table 5.14.9.

Table 5.14.9 Number of PAHs by Location on Private (Title-Holder) and Public Land (Non-Titled PAHs)

Name of Stations (Locations)	Title-holder PAHs					Non-title holder PAHs					Total PAHs	Total Population
	Residence	Business	Both	Others	Total	Residence	Temporary Shops	Rented in Shops	Others	Total		
Airport	0	0	0	0	0	1	196	18	-	215	215	976
Airport Terminal-3	0	0	0	0	0	0	0	0	-	0	0	00
Khilkhet	0	0	0	0	0	0	1	0	-	1	1	05
Basundhara	0	0	0	0	0	0	0	4	-	4	4	22
POHS	0	0	0	0	0	0	0	0	-	0	0	00
Mastul	0	0	0	0	0	0	0	0	-	0	0	00
Purbachal West	0	0	0	0	0	0	0	0	-	0	0	00
Purbachal Central	0	0	0	0	0	0	16	1	-	17	17	62
Purbachal East	0	0	0	0	0	0	0	0	-	0	0	00
Purbachalhal Terminal	0	14	0	0	14	0	0	0	-	0	14	69
Depot Area	463	17	20	179	679	4	5	10	-	19	698	2770
Jamuna Future Park	1	0	0	0	1	1	3	2	-	6	7	30
Nuton Bazar	0	1	0	0	1	0	16	13	-	29	30	125
Uttar Badda	1	0	0	0	1	0	0	2	-	2	3	14
Badda	0	1	0	1	2	2	1	4	-	7	9	46
Hatir Jheel	0	0	0	1	1	0	0	4	-	4	5	26
Rampura	4	3	1	0	8	0	1	15	-	16	24	107
Malibag	1	1	0	0	2	0	1	9	-	10	12	61
Rajarbag	1	0	0	0	1	0	2	2	-	4	5	24
Kamlapur	0	1	0	0	1	34	30	10	-	74	75	295
Total	471	38	21	181	711	42	272	94	-	408	1119	4632

Source: Census & Socioeconomic survey, April 2017, and June 2018 for Depot area

A total of 1,376 structures of 67,098 sq. m of different categories will be affected of which 26,126 sq. meter pucca, and 18,722 sq. meter semi pucca, 17,270 sq. meter tin shaded, 4,051 sq. meter katcha, 702.87 sq. meter and 227 sq. meter tarpaulin covered (Table 5.14.10).

Table 5.14.10 Quantity of all Affected Structure (sq. meter) by Type and by Location

Station Name	Type of Affected Structure						Total
	Thatched	Katcha	Tin	Semi pucca	Pucca	Tarpaulin	
Airport	0.00	54.45	458.3	736.4	4703	11.15	5963
Airport Terminal-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Khilkhet	0.00	0.00	5.95	0.00	0.00	0.00	5.95
Basundhara	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POHS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mastul	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Purbachal West	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Purbachal Central	0.00	0.00	0.00	0.00	0.00	208	208
Purbachal East	0.00	0.00	0.00	0.00	0.00	0.00	00.00
Purbachal Terminal	0.00	147.6	0.00	0.00	0.00	0.00	147.6
Depot Area	642.48	3122.06	15975.6	16277.9	16750.3	0.00	52768.3
Jamuna Future Park	0.00	0.00	0.00	0.00	59.1	0.00	59.1
Notun Bazar	0.00	288	583.9	1554	2923	0.00	5349
Uttar badda	0.00	33.46	29.56	0.00	0	0.00	63.02
Badda	0.00	0.00	6.69	0.00	232.3	0.00	239
Hatir Jheel	0.00	0.00	2.79	41.8	33.5	0.00	78.09
Rampura	0.00	0.00	0	33.5	510	0.00	544
Malibag	0.00	13.94	18.59	51.11	138.5	0.00	221.1
Rajarbag	0.00	0.00	5.95	0.00	51.11	0.00	57.06
Kamalpur	60.39	391.8	182.2	26.96	725.3	7.43	1394
Total	702.87	4051.31	17269.53	18721.67	26126.11	226.58	67097.22

Source: Census & Socioeconomic survey, April 2017, and June 2018 for Depot area

The stations will be built within the ROW; however, for the construction of exit, entrance and ventilation duct etc. some extent of private land acquisition will be required. To minimise the affect due to the land acquisition, the final location of ancillary facilities will be fixed through perusal study in detailed design stage.

In addition to the project affected units or households 42 Common Property Resources (CRP) are going to be affected. The CPRs include mosque, madrasa, school/college, graveyard, offices etc. Among the CPRs office seems to be out numbered 55 % (Table 5.14.11). For repairing or re-establishment of these CPRs the community people will be consulted.

Table 5.14.11 Distribution of CPR by Location

Name of Stations (Locations)	Type of CPRs						Total
	Mosque	School/College	Madrasa	Grave Yard	Office[8]	Others[9]	
Airport	1	0	0	0	5	1	7
Airport Terminal-3	0	0	0	0	0	0	0
Khilkhet	0	0	0	0	1	0	1
Basundhara	0	0	0	0	0	1	1
POHS	0	0	0	0	0	0	0
Mastul	0	0	0	0	0	0	0
Purbachal West	0	0	0	0	0	0	0
Purbachal Central	0	0	0	0	0	0	0
Purbachal East	0	0	0	0	0	0	0
Purbachal Terminal	0	0	0	0	0	0	0
Depot Area	1	0	1	2	2		6
Jamuna Future Park	0	0	0	0	0	2	2
Notun Bazar	2	0	0	0	5	2	9
Uttar badda	0	0	0	0	1	0	1
Badda	0	0	0	0	2	0	2
Hatir Jheel	0	0	1	0	1	1	3
Rampura	0	0	0	0	0	1	1
Malibag	0	0	0	0	1	0	1
Rajarbag	0	1	0	0	1	0	2
Kamalapur	1	0	0	0	4	1	6
Total	5	1	2	2	23	9	42

Source: Census & Socioeconomic survey, April 2017, and June 2018 for Depot area

5.14.6 AP Preference for Relocation

During the census survey as well as in stakeholder consultation meetings (SCM) and FGDs, the relocation choices of the affected persons were asked. The households to be relocated are homestead loser prefer to remain in the adjoining area of the project location to continue their present occupation. Almost all are demanding assistance from the project during relocation. Therefore the APs are encouraged for self-relocation to get mutual support of the kin groups.

More than 99.91 % of the affected PAUs preferred assistance as cash grant so that they can buy/shift their structure in new location and continue their livelihood. Rest of them wanted similar space for continuing their business. Details are shown in Table 5.14.12.

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[8] Airport, Roads and Highway Department, Limited Farm, Bank which will lose either boundary wall in the front or gate or secondary structure etc. None of CRP main building or office will be affected by the project

[9] Nursery, Park, Shopping Mall, Trading Enterprize which will lose either boundary wall in the front or gate or secondary structure etc. None of CRP main building or office will be affected by the project

Table 5.14.12 Preference of CBEs for Relocation by Location in Percentage

Name of Stations (Location)	Preferred Compensation				Total	%
	Cash Compensation	%	Kind for kind	%		
Airport	215	100.00	0	00	215	100.00
Airport Terminal-3	0	00	0	00	0	0.00
Khilkhet	1	100.00	0	00	1	100.00
Basundhara	4	100.00	0	00	4	100.00
POHS	0	00	0	00	0	0.00
Mastul	0	00	0	00	0	0.00
Purabachal West	0	00	0	00	0	0.00
Purbachal Central	17	00	0	00	17	0.00
Purbachal East	0	00	0	00	0	0.00
Purbachal Terminal	14	00	0	00	14	0.00
Depot Area	698	100.00	0	00	698	100.00
Jamuna Future Park	7	100.00	0	00	7	100.00
Notun Bazar	30	100.00	0	00	30	100.00
Uttar badda	3	00	0	00	3	00
Badda	9	00	0	00	9	00
Hatir Jheel	5	100.00	0	00	5	100.00
Rampura	23	95.83	1	4.17	24	100.00
Malibag	12	100.00	0	00	12	100.00
Rajarbag	5	100.00	0	00	5	100.00
Kamlpur	75	100.00	0	00	75	100.00
Total	1118	99.91	1	0.09	1119	100.00

Source: Census & Socioeconomic survey, April 2017, and June 2018 for Depot area

DMTS is advised to apply the principle that the business of PAPs would be continued where PAPs' set-back is available without acquiring the additional land like in Purbachal or obtain a consensus from PAPs where set-back is not physically available due to a populated area. In the latter case DMTC is recommended to conduct stakeholder meeting on compensation.

5.15 Eligibility Policy and Entitlement Matrix

5.15.1 Eligibility Criteria

All APs will be entitled to compensation and resettlement assistance based on severity (significance) of impacts. Nevertheless, eligibility to receive compensation and other assistance will be limited by the cut-off date. The cut-off date for compensation under law (Ordinance II of 1982 and its 1994 amendments) is considered for those identified on the project right of way land proposed for acquisition at the time of serving notice under Section 3 or joint verification by DC whichever is earlier. The cut-off date of eligibility for resettlement assistance under this RAP is the commencement date of the disclosure of entitlements and consultation meeting with the stakeholders which is the 2nd round stakeholder meetings in April 2017 for the APs staying on public lands. The absence of legal title will not bar APs from compensation and assistance, as specified in the entitlement matrix presented in

Table 5.15.1.

DMTC shall find a mechanism to purchase a subsurface easement from the property owners through one-time payment and make a deed agreement. In absence of any practice in Bangladesh examples from other countries like Philippines and Vietnam with similar legal strategy is being adopted in this project. For further study, the followings are extracted from the "Republic Act No. 10752", "Implementing Rules and Regulations of Republic Act (IRR) 10752, An Act Facilitating the Acquisition of Right-of-Way, Site or Relocation for National Government Infrastructure Projects" in Philippine, and "Circular37/2014/TT-BGTVT Regulating on Protection Area of Works, Safety Corridor of Urban Railway Transportation（1st of November, 2014）"in Vietnam which is attached in Annex-4.

5.15.2 Compensation and Entitlement Policy

An Entitlement Matrix has been prepared on the basis of census and socioeconomic survey conducted in 9th March to 4th April 2017. It identifies the categories of impact based on the census & SES and shows the entitlements for each type of loss. The matrix describes the units of entitlements for compensating the lost assets, and various resettlement benefits. Cash Compensation under law (CCL) for lost assets (land, tree, structure & other physical establishments) will be accorded to the owners through the DCs as per market value assessed through legal procedure. The resettlement benefit for indirect losses and difference between replacement value and the CCL will be paid by DMTC through RAP Implementing Agency (IA).

Table 5.15.1 Compensation and Entitlement Policy

Item No.	Type of loss	Entitled Persons (Beneficiaries)	Entitlement (Compensation Package)	Implementation issues/Guidelines
1	Loss of homestead, commercial, Agriculture land, pond, ditches and orchards etc.	Legal owner(s) of land	i. Replacement value (RV) of land (Cash Compensation under Law (CCL) and additional grant to cover the current market price of land and stamp duty & registration cost @ 11.5% of CMP for land) to be determined by PVAC. ii.Compensation for standing crops to actual owners/ cultivators as determined by PVAC.	Assessment of quantity and quality of land by Joint Verification Survey Assessment of Market Value by Land Market Survey (LMS) Assessment of Cash Compensation under Law (CCL) Updating of title of the affected persons Payment of Cash Compensation under Law (CCL) APs will be fully informed of the entitlements and procedures regarding payments Additional cash grant to be paid to cover the replacement value of land compensation based on DC's CCL . Stamp duty and registration fees will be added with current market price (CMP) for land @ 11.5% of CMP to facilitate the APs in purchasing alternative lands.
2	Loss of access to cultivable land by owner cultivator/ tenant/ sharecropper	Tenants/ sharecropper/ Legal owner/ grower/ socially recognized owner/ lessee/ unauthorized occupant of land	Compensation for standing crops to owner cultivator/ sharecroppers or lessees as determined by PVAC. ii. Owner/grower to take away the crop	All the individuals identified by the JVS as tenants or sharecroppers of land Grant to be paid after taking possession of land and the legal /socially recognized owner is paid CCL for land and on certification of receipt by legal/socially recognized owner Additional cash grant to cover current market value of crop compensation as

Item No.	Type of loss	Entitled Persons (Beneficiaries)	Entitlement (Compensation Package)	Implementation issues/Guidelines
				prescribed by PVAC in case of private owner himself cultivating crop Crop compensation and the crop will be shared between owner and sharecropper as per terms of sharecropping in case of privately owned land/socially recognized owner In case of dispute over verbal agreement on sharecropping, certification from the elected representative will be considered as legal document
3	Loss of Trees/ Perennials/ fish stocks	1. Person with Legal Ownership of the land Socially recognized owner/ Unauthorized occupant of the trees/ fishes	i. Cash compensation at market rates for replacement of trees/ perennials/ fish stocks value ii.For fruit bearing trees- compensation for fruits @ 30% of timber value X 1 year iii.Compensation for fish stocks as determined by PVAC. iv.5 saplings will be distributed free of cost among each affected household losing trees v.Owners will be allowed to fell and take away their trees, perennial crops/ fishes etc. free of cost without delaying the project works.	Assessment of loss and market value of affected trees Payment of CCL for trees Adequate compensation will be paid and the owner will be allowed to fell and take the tree free of cost Compensation for fruit will paid for small, medium and large categories of trees. 5 saplings (2 fruit tree, 2 timber types and 1 medicinal tree) free of cost will be distributed among the tree losing households.
4	Loss of residential /commercial structure by owner(s)/ squatters	Legal Owners or squatters	i. Replacement value of structure at market price determined by PVAC. ii. Structure Transfer Grant (STG) @ Tk.12.50% of the replacement value of main structure iii Structure Reconstruction Grant (SRG) @ Tk.12.50% of the replacement value of main structure. iv. One time Transfer Grant (TG) for portable materials at the rate of (a) BDT 3,000 (three thousand) for katcha structure and (b) BDT 5,000 (five thousand) for semi Pucca structure and BDT 7,000 (seven thousand) for Pucca structures v. Cost of transfer and reinstallation of the utility services like reinstallation of electricity connection, water supply line, telephone line etc. as grant @ 10% of CMP (5% for the structure to be demolished now and another 5% for its reconstruction) vi. For the legal owners Monthly Hiring Allowance (MHA) for the similar type of space in other structures for running their activities for a period up to 6 (six) months with the rate would be determined by DMTC through market survey by the IA for various categories of structures like pucca, semi-pucca and katcha. Salvageable materials will be taken away by the owners within the stipulated time notified by DMTC Owners to take away all salvage materials free of cost	a. Payment of CCL for the losses b. Verification of Joint Verification Survey (JVS) and other records c. APs will be fully informed about their entitlements and assisted to obtaining it.

Item No.	Type of loss	Entitled Persons (Beneficiaries)	Entitlement (Compensation Package)	Implementation issues/Guidelines
5	Loss of access to Residential houses/ commercial structures (rented or leased)	Tenants of rented/ leased properties	i.House Transfer Grant (HTG) for shifting of furniture and belongings of residential structure (@ BDT 2,000 (two thousand) for katcha structure, BDT 4,000 (four thousand for semi-Pucca structure and BDT 6,000 (six thousand) for Pucca structure to each shifting tenant. Stock Transfer Cost (STC) for commercial entities @BDT 5,000 (five thousand) for small business; BDT 10,000 (ten thousand) for medium business and BDT 15,000 (fifteen thousand) for large business. One time cash grant for facilitating alternative housing/CBEs Tk. 5000 (Five thousand) per household or entity	Verification of JVS and records Transfer grants will be paid on relocation from project site
6	Loss of business by CBEs due to dislocation	Owner/operator of the business including vendors s as recorded by JVS	i. CCL for business loss. ii. Businesses without any income tax payment record: Transition allowance (TA) for the permanent loss of business/income equivalent to 03 (three) months' income subsistence at the rate of BDT 5,000 (five thousand) for Small business, BDT 10,000 (ten thousand) for medium business and BDT 15,000 (fifteen thousand) for large business. iii.Business with records of income tax payment: TA equivalent to 3(three) months' income calculated on the basis of income tax payment record for the preceding year, not exceeding BDT 20,000 (twenty thousand) for Small business, BDT 50,000 (fifty thousand) for medium business and BDT 75,000 (seventy five thousand) for large business.	a. All persons recorded by the JVS b. Cash grant to be paid while taking possession of land c. Small business will be defined as having Investment up to BDT 50,000 (fifty thousand), Medium business with Investment between BDT 50,000 to BDT 250,000 and Large business will have investment above BDT 250,000 (two hundred fifty thousand)
7.	Loss of rental income	Owners of rental premises (residential, commercial) as recorded by JVS	i. Transition allowance (TA) for the loss of rental income equivalent monthly allowance for 3 (three) months for each affected rented out premises at the rate of (a) BDT 5,000 (five thousand) per month for katcha structure; (b) BDT 10,000 (ten thousand) per month for semi-Pucca structure (or Pucca structure less than 500 (five hundred) sft. and (c) BDT 15,000 (fifteen thousand) per month for Pucca structure/apartment.	a. All persons recorded by the JVS b. cash grant to be paid on relocation from project site
8.	Loss of Income and work days due to displacement	Employees identified by the Joint Verification Committee (JVC)	i. Cash grant to the affected employees/wage earners equivalent to 45 days wage @ BDT 400/per day for unskilled laborers and @ BDT 600/per day for skilled laborers. ii. Preferential employment in the project construction work, if available.	All persons recorded by the JVS Cash grant to be paid while taking possession Involvement of the incumbents in project civil works Training on income generating activities.
9.	Poor and vulnerable households	Poor and vulnerable households as identified by JVC	i. Additional cash grant of BDT 10,000 (ten thousand) for affected poor women headed households and other vulnerable households ii. Training on IGA for AP/ nominated by AP.	Identification of Vulnerable households Income restoration schemes for vulnerable households Arrange training on income generating activities
10.	Temporary impact during construction	Community / Individual	The contractor shall bear the cost of any impact on structure or land due to movement of machinery and in connection with collection and transportation of borrow materials.	Community people should be consulted before starting of construction regarding air pollution, noise pollution and other environmental impact

Item No.	Type of loss	Entitled Persons (Beneficiaries)	Entitlement (Compensation Package)	Implementation issues/Guidelines
			All temporary use of lands outside proposed RoW to be through written approval of the landowner and contractor. Land will be returned to owner rehabilitated to original preferably better standard.	The laborers in the camp would be trained about safety measures during construction, aware of health safety, STDs, safe sex etc. The contractor shall ensure first aid box and other safety measures like condoms at construction site.

Source: RAP

5.15.3 Income and Livelihood Restoration Strategy

Additional measures will be taken to provide appropriate support to the livelihood restoration aspects of AHs.

In compliance with the RAP, the updated RAP will identify resources, in addition to compensation, for income restoration assistance. This will be through linking resettlement activities with a Livelihood and Income Restoration Program (LIRP).

The RAP includes the following categories of AHs for income restoration and livelihood support:

- Vulnerable households to be relocated from the project right of way. Eligible members of such family will be identified during planning the LIRP.
- Vulnerable households having no adult male members to shoulder household responsibility (women headed households in particular). The women heading the household will preferably be the eligible member.
- Vulnerable households of the employees and daily wage earners of the affected businesses or their nominated representatives.
- Vulnerable households losing access to agriculture land including sharecropper, and leaseholders.
- Vulnerable households losing access to commercial land including business proprietorship.
- Vulnerable households losing more than 10% of their agricultural income due to acquisition of agricultural land.

For additional support to usual income restoration assistance as mentioned above, the RAP Implementing NGO (INGO)/IA will specifically undertake assessment of needs and skill base of vulnerable APs of ages between 15 to 60 years. The IA (NGO or Consulting Firm) will recommend the eligible members of affected vulnerable households with their relevant profile to the LIRP implementing organization through DMTC. The short-term livelihood regeneration assistance under the RAP and long-term income generation program under the LIRP will be organized as follows:

Table 5.15.2 Livelihood Restoration Options

1. Eligible members of poor households to be relocated from the project right of way.	1.1 Short-term: Compensation for structure, shifting allowance, reconstruction assistance, cash assistance for loss of workdays due to relocation, and priority in employment in construction. 1.2 Long-term: Needs and capacity identification, human development and skill training, institutional support under the LIRP.
2. Eligible members from poor female headed households having no adult male members to shoulder household responsibility.	Similar to 1.1 and 1.2.
3. Poor and vulnerable employees of affected	3.1 Short-term: Subsistence for loss of income and employment.

businesses.	3.2 Long-term: As 1.2 above.
4. Eligible members of poor households losing access to agriculture land including sharecroppers, and leaseholders.	4.1 Short-term: Compensation for crops. 4.2 Long-term: As 1.2 above.
5. Eligible members of poor households losing access to commercial land including business proprietorship.	5.1 Short-term: Compensation for loss of business income, shifting and reconstruction assistance. 5.2 Long-term: As per need, livelihood and income generating training and employment in project construction.
6. Eligible members of poor households losing more than 10% of their agricultural land.	6.1 Short-term: Compensation for crops, replacement value of land, assistance for land purchase, and employment in construction. 6.2 Long-term: As 1.2 above.

Source: RAP

5.15.4 Information on Depot

The JICA Study Team had provided a plan (Plan - 1 of Depot - 4) with which the sub-consultant proceeded to hold the SHM on 03 March, 2018 at the Pitolganj, Dakhil Madrasha premises. The DMTC officials through agreed initially failed to turn up due to preoccupations as they said. About 100 people attended, the consultants described the purpose of the project, its benefits and loses to be sustained by the APs, compensation packages and methods of payment. The large majority expressed their views against shifting of the Depot in the new area and expressed that 3 sites were studied earlier and they looked lucrative by them why this shift which will impact on much larger land more APs. They vehemently expressed their dissatisfaction and did not appear to agree with the new site. The meeting could not be properly concluded and people attending started to diffuse out without signing the list of people attended and the SHM remained inconclusive.

In this circumstances, the JICA Study Team proposed a depot plan in zigzag shape which on mainly agricultural land and few households to be affected (Plan - 2 of Depot - 4) but DMTC did not like it and came up with another plan (say Plan - 3 of Depot - 4) and the sub-consultant was advised to study the Plan - 3. After several efforts and assistance from DMTC, SHM was repeated at the same location on 14 May, 2018. This time the Upazila Nirbahi Officer (UNO) of Rupgonj Upazila presided. In the meeting, situation improved but people were not unanimous but a good deal of change in opinion was observed to shift in favour of the acquisition. The people started expressing that they will cooperate if their household lands were spared. People appeared to express opinion in favour of the acquisition.

Some families are requesting alternative site to relocate, therefore, DMTC must prepare the resettlement site which qualify the principle of JICA policies on involuntary resettlement as follows.

① Describe the selection method on resettlement site, detail of basic infrastructure which will be provided, transfer of ownership plan and resettlement schedule.

② Describe the considerations on host community such as; implementation of stakeholder consultation meeting with the host community, grievance redress mechanism and any measures necessary to augment services in the host community.

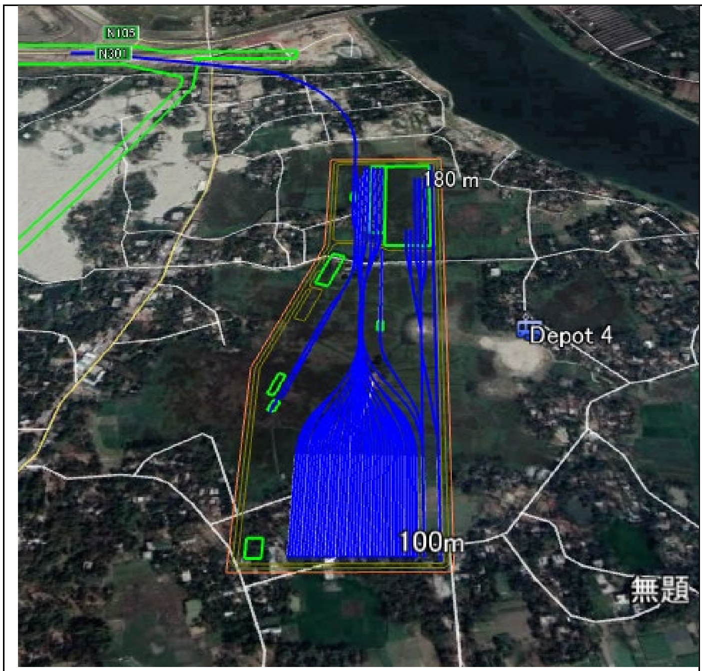
③ Describe the measures to prevent influx of ineligible persons to the selected site.

④ The replacement site must be comparable productive capacity and potential.

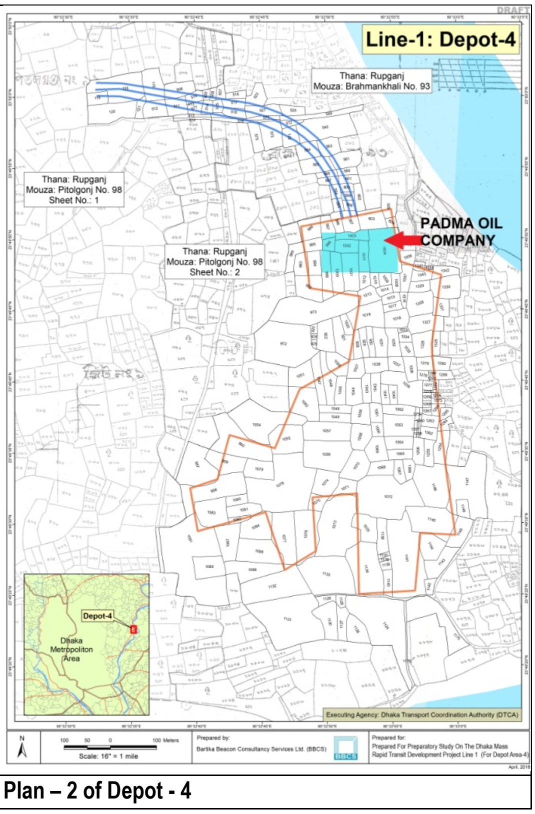
⑤ Compensation for PAPs those dependent on agricultural activities will be land-based whenever possible.

⑥ Provide resettlement schedule is subsequent to the basic infrastructure; electricity, drinking water, housing and school which will be prepared and secured

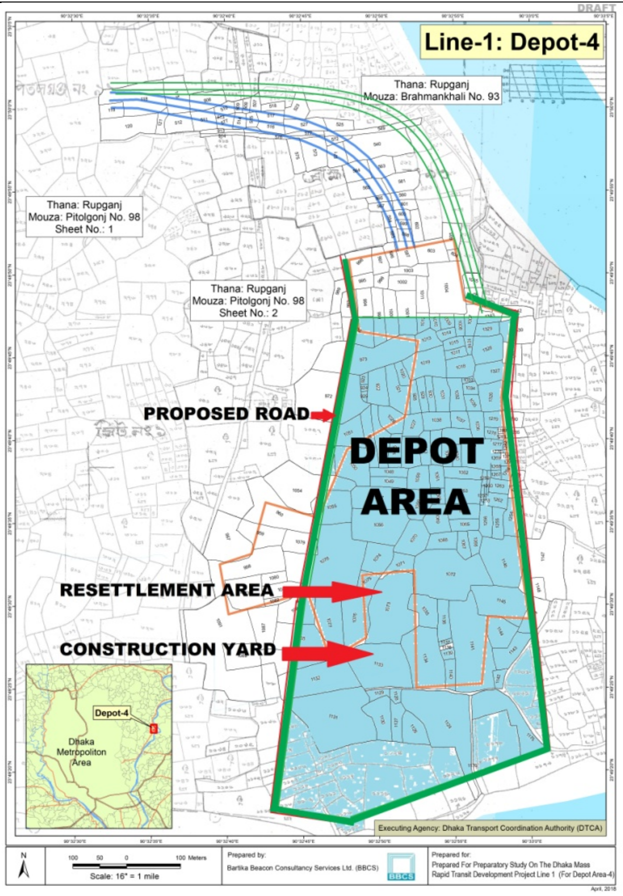
On 22nd September 2018, DMTC managed to hold a SHM to gain PAPs' understanding. Approximately 430 persons including local elites, teachers, imams and PAPs took part in the SHM. Attendees generally expressed consent on the project implementation and land acquisition for the depot site. However, they ventilated their requests such as exclusion of involvement or hassle of intermediate broker (Dalal) on compensation payment, and compensation that they can remain close to their current living areas. The authorities including DMTC agreed with their requests and promised to assist the PAPs in all respects.



Plan – 1 of Depot - 4



Plan – 2 of Depot - 4

	
Plan – 3 of Depot – 4 proposed by DMTC	

Source: JICA Study Team

Figure 5.15.1 Depot

5.16 Grievance Redress Committee

The complex land record system in Bangladesh leaves considerable room for conflicts over titles to land and properties involving land, structures, trees, ponds etc. Grievances may also be aired about the road alignment and/or the valuation of land and/or other properties in determining compensation. There are established procedures in the LA Ordinance of 1982 regarding compensation for some of these grievances. But recourse to law is always a complicated process, which usually discriminates against the poor due to their lack of knowledge and resources for litigation and is always time consuming. There are grievances, which can be easily resolved out of court if the law is properly explained and fair play made clear. It is with these objectives that a Grievance Redress Committee (GRC) will be set-up in each union where land acquisition will be taking place.

GRCs will be formed at Ward level for any grievances involving resettlement benefits, relocation, and other assistance. A gazette notification on the formation and scope of the GRCs will be required from the MORTB. The GRC for each Ward will comprised of;

Executive Engineer, DMTC - Convener

Area Manager, RAP Implementing Agency - member secretary.

UP Chairman - member.

One representative of APs – member

One UP member (female)- member

And the Procedures and Mechanism are presented in Table 5.16.1 and Figure 5.16.1, respectively.

Table 5.16.1 Grievance Redress Procedures

Step 1	The Implementing Agency informs DPs/APs about their losses and entitlements. If satisfied, the DPs/APs claims of resettlement payments forwarded to the EA. If confused,
Step 2	The DPs/APs approach the IA field level officials for clarification. The IA will clarify the DPs/APs about their losses & entitlements as per RAP. If resolved, the DPs/APs claim resettlement payments to the EA. If not resolved,
Step 3	The DPs/APs approaches to the GRC. IA staff assists the DPs/APs producing the complaints and organize hearing in 15-21 days of receiving the complaints.
Step 4	GRC to scrutinize applications, cases referred to DC through EA if beyond their mandate as per scope of work
Step 5	If within the mandate, GRC sessions held with aggrieved DPs/APs, minutes recorded. If resolved, the Project Director approves. If not resolved,
Step 6	The DP/AP may accept GRC decision. If not, he/she may file a case to the court of law for settlement.
Step 7	The GRC minutes, approved by the Project Director, received at Conveners' office back. The approved verdict is communicated to the complainant DP/AP in writing. The DP/AP then claims resettlement payments to EA

Source: JICA Study Team

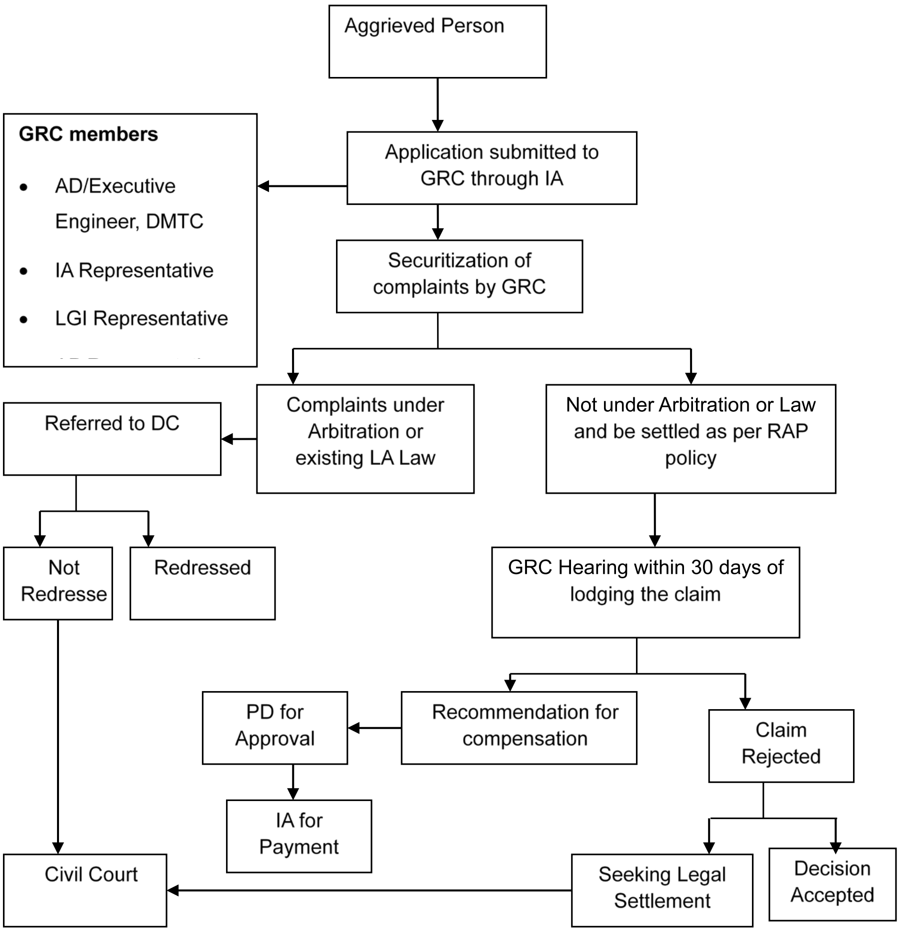


Figure 5.16.1 Grievance Redress Mechanism

Source: JICA Study Team

5.17 Implementation Organization

5.17.1 Implementation Organization

DMTC will establish a Project Implementation Unit (PIU) headed by a Project Director (PD), at the project office that will be responsible for the overall execution of the Project. The PIU will consist of three units: Engineering Service Unit (ESU), Environmental Management Unit (EMU) and Resettlement Unit (RU) for total implementation of the project. The PD will work on deputation from RHD at the level of Superintending Engineer or Additional Chief Engineer. The project will be overseen by the PD, RHD. The RU will be responsible for the overall implementation, management and monitoring of the RAP of the project. RAP Implementing Agency (IA) plays an important role in the field level in coordination with the DC, RHD and consultants. Their main activities are;

(a) To create ID numbers for each affected person as identified during the Joint Verification survey by JVT for both title and non-title holders.
(b) To assist the APs in preparing a record of rights to the property and receiving compensation under law (CCL) from DC office.
(c) To form focus groups with the affected people based on homogeneity and/or proximity and hold meetings on a regular basis to let them know their rights and entitlements as prescribed in the RAP.
(d) To form the union based resettlement advisory committee (RAC) to involve the local communities and APs in the implementation process.
(e) To prepare payment debit vouchers and other documents and disburse account payee checks to the APs.

The implementation organizations and hierarchy involved in the implementation process are shown in Figure 5.17.1**.**

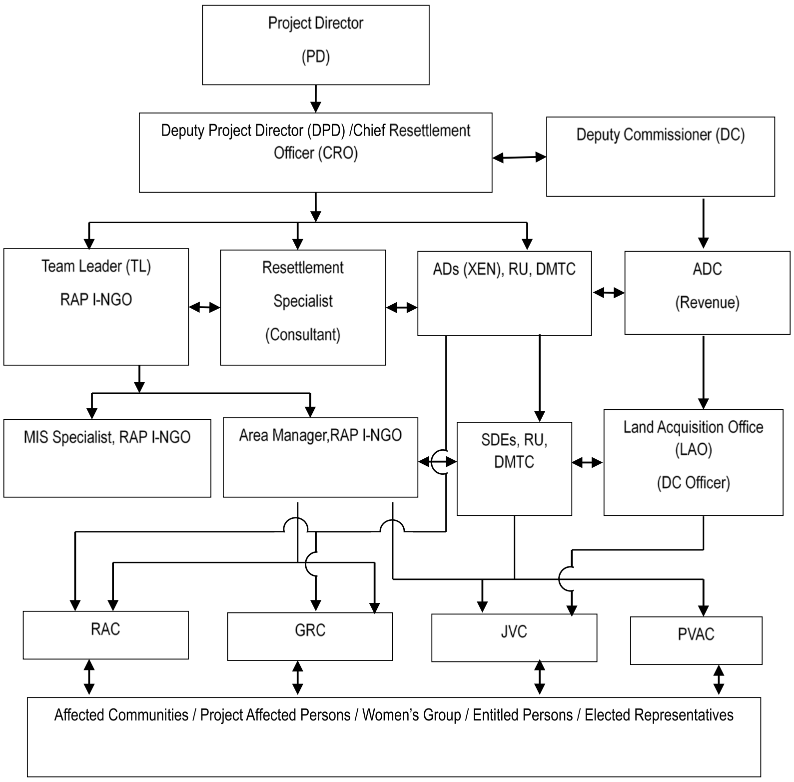


Figure 5.17.1 RAP Implementation Organogram

Source: JICA Study Team

5.17.2 Appointment of Implementing Agency (I-NGO)

DMTC will appoint an experienced Implementing Agency (IA) through standard procurement system. The IA can be a Non-Government Organization (NGO) or Social Consulting Firm. This IA will be appointed for implementation of the RAP in the field level in coordination with DC, DMTC and National Resettlement Consultant (NRS). The EA will contract out clearly defined tasks of the RAP with details Terms of Reference. A TOR is attached in Annex-5 of this document for the implementing agency.

5.18 Implementation Schedule

A time-bound implementation schedule for the RAP has been prepared in accordance with the project construction schedule. The overall schedule of implementation is based on the principle that people affected by the project are paid their due resettlement benefits prior to displacement. The Implementing Agency (IA) will assist the APs in the process of relocation and resettlement. Individual entitlements on household basis will be processed by the IA. Each EP will receive an ID card and an entitlement card. The ID card will be issued to the EPs as identified by the DC and/or Joint Verification Survey (JVS) with joint signature of the DMTC and IA representatives. Photograph of the EPs will be attested by the concerned UP Chairman/Ward Commissioner and pasted on the ID card.

Implementation of RAP will be started before starting of the construction works and will continue up to one year after completion of the construction work for entertaining claims /grievances of the EPs regarding additional payment of compensation and other resettlement grants. However, some of the activities for RAP implementation may extend further. The preliminary time bound implementation schedule over a period of 26 months from May 2019 to June 2021 is presented in Table 5.18.1.

Restoration and rehabilitation of livelihood program is expected to start from December 2020.

Table 5.18.1 RAP Implementation Schedule

Year/ Month	2019												2020												2021												2022			
Work Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Engineering Service			■	■	■	■	■	■	■	■	■	■	■	■	■	■																								
1. Selection of Implementation Agency (IA: NGO or local consultant)					■	■																																		
2. Formation of Committee by DMTC							■	■																																
3. Establishment of Joint Verification Team (JVT) in Project Implementation Unit (PIU)									■	■																														
4. Confirmation of RAP and Compensation Tools											■	■																												
5. Local Stakeholder Meeting (SHM)													■	■																										
6. Detailed Measurement Survey by JVT and Agreement with PAPs															■	■	■	■																						
7. Report on the result of SHM and DMS																		■	■	■	■																			
8. Preparation of Land Acquisition and Resettlemet Budget by IA to DMTC																				■	■																			
9. Approval of Budget by DMTC																						■	■																	
10. Payment of compensation/resettlement benefit by DMTC through IA																								■	■	■														
11. Income and Livelihood Restoration																								■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
12. Relocation of affected structures																											■	■	■											
13. Revision of RAP													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
14. Monitoring and Evaluation				■			■			■			■			■			■			■			■			■			■	■							■	■
Construction Works																															■	■	■	■	■	■	■	■	■	■
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Year	2019												2020												2021												2022			

Source: RA

5.19 Resettlement and Compensation Costs & Budget

The RAP budgets for compensation for land, structures, other assets, crops and trees, and special assistance will be calculated using the market rates reflecting replacement cost at the time of dispossession. The costs for relocation and special assistance will be consistent with the resettlement policy. Other costs involving project disclosure, public consultations and focus group discussions, training on IGA have been included in the RAP budget under 'Operation cost for IA' head. There is also a budget allocation for 05% as contingency.

The budget also includes operational cost of the Implementing Agency (IA) and capacity building training cost of the Executing Agency (EA). The total estimated cost for implementation of the RAP is **BDT- 19,476,844,278** including CCL amount to be determined by the DC for land and other physical assets. These estimates and the budget must be regarded as provisional, given the need for updating the RAP (if required) during implementation. Final rates per unit for land, structures, trees and other affected properties will be determined by the PVAC. Based on the rate and RAP policy a final resettlement budget would be prepared and approved by the EA. All resettlement funds will be provided by the EA (DMTC) based on the financing plan agreed by the GoB and the Donor. The total estimate is shown in Table 5.19.1.

Table 5.19.1 Summary and Indicative Budget of Land Acquisition and Resettlement of MRT Line 1

Sl. No	Category of loss	Unit	Quantity	Rate in Tk.	Amount in Tk.
A.	*Land with Types*				
1	Agriculture/vita	hectare	38.993	374,480,000	14,602,098,640
2	Others	hectare	0.2344	2,712,108,362	635,718,200
	Sub Total Land Acquisition,		*39.23*		*15,237,816,840*
B.	Stamp duty and Registration fees (@11.5%				1,752,348,937
C.	*Main Structure (Residential and Commercial)*				
1	Thatched	Sm	702.87	1,398.80	983,175
2	Katcha	Sm	4,051	2,399.48	9,721,061
3	Semipucca	Sm	18,722	8,575.00	160,573,463
4	Pucca	Sm	26,126	19,798.40	517,245,673
5	Tin	Sm	17,270	2,872.92	49,614,179
6	Tirpal	Sm	227	946.88	214,677
	Sub-total of Main Structure		67,098		738,316,227
D.	Secondary Structure				
1	Latrine (Pucca)	Nos	97	45,846	4,447,062
2	Latrine (Slab)	Nos	1	5,591	5,591
3	Latrine (Katcha)	Nos	3	3,332	9,996
4	Tube well	Nos	56	30,244	1,693,664
5	Boundary wall (Pucca and Tin)	RM	1,065	1,696	1,806,766
	Sub Total of Secondary Structure				*7,963,079*
E.	*Trees (Calculation made on average rate)*				
1	Large	Nos	29,441	2,982	87,793,062
2	Medium	Nos	7,426	716	5,317,016
3	Small	Nos	5,132	633	3,248,556
4	Sapling	Nos	35,700	509	18,171,300
5	Bamboo	Nos	35,556	360	12,800,160
6	Banana	Nos	12,307	467	5,747,369
	Sub Total of Trees		*125,562*		*133,077,463*
F.	*Resettlement Benefit*				
1	Crop compensation (80% of Agriculture/Others @ 400/dec or 98,800/ha)	hectare	31.19	98,800	3,082,007
2	Fruit compensation (30% of timber value for fruit bearing trees, big and medium)				1,419,690
3	Sapling Cost for each affected households losing trees, 5 trees@cost 250=1250 taka	Nos	471	1,250	588,750

4	Structure Transfer Grant (STG) @12.5% of the replacement value of main structure.				92,289,528
5	Structure Reconstruction Grant (SRG) @12.5% of the replacement value of main structure.				92,289,528
6	One time Transfer Grant (TG) for portable materials at the rate of (a) Nos 18 @ BDT 3,000 (three thousand) for katcha structure and (b) Nos 6@ BDT 5,000 (five thousand) for semi Pucca structure and Nos 29 @ BDT 7,000 (seven thousand) for Pucca structures	Nos			3,344,000
7	Cost of transfer and reinstallation of the utility services like reinstallation of electricity connection, water supply line, telephone line etc. as grant @ 10% of CMP of structure				73,831,623
8	Monthly Hiring Allowance (MHA) for the similar type of space in other structures for running their activities for a period up to 6 (six) months, per month @1500/=	Nos	938	9,000	8,442,000
9	Dismantling and reconstruction cash assistance of CPRs	Nos	42	300,000	12,600,000
10	House Transfer Grant (HTG) for shifting of furniture and belongings of residential structure to each shifting tenant.	Nos	42	4,000	168,000
11	Stock Transfer Cost (STC) for commercial entities @BDT 5,000 (five thousand) for small business (Nos-14); BDT 10,000 (ten thousand) for medium business (Nos-16) and BDT 15,000 (fifteen thousand) for large business (Nos-21).	Nos	446		3,335,000
12	One time cash grant for facilitating alternative housing/CBEs Tk. 5000 (Five thousand) per household or entity	Nos	530	5,000	2,650,000
13	Loss of business/income equivalent to 03 (three) months' income subsistence at the rate of BDT 6,000 (six thousand) (BDT 2,000X3) for Small business (Nos-45), BDT 12,000 (twelve thousand) (BDT 4,000X3) for medium business (Nos-33) and BDT 18,000 (eighteen thousand) (BDT 6,000X3) for large business (Nos-24).	Nos	446		4,002,000
14	Transition allowance (TA) for the loss of rental income equivalent monthly allowance for 3 (three) months for each affected rented out premise	Nos	136	30,000	4,080,000
15	Cash grant to the affected employees/wage earners equivalent to 45 days wage @ BDT 400/per day for unskilled laborers (Nos-111) and @ BDT 600/per day for skilled laborers (Nos-35).	Nos	573		11,268,000
16	Additional cash grant of BDT 10,000 (ten thousand) for affected poor women headed households and other vulnerable households	Nos	395	10,000	3,950,000
17	Training on IGA for AP/ nominated by AP.	Nos	395	20,000	7,900,000
	Sub Total-F				*325,240,126*
	Sub-Total of (A-F)				*18,194,762,672*
G.	*Others*				
1	Operation Cost for RAP implementing NGO (INGO)			LS	40,000,000
2	External monitorin Cost			LS	10,000,000
3	Contingency for unforeseen issues @ 5% of total budget (Item A-F)			LS	909,738,134
4	Administration cost of DC on compensation (Item A, C,D and E) @ 2%			LS	322,343,472
	Grant Total Taka				*19,476,844,278*

Source: RAP

5.20 Monitoring and Evaluation

5.20.1 Monitoring and Evaluation

The RAP implementation monitoring will be done both internally and externally to provide feedback to RU (DMTC) and to assess the effectiveness. Mid-term reviews of the resettlement activities drawing upon monitoring and evaluation reports and other relevant data to identify any action needed to improve resettlement performance or respond to the changing circumstances. Evaluation of the resettlement activities will be resorted to during and after implementation of the RAP to assess whether the resettlement objectives were appropriate and whether they were met, specifically, whether livelihoods and living standards have been restored or enhanced. The evaluation will also assess resettlement efficiency, effectiveness, impact and sustainability, drawing lessons as a guide to future resettlement planning.

A RAP implementation monitoring format is enclosed in Annex VII.

5.20.2 Internal Monitoring

Internal monitoring will be undertaken by the RU with assistance from the NRS and IA. The IA will gather information on RAP implementation covering relevant activities as per schedule. All activities listed will be illustrated in Gantt Charts showing the target dates for completing resettlement activities. Internal monitoring reports on RAP implementation will be included in the quarterly Project Progress Report (PPR) to be prepared by RU, DMTC. The report of RU will contain: (i) accomplishment to-date, (ii) objectives attained and not attained during the period, (iii) challenges encountered, and (iv) targets for the next quarter. The internal monitoring report will then be integrated by the RU with the overall PPR submitted to Donor. The NRS will assist PMU preparing the overall PPR for Donor. However, the NRS will monitor the activities of IA and report to DPD/CRO, RU on a monthly basis. Table 5.20.1 shows the potential monitoring indicators that will be reported.

Table 5.20.1 Potential Monitoring Indicators

Monitoring Issues	Monitoring Indicators
Budget and Timeframe	Have all land acquisition and resettlement staff been appointed and mobilized for field and office work on schedule? Have capacity building and training activities been completed on schedule? Are resettlement implementation activities being achieved against agreed implementation plan? Are funds for resettlement being allocated to resettlement agencies on time? Have resettlement offices received the scheduled funds? Have funds been disbursed according to RAP? Has all land been acquired and occupied in time for project implementation?
Delivery of AP Entitlements	Have all APs received entitlements according to numbers and categories of loss set out in the entitlement matrix? How many affected households have received land titles? How many affected households relocated and built their new structure at new location? Are income and livelihood restoration activities being implemented as planned? Have affected businesses received entitlements? Have the APs losing their eroded land received proper compensation? Have the squatters, encroachers of DMTC or government land, displaced due to the project, been compensated? Have the community structures are compensated and rebuilt at new site?
Consultation, Grievances and Special Issues	Have resettlement information brochures/leaflets been prepared and distributed? Have consultations taken place as scheduled including meetings, groups, community activities? Have any APs used the grievance redress procedures? What were the outcomes? Have conflicts been resolved?
Benefit Monitoring	What changes have occurred in patterns of occupation compared to the pre-project situation?

Monitoring Issues	Monitoring Indicators
	What changes have occurred in income and expenditure patterns compared to pre-project situation? Have APs income kept pace with these changes? What changes have occurred for vulnerable groups?

Source: RAP

5.20.3 External Monitoring

DMTC will monitor the project activities through an external monitor. The NRS will assist RU for preparation of quarterly report for Donor. The DMTC will as per their set guideline monitor land acquisition/resettlement activities in timely manner. External monitoring will be in two phases: compliance monitoring and social impact evaluation.

1) Compliance Monitoring

Compliance monitoring of RAP implementation will cover (i) Project compensation and entitlement policies, (ii) adequacy of organizational mechanism for implementing the RAP, (iii) restoration of APs incomes, (iv) setting complaints and grievances, and (v) provisions for adequate budgetary support by DMTC for implementing the RAP. DMTC will assess if the APs: (i) have re-established their houses in new location; (ii) have re-established their business; and (iii) were extended assistance to restore their incomes from pre-project levels. It will also appraise the accounting documents used in recording the payments of compensation to APs by the EA.

2) Social Impact Evaluation

DMTC will engage individual/firm to conduct a one-time social impact evaluation, at least six months following the completion of resettlement. It will use appropriate investigative and analytical techniques in assessing the post-project socio-economic conditions of the APs in relation to the baseline socio-economic data generated before undertaking of the resettlement implementation.

The evaluation will describe any outstanding future issues that are required to bring the resettlement into compliance with JICA’s Guidelines for Environmental and Social Considerations and Government policies, and further mitigation measures needed to meet the needs of any APs or families perceiving themselves to be worse off as the result of resettlement. It will include lessons learned from the evaluation that may be useful in developing future policies on involuntary resettlement of APs in Bangladesh.

The Resettlement Specialist within the project consultants will conduct periodic review and supervision mission during the implementation stage. In addition to regular review missions, DMTC will undertake a comprehensive mid-term review of the RAP implementation. A post-evaluation of RAP activities will be carried out by DMTC to assess the resettlement impact in terms of adequacy and deficiency in planning and R&R operations following the social impact evaluation. Terms of Reference (TOR) of the External Monitoring Agency (EMA) is attached as Annex -7.

5.20.4 Reporting Requirements

During the implementation phase, the Project Director will prepare quarterly report on the progress of resettlement activities and forward copies to the GoB and the donors. A format for resettlement implementation monitoring will be devised for quarterly monitoring and data collection by the field officials. The Resettlement Specialist of the Project Supervision Consultants and Supervision Missions every six months during the implementation stage will conduct review and report to DMTC and the donors on the progress of all aspects of land acquisition and resettlement activities.

Table 5.20.2 Model format for RAP implementation Monitoring – Quarterly Report

Component	Unit Total	Completed %	Cumulative Achievement Total	Completed%	Progress During Reporting Month			Status & Remarks
					Target	Achievement	%	
Resettlement Preparation								
Distribution of Brochures								
Identification of AHs/CBEs								
Issuance of ID cards								
Consultation Meetings								
Formation of PVAT/RAC/GRC								
Payment of Compensation								
Compensation for land								
Compensation for tree/crop/fish								
Res/Commercial structure								
Payment for rent/leaseholder								
Shifting/relocation costs								
Social Development Activities								
Grant for loss of wages								
Loss of business grant								
Business restoration grant								
Payment for indirect impact								
LIRP activities								

Source: RAP

5.21 Local Stakeholder Meeting (RAP)

Stakeholders meetings were conducted in two stages. At the first stage, consultations were held informing the goal, objective, component of the project Consultants also narrated the potential land acquisition status in that specific area. Feedback of the consultation meetings were incorporated and considered to finalize the project alignment/location in February and March, 2017 prior to start the census survey.

Consequently, the second stage of consultation took place in April and May after census survey was conducted. The Consultants disclosed the entitlements of the affected households and other stakeholders as designed in the RAP based on GOB policy and JICA's Guidelines, and the cut-off date was declared for eligibility of receiving resettlement benefits for the non-titled affected peoples.

The minutes of SHMs is attached in Annex-6.

By the way, women group in Bangladesh have not enough opportunity to participate the SHMs, therefore, the focus group discussion was considered and conducted. Details are described in Annex-8: Gender in the Report.

5.21.1 1st Round Local SHM

In the initial stage of the project in February 2017 the local potential affected persons of different locations along the RoW with local community leaders and other stakeholders like DMTC representatives, local government representatives were consulted through consultation meetings and personal contact. Stakeholders were informed about the meeting time and location ahead of time through personal contact and over telephone and through the local public representatives. Local people were also called by announcing in person and well as instantly through using hand microphone.

The consultants narrated the goal and objective of the project, different components of the project and proposed design of the stations with location were also discussed. Consultants also narrated the potential land acquisition status in that specific area. GoB policy, Donors' policy including JICA on land acquisition and compensation were discussed in the meetings. The opinion of the different levels stakeholders regarding the project was considered during finalization of the RoW and stations both above and under the surface with location for improvement.

Stakeholders of the most of the area expressed their positive view regarding the construction of the MRT line provided the affected people get appropriate compensation according to the present full replacement cost. However, during the initial level of discussion held on 18th February at Purbachal RAJUK Bhaban on Depot 1 and Depot 2 some stakeholders expressed their concern about the proposed location of construction of depot. Many of them expressed social issues like depot going to be built on private land, they are not in favor of giving up the land as previous experience of compensation receiving from government was not pleasant, some of the community institutions like mosque, school, graveyard, will be affected.

To cope with the above, the stakeholder meeting on Depot was held on 14th March one more time. Compared with and Depot 1 and 2 this made displacement nil and people agreed to Depot 3 tentatively.

In addition to the Depot 3, plan for Depot 4 was arisen and SHM was held on 3rd March, 2018.

The inputs from the stakeholders meetings have been used to finalize the project, developed measures and principles for mitigation of loss on APs. Summary of consultation meetings with affected people and other stakeholders are described in Table 6.21.1.

Table 5.21.1 Summary of the Local Stakeholder Meeting

Line	Place	Participants		Inquiry	Answer
		Male	Female		
Line1	Airport Railway Station (15th February)	63	2	Request an appropriate compensation and restoration of livelihood. Request compensation when loss of business is arisen.	This will be available when PAPs give the precise information on land acquisition and restoration. Job training is anticipated to mitigate negative impact when loss of business is assumed

Line	Place	Participants		Inquiry	Answer
		Male	Female		
Line1	Purbachal RAJUK Brabant (18th February)	29	1	Governmental compensation is lower than market price. Compensated price differs even to the same mouza number	Compensation is assessed according to the resettlement value of present market price Compensation to land and asset will be conducted in accordance with the present resettlement value
Line1	Uttar Badda and Badda Commissioner's Office (19th February)	27	1	Inform the exact location of stations and quantity	It will be informed when detail design has completed
Line1	East Rampura High School (22nd February)	42	5	Is it available for elder/handicapped persons to utilize the Metro? Is the compensation to the above ground available where Metro will be locating?	The preparation of dedicated seats is considered to those people Compensation is not considered at this moment because the loss is not assumed
Line1	Children Academy & Pre-Cadet School Notun Bazar (25th February)	44	5	Request land acquisition shall follow the record for land ownership and wanted payment of compensation from DC office without any harassment.	When local government feels difficulties to decide if the PAP is appropriate to receive the compensation then they will cooperate with competent authority to make final judgement
Line1	Bir Muktijodhha Sadek Hossain Khola Community Centre (4th March)	38	0	Is the project under jurisdiction of Ministry of Railway?	The project proponent is not MOR, it is DTCA.
Line1	Lion Habibur Rahman Harez School and College (14th March)	48	12	The depot site must be decided where makes negative impact as less as possible.	The request shall be transferred both DTCA and the Study Team
Line 1	1st Floor of Pitolganj Dakhil Madrasa (3rd March, 2018)	100 (approximately)		PAHs insisted the compensation should conform to the Land Acquisition Act of 2017	The Consultants explained that the LA Act of 2017 will be followed.

Source: JICA Study Team

5.21.2 2nd Round Local SHM

After finalization of the RoW of the project, community level stakeholders consultations were held in all the earlier locations in April 2017. Stakeholders were informed about the meeting time and location ahead of time through personal contact and over telephone as well as through public representative. Local people were also called by announcing in person as well as instantly through using hand microphone.

Process of land acquisition, DC's payment procedure, donor's policy on involuntary resettlement, entitlements of the affected PAUs and vulnerable people, declaration of cut-off date for listing property and probable resettlement benefits, etc. were discussed in the meetings.
Furthermore, the cut-off date at Depot 4 area was declared on 14th May, 2018.

The RAP design, compensation, relocation options, benefits and adverse social impacts were discussed with the affected persons and their community. Stakeholders were asked for their views on the project overall as well as more specific discussion about their perception on land acquisition process, compensation payment process, relocation requirements, and views on alternative options.

Summary of consultation meetings with affected people and other stakeholders are described in **Table 5.21.2** .

Table 5.21.2 Summary of the Local Stakeholder Meeting

Line	Place	Participants		Inquiry	Answer
		Male	Female		
Line1	Airport and Khilkhet Sramik League Office, Biman Bandar Railway Station (15th April)	27	0	Request adequate compensation for loss of his business. Request appropriate compensation for loss of business so that they can continue with their livelihood.	Full replacement cost on compensation will be applied. Compensation on CPR will be paid to community level management firm. PAPs can bring salvaged materials. House rental fee will be paid for some extent. Technical training program will be applied as LIRP
Line1	Purbachal Depot 107 No. Modhukhali Govt. Primary School (17th April)	31	10	Expressed deep sympathy for the affected persons of previous project. They do not want to lose any further of their property due to this project. On behalf of them I suggest appropriate land compensation on the Purbachal RAJUK Area. Affected persons of GoB initiated projects did not get proper compensation. People are victimized and their lives & livelihoods are marginalized so if an elected person should be a member of committee for depot land at Rupganj then it will be better for the people.	Explain the reason why Depot 3 was proposed as alternative of Depot 1 & 2. Compensation on CPR will be paid to community level management firm. PAPs can bring salvaged materials. House rental fee will be paid for some extent. Technical training program will be applied as LIRP
Line1	Uttar Badda and Badda	16	1	Request to shift the station some meters away	Proposed location of station is tentative one. Final location will be

Line	**Place**	**Participants**		**Inquiry**	**Answer**
		Male	**Female**		
	Ward Commissioner's Office (20th April)			so that his business establishment remains unaffected. Demand to look after welfare of the affected persons so that they can continue their livelihood properly as before.	fixed in detailed design stage. Compensation on CPR will be paid to community level management firm. PAPs can bring salvaged materials. House rental fee will be paid for some extent. Technical training program will be applied as LIRP
Line1	Hatirjheel Rampura East Rampura High School (22nd April)	59	5	What action will be taken because some households would be affected by the exit/ entry point of Rampura station? The road will be closed for communication during the construction period. Suggested to shift the exit/ entry point towards a nearby vacant Area. Complained the process at DC's office is too cumbersome.	Proposed location of station is tentative one. Final location will be fixed in detailed design stage. Compensation on CPR will be paid to community level management firm. PAPs can bring salvaged materials. House rental fee will be paid for some extent. Technical training program will be applied as LIRP
Line1	Kamalapur Malibagh (24th April)	33	0	The D C office's payment procedure is very complex and cumbersome. If possible, shift the exit entry point which is now selected, otherwise the livelihood and profession will be at stake. Welcome the project and emphasized on taking right decision. Development should be for the people but should cause minimum loss to them.	Proposed location of station is tentative one. Final location will be fixed in detailed design stage. Compensation on CPR will be paid to community level management firm. PAPs can bring salvaged materials. House rental fee will be paid for some extent. Technical training program will be applied as LIRP Explains the views for maximization of land use so that people are least affected.
Line 1	1st Floor of Pitolganj Dakhil Madrasa (14th May, 2018)	80 (approximately)		They spoke in favour of sparing the households from acquisition. They urged to save their households, pay adequate compensation for acquired land so that they can survive. If land acquisition is necessary, pay compensation @ 3 times of current market price.	The DMTC has elaborately described the project and presented the compensation packages and payment mode, he had answered almost all the queries of the audience.

Line	Place	Participants		Inquiry	Answer
		Male	Female		
Line 1	1st Floor of Pitolganj Dakhil Madrasa (22nd September, 2018)	430 (approximately)		Generally, PAPs agreed necessity of the project and land acquisition of depot site. They asserted exclusion of involvement or hassle of intermediate broker (Dalal) on compensation payment, and compensation that they can remain close to their current living areas. Compensation should be referred to the other project near the project site.	The authorities including DMTC agreed with their requests and promised to assist the PAPs in all respects.

Source: JICA Study Team

5.21.3 Focus Group Discussion on Gender

At the project sites, 4 Focus Group Discussions (FGD) were held for both Line 1 and Line 5. Particularly, regarding the SHM, there were relatively limited female participants, and it was difficult for them to express their opinions in front of male counterparts. Thus, the FGDs which targeted only women were separately organized. Date and number of participants is presented **Table 5.21.3**.

Table 5.21.3 Summary of the Focus Group Discussion

Date	Venue	Number of Participant
20th of March	Purbachal	6
2nd of May	Purbachal	12

Source: JICA Study Team

The needs of the potential female users are obtained through FGD as listed below. Those needs are reflected to design of station and rolling stock as well as compiled in the gender action plan. In addition, the needs will be reflected to items in bid documents those muse be complied by the Contractor. Furthermore, women are not accustomed not only METRO but also public transport system, adequate consideration must be taken on design and operation etc.

In detailed design stage, the policy on designing cares on station and rolling stocks, management of METRO and environmental social consideration will be taken. Especially, it is suggested that female employment at METRO is an urgent challenges to be achieved.

3) Design of Station

- Separate ticket booths for male and female passengers
- Separate washrooms for male and female passengers
- Separate prayer rooms (space) for male and female passengers
- Adequate lighting facilities
- Clean waiting room (space) and platform
- Installation of escalator/lift
- Installation of drinking water facility
- Allocation of vendor (small business) area (space) for women

4) Design of Rolling Stock

- Separate compartments for male and female passengers
- Reserved/priority seats for pregnant women, women with young children, children, elderly people and physically challenged passengers
- Adequate lighting

5) Construction

- Employment of women for construction work
- Equal pay/work/opportunities for male/female workers
- Employment of women for construction project related work (e.g.: supporting staff, cooking, cleaning, laundry, catering, etc.)
- Separate prayer rooms (space), washroom, changing rooms, dining space (different timing between male/female for lunch break) for male/female workers/staff
- Provision of training to raise awareness on gender
- Provision of training on prevention of HIV/AIDS

6) Operation

- Deployment of female staff for both ground operation and on board
- Setting affordable fares
- Setting time schedule to meet women's needs
- Keep clean (station, platform, train, etc.)
- Responding to gender issues, measures on sexual harassment and implementation of those

7) Others

- Concerning the resettlement plan, consideration should be given to the women so that they will also be able to obtain financial compensation
- In relation with the above, not only the financial compensation but provision of employment opportunities should be also considered
- During the planning stage, women’s opinions should be heard as well as women’s participation of decision making should be secured

In addition to the opinions of participants of the FGDs mentioned above, suggestions and advice from the other donors and Department of Women, informal views of the said people/official concerned as well as the local staff of the Project are listed below.

- Many educational institutions such as universities, including girls' universities, have been established around the project sites. Specifically, along the MRT Line 1, there are approximately 30 educational institutions (high school level or above), for example, Viqarunnisa Noon School & College (girls), Motijieel Girls School, and Habibullah Bahar University College (co-education)[10]. It is expected that the students going to these educational institutions would utilize the MRT. Moreover, in consideration of the present situation in Bangladesh, when the daughters passed the university entrance examination, there are cases that the parents decide to relocate their houses/apartments to the nearby area of their daughters’ university[11]. It is due to the safety reason of the daughters. Given this situation, it is also expected that the

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[10] Refer to the Appendix 1.

[11] Those who do not have private cars, such as lower middle classes, they cannot send/pick up their daughters to/ from their schools. Thus there are cases that the family may relocate their homes to nearby their daughter’s school.

women's educational opportunities will be expanded as well as easy access to educational institutions will be secured.

- There is a necessity to take measures to prevent intrusion of homeless, etc. inside the station premises after closure of the business hour of the MRT operation. Particularly, as a security point of view, it is required to take thorough precautions to prevent women from not using the MRT because of the security reason.
- It is ideal to secure stroller and wheelchair spaces in the compartments of MRT.
- Followings are to enhance utilization of the MRT for children and women: cartoon images and soft music in the station and the compartments12.
- Give due consideration to not only women but also physically handicapped people.
- As for the tickets, weekly and monthly passes to be issued.
- Clean separate "public type of "washrooms for men and women (open to non-MRT users)

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[12] With regard to this matter, advertisements can be an alternative plan.

6 Project Evaluation

This chapter analyses the validity of the project. Firstly, the economic viability of the project implementation from a national feasibility viewpoint is evaluated by economic analysis. Secondly, evaluation of the financial viability of the project from a project management viewpoint is conducted by financial analysis.

6.1 Economic Evaluation

The main purpose of economic analysis is to show the effects of the project implementation from a national economy viewpoint as it aims to evaluate the economical validity of the project implementation. Although there are many projects in the public sector, which must be carried out for the improvement of life of the people, the budget that can be spent is restrained. Economic analysis evaluates whether it is the project that benefits the national economy. While financial analysis assesses the project viability from a viewpoint of a project entity, the benefits of firms and institutions will be calculated and the actual figure spent will be calculated as cost. Economic analysis assesses the national benefit that the project produces and the consumption of resources that the national economy holds. The evaluation uses discounted cash flow analysis, which is the method that compares economic benefits and economic costs.

6.1.1 Review of Methodology of Economic Analysis

Comparison of the benefits and expenses of the cases with and without project is carried out for the analysis of this project. Benefit is regarded as various desirable effects given to national economy when the project is carried out, and expense is regarded as an all-national economy-expenditure required for the concerned project implementation. Of course, it is impossible to measure all benefits and expenses; thus, quantitively measurable benefits and costs will be added up. As an evaluation index, which shows the economic analysis results, the following will be used:

- Economic internal rate of return (EIRR).
- Net present value (NPV).
- Benefit-Cost ratio (B/C ratio).

6.1.2 Project Costs and Economic Analysis

For the economic analysis, all project costs estimated in the market price need to be converted into the economic price at social discount rate for the national economy. The criteria of the price conversion are (i) the resource is truly used for the project and (ii) the price represents the real value. According to the former criteria, transfer items such as taxes, interests, subsidies need to be excluded from the economic costs since they are the items just transferred within the national economy. The latter criteria is the price distortion intentionally caused by imposition, limited opportunity, etc., which needs adjustment to show the real price. Economic price is the price converted by these adjustments. The process of conversion is described as follows.

(a) Exclusion of transferred items

Transferred items such as taxes, interests, and subsidies shall be excluded from the cost as well as benefit in the economic evaluation. These items are not the resources truly used for the project but just transferred among the composition members of the state such as consumers, manufacturer, etc.

(b) Adjustment of the distorted prices

In many developing economies, politically distorted prices such as customs duty and double price in the labour market prevent appropriate resource allocation. Therefore, it is necessary to adjust these price distortions to show the true prices for economic evaluation. In this economic analysis, financial project cost will be converted into economic project cost by deducting taxes and applying standard conversion factor (SCF) for the non-trade goods to estimate economic price of the project cost. Details of the methodology is explained hereafter.

The Ministry of Planning of Bangladesh officially defines the SCF as 0.78 for project evaluation, so that shall be applied in this study.[1] All costs are classified into items of trade goods, non-trade goods, and transfer items. In the calculation of economic price, transfer items shall be excluded first and then economic price of the whole portion of non-trade goods shall be obtained by application of SCF.

1) Project cost:

The estimated project cost for MRT Line 1, which was determined through process of cost estimation, is shown in Table 6.1.1.

Table 6.1.1 Project Cost

Unit: Million Yen

Item		Local	Foreign	Total
A. JICA Portion				
1.Civil Works and Procurement of Equipment				
	Base Cost	111,135	221,749	368,448
	Price Escalation	33,616	22,135	66,508
	Physical Contingency	14,475	24,388	43,496
	Sub-Total	159,227	268,273	478,452
2. Consulting Service				
	Base Cost	5,980	15,577	23,471
	Price Escalation	1,604	1,266	3,384
	Physical Contingency	379	842	1,343
	Sub-Total	7,964	17,685	28,197
Total		167,148	167,190	285,958
B. Borrower Portion				
a. Civil Works and Procurement of Equipment				
	Base Cost	0	0	0
	Price Escalation	0	0	0
	Physical Contingency	0	0	0
	Sub-Total	0	0	0
b. Panel of Experts				
	Sub-Total	0	19	19
c. Land Acquisition				
	Base Cost	15,768	0	20,814
	Price Escalation	1,565	0	2,066
	Physical Contingency	1,733	0	2,288
	Sub-Total	19,067	0	25,168

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[1] Government of the People's Republic of Bangladesh, General Economics Division (GED), Planning Commission, Ministry of Planning. March 2014. *Development Project Proposal (DPP) Manual*.

d. Local Administration			
Sub-Total	20,145	0	26,591
e. Tax			
VAT	12,758	0	16,840
Import Tax	60,971	0	80,482
Other Taxes	27,936	0	36,875
Sub-Total	101,665	0	134,197
Total	140,876	19	185,975
A+B			
Base Cost	153,028	237,345	439,342
Price Escalation	36,786	23,401	71,959
Physical Contingency	16,588	25,231	47,126
VAT	12,758	0	16,840
Import Tax	60,971	0	80,482
Other Taxes	27,936	0	36,875
Total	308,067	285,976	692,624
C. IDC & Front-End Fee			
IDC (Construction)	0	26,851	26,851
IDC (Consultant)	0	14	14
Front-End Fee	0	1,013	1,013
Total	0	27,878	27,878
Grand Total	308,067	313,854	720,502

Source：JICA Study Team

2) Economic Price of the Project Cost

In the calculation of economic price of the project cost, price escalation contingency will be excluded from both cost and benefit while physical contingency remains included.[2] After adjustment to the economic prices using the described method , the economic price of the project cost is calculated. Table 6.1.2 shows the calculated economic price of the project in comparison with the financial price of the project.

Table 6.1.2 Project Cost (Economic and Financial Price)

Unit: Million Yen

Item	Economic Price			Financial Price		
	Local	Foreign	Total	Local	Foreign	Total
A. JICA Portion						
1.Civil Works and Procurement of Equipment						
Base Cost	86,686	221,749	336,174	111,135	221,749	368,448
Physical Contingency	11,291	24,388	39,292	14,475	24,388	43,496
Sub-Total	97,976	246,138	375,466	125,610	246,138	411,943
2. Consulting Service						
Base Cost	4,665	15,577	21,734	5,980	15,577	23,471
Physical Contingency	296	842	1,233	379	842	1,343
Sub-Total	4,961	16,419	22,967	6,360	16,419	24,814
B. Borrower Portion						
a.Civil Works and Procurement of Equipment						
Base Cost	0	0	0	0	0	0

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[2] JICA. March 2002. *Study on the Methodology of Economic Evaluation in the development project.*

	b.Panel of Experts	0	19	19	0	19	19
	c.Land Acquisition						
	Base Cost	12,299	0	16,235	15,768	0	20,814
	Physical Contingency	1,352	0	1,785	1,733	0	2,288
	d.Local Administration	15,713	0	20,741	20,145	0	26,591
	e. Tax						
	VAT	Excluded	Excluded	Excluded	12,758	0	16,840
	Import Tax	Excluded	Excluded	Excluded	60,971	0	80,482
	Other Taxes	Excluded	Excluded	Excluded	27,936	0	36,875
	Sub-Total	29,364	19	38,779	139,311	19	183,909
A+B							
	Base Cost	119,362	237,345	394,902	153,028	237,345	439,342
	Physical Contingency	12,938	25,231	42,309	16,588	25,231	47,126
	VAT	Excluded	Excluded	Excluded	12,758	0	16,840
	Import Tax	Excluded	Excluded	Excluded	60,971	0	80,482
	Other Taxes	Excluded	Excluded	Excluded	27,936	0	36,875
Grand Total		132,300	262,575	437,212	271,281	262,575	620,666

Source：JICA Study Team

6.1.3 Operation and Maintenance (O&M) Cost

O&M cost for the project is estimated through the process of cost estimation and shall be converted to economic price using the same methodology explained previously. Price escalation is not included, but salary fee is assumed to increase by 10% every five years. Table 6.1.3 shows the O&M cost in economic price.

Table 6.1.3 O&M Cost of the Project (Economic Price)

Unit: Yen in million

Year	Train Operation	Staff Salary	O&M Cost	Rolling stock Maintenance	General / O&M Administration	Additional Car	Reinvestment/ Replacement Cost	Total
2026	105	80	142	59	129	0	0	516
2027	1,262	962	1,709	710	1,554	0	0	6,197
2028	1,262	962	1,709	710	1,554	0	0	6,197
2029	1,262	962	1,709	710	1,554	0	0	6,197
2030	1,262	962	1,709	710	1,554	0	0	6,197
2031	1,447	1,179	1,709	815	1,782	6,589	0	13,521
2032	1,447	1,179	1,709	815	1,782	0	0	6,931
2033	1,447	1,179	1,709	815	1,782	0	0	6,931
2034	1,447	1,179	1,709	815	1,782	0	0	6,931
2035	1,447	1,179	1,709	815	1,782	0	0	6,931
2036	1,632	1,297	1,709	919	2,010	8,237	5,445	15,804
2037	1,632	1,297	1,709	919	2,010	0	0	7,567
2038	1,632	1,297	1,709	919	2,010	0	0	7,567
2039	1,632	1,297	1,709	919	2,010	0	0	7,567
2040	1,632	1,297	1,709	919	2,010	0	0	7,567
2041	1,632	1,427	1,709	919	2,010	0	3,161	10,858
2042	1,632	1,427	1,709	919	2,010	0	0	7,697
2043	1,632	1,427	1,709	919	2,010	0	0	7,697
2044	1,632	1,427	1,709	919	2,010	0	0	7,697
2045	1,632	1,427	1,709	919	2,010	0	0	7,697
2046	1,632	1,569	1,709	919	2,010	0	0	7,840
2047	1,632	1,569	1,709	919	2,010	0	5,445	13,284
2048	1,632	1,569	1,709	919	2,010	0	0	7,840
2049	1,632	1,569	1,709	919	2,010	0	0	7,840
2050	1,632	1,569	1,709	919	2,010	0	0	7,840

2051	1,632	1,726	1,709	919	2,010	0	0	7,997
2052	1,632	1,726	1,709	919	2,010	0	0	7,997
2053	1,632	1,726	1,709	919	2,010	0	0	7,997
2054	1,632	1,726	1,709	919	2,010	0	0	7,997
2055	1,632	1,726	1,709	919	2,010	0	0	7,997
Total	45,033	39,920	49,704	25,351	55,456	14,826	14,051	238,897

Source: Study Team

6.1.4 Economic Benefit

1) Basic Assumptions

(a) Economic Benefit of the Project

Economic benefits upon implementation of the project are reduced vehicle operating cost (VOC), travel time cost (TTC), and CO_2. Based on the result of the traffic demand forecast, the reduced amount of VOC, TTC, and CO_2 will be calculated and then summed to calculate for the economic benefit in years 2025 and 2035. Reduced amounts will be measured by comparison of the cases with project wherein MRT Line 1 will be implemented and without project wherein MRT Line 1 will not be implemented. The benefits in other years are estimated by interpolation.

(b) Implementation Schedule

The construction of the project starts in 2021 and the assumed completion year is 2026. Operation starts in December 2026 and the assumed project life is 30 years from commencement of operation. Residual value is assumed as zero.

(c) Discount Rate

DPP Manual suggests a discount rate of 15% in the financial and economic analysis of any proposed project; therefore, this study used that rate.[3]

2) Estimation of VOC

Vehicle operating costs (VOC) refer to costs that vary with mileage, travel time, travel speed, and road conditions (road surface, gradient etc.). VOC could include items such as fuel and tire. It is normal that VOC is estimated by vehicle type through measuring the costs subject to distance and time. In Bangladesh, an official VOC was published in the Road User Cost Annual Report by the Economics Circle of the Roads and Highways Department (RHD); however, it was not published after the 2004/2005 version. For this study, we have conducted an update on the transportation related costs by referring to transport-relevant indicators such as vehicle fleet information collected from the Bangladesh Road Transport Authority (BRTA) and related statistical data. VOC includes the items listed below. Their prices were converted to economic price and summarized as VOC by speed (Table 6.1.4).

- Fuel
- Oil
- Tire
- Repair cost
- Depreciation
- Insurance and Tax
- Personnel cost (cost for driver and crew)

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[3] Government of the People's Republic of Bangladesh, General Economics Division (GED), Planning Commission, Ministry of Planning. March 2014. *DPP Manual*.

Table 6.1.4 VOC by Type of Vehicles and Speed（Economic Price）

Unit: BDT/1000km

Speed (km/hr)	Motor Cycle	Auto Rickshaw	Car	Large Bus	Medium Truck
5	22,382	26,534	65,694	102,240	96,685
10	12,525	14,041	36,913	64,032	57,072
20	7,484	7,722	22,156	44,033	36,658
30	5,797	5,604	17,182	37,345	28,741
40	4,910	4,524	14,678	33,901	25,419
50	4,476	3,938	13,206	33,956	24,025
60	4,353	3,638	12,849	36,135	23,791
70	4,364	3,476	12,890	39,296	23,990
80	4,493	3,423	13,220	42,841	25,578
90	4,750	3,468	13,892	46,059	27,793

Source : JICA Study Team

By using this information, the total VOC was calculated for cases with and without MRT Lines 1 and 5 in 2025 and 2035 by using a demand forecast model as shown in Table 6.1.5.

Table 6.1.5 Total VOC of With and Without Project

Unit : million BDT

Year	With/Without		Motorcycle	Auto Rickshaw	Car	Large Bus	Medium Truck	Total
2025	Without		104	198	367	526	106	1,301
	With Line1		102	197	362	495	105	1,261
2035	Without		62	138	260	430	77	967
	With	Lines 1 & 5	60	132	251	343	74	860
		Line 1	60	135	257	385	74	910
		Line 5	61	135	254	376	75	900

Source : JICA Study Team

3) Estimation of TTC

TTC is calculated with value of time (VOT) and passenger's travel time. A reduced amount of TTC is considered as economic benefit. VOT refers to opportunity costs of time. For instance, when travel time is reduced by 1 minute, the largest sum of money an individual is agreeable to pay for the reduction means the value of time per minute. As for transport projects, the benefit of TTC is estimated by multiplying reduced time by the project by VOT. VOT by type of vehicle was referred to the data calculated in JICA's Project on the Revision and Updating of the Strategic Transport Plan for Dhaka (RSTP). Table 6.1.6 shows the VOT by type of vehicle.

Table 6.1.6 VOT by Type of Vehicle

Unit : BDT/hour/person

Year	Motor Cycle	Auto Rickshaw	Car	Large Bus	Medium Truck
2018	186	105	390	111	111
2025	252	144	536	150	150
2028	276	157	586	165	165
2035	343	192	723	204	204

Source: The Project on The Revision and Updating of the Strategic Transport Plan for Dhaka (RSTP)

Using this information, the total TTC was calculated for the cases with and without project in 2025 and 2035 by vehicle type as shown in Table 6.1.7.

Table 6.1.7 Total TTC of With and Without Project

Unit : Million BDT

Year	With/Without		Motorcycle	Auto Rickshaw	Car	Large Bus	Medium Truck	BRT, railway and MRT*	Total
2025	Without		320	660	1,456	1,723	69	216	4,443
	With Line1		314	649	1,429	1,615	68	240	4,316
2035	Without		303	584	1,576	2,022	80	617	5,183
	With	Lines 1 & 5	285	552	1,483	1,577	77	897	4,872
		Line 1	295	567	1,535	1,814	78	673	4,963
		Line 5	293	567	1,521	1,756	78	874	5,090

* : VOTs for BRT, railway, and MRT are assumed to be the same as that for bus
Source : JICA Study Team

Economic benefit of MRT Line 1 is calculated for the years 2025 and 2035 by comparing the totals of VOC and TTC for the cases with and without project. It is assumed that other urban railway modes and urban expressway will be developed in 2035; therefore, benefits from the VOC reduction will be reduced. But urbanization and traffic congestion in Dhaka could increase continuously.

Table 6.1.8 Economic Benefit of MRT Line5 by VOC & TTC Reduction

Unit : Million BDT/day

Year	TTC/VOC	With Line 1 (a)	Without Line 1 and Line 5, With Line 6 (b)	Benefit (b-a)
2025	Total TTC	4,316	4,443	127
	Total VOC	1,261	1,301	40
	Total	5,577	5,744	**167**
Year	TTC/VOC	With Line 1, Line 5, and Line 6 (a)	Without Line1, With Line 5 and Line 6 (a)	Benefit (b-a)
2035	Total TTC	4,872	5,090	218
	Total VOC	860	900	40
	Total	5,732	5,990	**258**

Source : JICA Study Team

Yearly economic benefits in 2025 and 2035 were estimated by multiplying the daily benefit calculated above by 365 days and then converted into Japanese yen with the exchange rate of ¥1.32. VOC benefits is ¥19,272 million (40 × 365 × 1.32) in 2025 and ¥19,272 million (40 × 365 × 1.32) in 2035, while TTC benefits is ¥61,189 million (127 × 365 × 1.32) in 2025 and ¥105,032 million (218 × 365 × 1.32) in 2035.

4) Reduction of GHG (Greenhouse Gas)

The reduction of GHG was calculated using the demand forecast model as shown in Table 6.1.9.

Table 6.1.9 Reduction of GHG by the Project

		Value	Unit
Emission reduction		63421	tCO$_2$/year
Baseline emission		141648	tCO$_2$/year
Number of passenger of the project activity in year y		371,205,000	passenger/year
Average trip distance of the passenger of the project activity in year y		9.8	km
CO$_2$ emission factor per passenger kilometer for transport mode i	Auto Tempo	0.000034195	tCO$_2$/passenger-km
	Microbus	0.000117188	tCO$_2$/passenger-km
	Standard Bus	0.000023565	tCO$_2$/passenger-km
	Other1	0	tCO$_2$/passenger-km
	Other1	0	tCO$_2$/passenger-km
	Other1	0	tCO$_2$/passenger-km
Share of passengers by transport mode i in the baseline scenario in year y	Auto Tempo	7.289	%
	Microbus	15.729	%
	Standard Bus	76.982	%
	Other1	0	%
	Other1	0	%
	Other1	0	%
Project emission		78227	tCO$_2$/y
Annual electricity consumption associated with the operation of the project activity in year y		171550	MWh/year
CO$_2$ emission factor of the grid electricity		0.456	tCO$_2$/MWh
Annual consumption of fuel i associated with the operation of the project activity in year y		0	t/year
CO$_2$ emission factor of fuel i		0	tCO$_2$/TJ
Net calorific value of fuel i		0	TJ/t

Source: JICA Study team

The reduced GHG emission is the difference between the emissions produced by the project and baseline emissions in the case without project. As seen in Table 6.1.10, emission reduction was calculated by subtracting 78,227 tCO$_2$/year from 141,648 tCO$_2$/year, resulting to 63,421 tCO$_2$/year.

Table 6.1.10 Reduction of GHG Emission

		Value	Unit
ER$_y$	Emission reduction	**63,421**	tCO$_2$/year
BE$_y$	Baseline emission	141,648	tCO$_2$/year
PE$_y$	Project emission	78,227	tCO$_2$/year

Source: JICA Study team

Though CO$_2$ was actively traded in major global emission markets and the CO$_2$ price reached nearly as high as EUR 30 per ton in 2008, markets shrank after the Lehman Shock. Currently, it is mainly traded through negotiated transaction. In consequence, traded prices were affected by supply and demand at the time of the trade with little influence by the market itself.[4] For this study, referring to the prices in EU Carbon Market and individual rates,[5] US$15 per ton is applied. Therefore, the benefit of emission reduction upon implementation of the project is calculated as 63,421 tCO$_2$/year × US$25/ton = US$1,585,525/year. Yearly economic benefit of CO$_2$ reduction is ¥174 million by converting $1,585,525/year with the exchange rate of $1 = ¥110.

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[4] JICA Capacity Development Training 2017. *Climate Change through Forest Preservation* (REDD+), 1 August 2017.

[5] CO2 price in EU Carbon Market (EU-ETS) on 24 September 2018 was EUR22.39/ton.

6.1.5 Result of Economic Analysis

Based on the estimated economic benefits and costs, the cost benefit analysis was made and calculation results are summarized in Table 6.1.11. The details of cash flow of the cost benefit analysis are shown in Table 6.1.12.

Economic Internal Rate of Return (EIRR) is the discount rate at which the total net present value will be zero. It shows the efficiency of the project in terms of national economy. When the calculated EIRR is larger than the social discount rate, the project is assumed to be feasible.

Net present value (NPV) represents the present value of social surplus produced by the project implementation. NPV calculates the present value of the difference between the total cost and the total benefit in the project period. In infrastructure projects, generally, a large amount of investment cost will be required in the initial stage followed by smaller amount of O&M cost. On the other hand, benefit of the project will be generated after completion of the project and will be maintained or expected to grow larger. In such cases, application of higher discount rate will cause the reduction of NPV. When the calculated NPV is larger than zero, the project is assumed to be feasible.

Cost-benefit ratio (B/C) is the ratio of total benefit to total cost of the project that are discounted from the present value. Similar to EIRR, B/C shows the economic efficiency of the project and when B/C is larger than the value of one, the project is assumed to be feasible. In summary, EIRR and B/C show the economic efficiency of the project and NPV shows the surplus in national economy that is produced by the project.

As shown in Table 6.1.11, EIRR is higher than 15%, which is considered the social opportunity cost of the Bangladesh. B/C is over one and NPV is also positive; therefore, all three evaluation indicators show that the project is economically feasible.

Table 6.1.11 Summary Result of Cost Benefit Analysis

Indicator	Value
EIRR	15.1%
B/C (at discounted rate of 15%)	1.05
NPV (million Yen at discounted rate of 15%)	2,587

Source: JICA Study Team

Table 6.1.12 Cash Flow of the Economic Analysis

unit: million Yen

	Cost			Benefit				B-C
	Investment	O&M	Total	VOC saved	TTC saved	CO2	Total	
2018	333	0	333	0	0	0	0	-333
2019	7,552	0	7,552	0	0	0	0	-7,552
2020	11,776	0	11,776	0	0	0	0	-11,776
2021	47,653	0	47,653	0	0	0	0	-47,653
2022	101,538	0	101,538	0	0	0	0	-101,538
2023	71,208	0	71,208	0	0	0	0	-71,208
2024	71,425	0	71,425	0	0	0	0	-71,425
2025	70,984	0	70,984	0	0	0	0	-70,984
2026	34,910	43	34,954	1,606	5,464	15	7,085	-27,869
2027	13,040	6,197	19,236	19,980	67,983	174	88,138	68,902
2028	6,768	6,197	12,965	20,715	70,482	174	91,372	78,407
2029	25	6,197	6,222	21,476	73,073	174	94,724	88,502
2030	0	6,197	6,197	22,266	75,760	174	98,200	92,003
2031	0	13,521	13,521	23,084	78,544	174	101,803	88,282
2032	0	6,931	6,931	23,933	81,432	174	105,539	98,607

2033	0	6,931	6,931	24,813	84,425	174	109,412	102,481
2034	0	6,931	6,931	25,725	87,528	174	113,428	106,496
2035 1)	0	6,931	6,931	19,272	105,032	174	124,479	117,547
2036 2)	0	15,804	15,804	19,465	106,083	174	125,722	109,918
2037	0	7,567	7,567	19,659	107,144	174	126,977	119,410
2038	0	7,567	7,567	19,856	108,215	174	128,245	120,678
2039	0	7,567	7,567	20,055	109,297	174	129,526	121,959
2040	0	7,567	7,567	20,255	110,390	174	130,820	123,252
2041	0	10,858	10,858	20,458	111,494	174	132,126	121,268
2042	0	7,697	7,697	20,662	112,609	174	133,446	125,749
2043	0	7,697	7,697	20,869	113,735	174	134,778	127,081
2044	0	7,697	7,697	21,078	114,872	174	136,124	128,427
2045	0	7,697	7,697	21,288	116,021	174	137,484	129,787
2046	0	7,840	7,840	21,501	117,181	174	138,857	131,017
2047	0	13,284	13,284	21,716	118,353	174	140,244	126,959
2048	0	7,840	7,840	21,933	119,537	174	141,644	133,805
2049	0	7,840	7,840	22,153	120,732	174	143,059	135,219
2050	0	7,840	7,840	22,374	121,939	174	144,488	136,648
2051	0	7,997	7,997	22,598	123,159	174	145,931	137,934
2052	0	7,997	7,997	22,824	124,390	174	147,389	139,392
2053	0	7,997	7,997	23,052	125,634	174	148,861	140,864
2054	0	7,997	7,997	23,283	126,891	174	150,348	142,351
2055	0	7,997	7,997	23,516	128,159	174	151,849	143,853
Total	437,212	238,423	675,635	631,464	3,065,561	5,072	3,702,097	3,026,462
PV	186,918	14,398	201,316	40,681	162,893	329	203,903	2,587
				B/C :	1.01		IRR :	15.1%

1) Benefit of VOC will be reduced in 2035 since other infrastructure such as urban expressways will be developed until 2035.
2) Growth of 1% is assumed from 2036 to 2055.
Source : JICA Study Team

6.1.6 Sensitivity Analysis

Estimation of benefit for this project is based on the assumed 30 years project life. Although future forecast is made on the premises presumed most suitable at the time of estimation, the actual benefit could still be either larger or smaller than estimated. Technical progress beyond assumption, occurrence of unforeseen technical objection, and fluctuation of foreign exchange may be expected. If these unpredicted cases happen, figures in the previous result should change. For these unpredicted cases, sensitivity study is made when the demand (benefit) and the project cost vary between -20% and +20%. As shown in Table 6.1.13, when the project cost decreases, EIRR is over 15% even when there is a 10% decrease in demand. When demand increases by 20%, EIRR is also still higher than 15% when there is 20% increase in project cost. The project is economically feasible when the project cost increases by 10%, but if there is a 10% increase in demand. On the other hand, when demand decreases by 20%, EIRR is lower than 15% in every case. Other than that, the project is not economically feasible in cases when demand decreases or cost increases, or both. (EIRR over 15% is highlighted in the following table.)

Table 6.1.13 Sensitivity of Economic Analysis

		Project Cost				
		20%Decrease	10%Decrease	Base Case	10% Increase	20% Increase
Traffic Demand	20% Increase	19.8%	18.4%	17.2%	16.2%	15.3%
	10% Increase	18.7%	17.4%	16.2%	15.2%	14.3%
	Base Case	17.6%	16.3%	15.1%	14.2%	13.3%
	10%Decrease	16.3%	15.1%	14.0%	13.1%	12.3%
	20%Decrease	14.9%	13.8%	12.8%	11.9%	11.1%

Source: JICA Study Team

6.2 Financial Evaluation

The main purpose of financial analysis is to examine the financial viability of the implementation of the project from the viewpoint of the implementation body. While the economic analysis evaluates the project from the viewpoint of the national economy, financial analysis evaluates the project to see its financial viability (profitability), hence its financial sustainability. As an evaluation index, which shows the financial analysis result, financial internal rate of return (FIRR) is broadly accepted.

6.2.1 Review of Methodology of Financial Analysis

Financial analysis of projects is based on the estimation of the revenue produced by the investment in a certain period, and compared with FIRR results with social opportunity cost of capital (OCC) to determine profitability of the projects. For this purpose, the FIRR without interest rate is calculated in order to examine a return on the total investment capital that does not consider investment factor. In this case, FIRR is the calculation regardless of fund-raising conditions without interest cost in which the initial investment is done without any loan. Another calculation of FIRR with investment factors, such as own capital and loan, with/without interest costs, is done for financial profitability and fund-raising plan for each investor. In this study, FIRR for the former case will be analysed for sustainability evaluation of the project.

Items used for the financial project costs in the discounted cash flow of the financial analysis are base cost and physical contingency in the cost estimation; therefore, price contingency (price escalation cost) is excluded from both costs and revenues. Interest during construction (IDC) is also excluded from the viewpoint of return-based investment without fund raising plan as mentioned above.[6]

6.2.2 Basic Assumptions

1) Estimation of Revenue

Fare revenue of Metro Line 1 is provided as a result of demand forecast for years 2025 and 2035 in accordance with the result of traffic demand forecast. Between 2026 and 2034, estimation is made by interpolation. From 2036 to 2058, 1% increase is assumed in accordance with the growth rate of demand.

2) Implementation Schedule

In this financial analysis, the construction of Metro Line 1 starts in 2021 and the assumed completion is in 2026. Operation starts in December 2026 and project life is assumed 30

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[6] Japan Bank for International Cooperation. September 2002. *IRR Calculation Manual for Yen Loan*.

years from the commencement of operation. Residual value is assumed as zero. (See Table 6.2.1.)

Table 6.2.1 Investment Schedule

Unit: million Yen

Items		Total	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
JICA	Procurement/Construction	**411,943**	0	0	0	44,308	101,714	71,059	70,991	70,599	32,820	13,902	6,549	0
	Consulting Services	**24,814**	340	2,098	2,325	2,693	4,236	3,526	3,749	3,573	2,108	84	58	26
Borrower	Procurement/Construction	**0**	0	0	0	0	0	0	0	0	0	0	0	0
	Panel of Experts/Land Acquisition/Resettlement/Admin	**49,711**	20	7,175	12,317	7,692	5,900	4,282	4,414	4,504	2,082	929	397	2
	VAT & Imoprt Tax & Other Taxes	**134,197**	92	581	661	12,351	31,851	22,509	23,065	23,390	12,820	4,178	2,691	9
Total Investment Cost		**620,666**	451	9,854	15,302	67,044	143,700	101,375	102,219	102,066	49,830	19,093	9,695	36

Source : JICA Study Team

3) Discount Rate

DPP Manual issued by the GOB suggests a discount rate of 15% in the financial and economic analysis of any proposed project; therefore, this study used that rate.

6.2.3 Estimation of Revenue

1) Fare Level

Fare for Line 1 is the same as the fare for Line 6 set by the Institutional Development Consultant (IDC) as mentioned in Chapter 3 (Table 6.2.2).

Table 6.2.2 Fare Setting

Year	Fare
2025	22.6 + 2.8/km BDT

Source : JICA Study Team

2) Estimation of Revenue

Based on the average annual daily traveller volume and fare level produced in the process of demand forecast, the annual fare revenue was calculated as shown in Table 6.2.3. For the calculation of cashflow for financial analysis, annual fare revenue is calculated from the daily fare revenue and then converted to Japanese yen.

Table 6.2.3 Fare Revenue of MRT Line 1

	Ridership (000)	Ave Trip Length (km)	Fare Revenue (mil BDT)
2025	1,017	9.0	48.6
2035	1,818	10.0	92.0

Source : JICA Study Team

6.2.4 Project Cost

The project cost was calculated through cost estimation and described in Table 6.1.1. For the calculation of financial analysis, as mentioned earlier, price contingency (price escalation cost) is excluded (refer to Table 6.2.4 that is same as Table 6.1.2 except without economic price).

Table 6.2.4 Project Cost (Financial Price)

Unit: Million Yen

Item		Local	Foreign	Total
A. JICA Portion				
1.Civil Works and Procurement of Equipment				
	Base Cost	111,135	221,749	368,448
	Physical Contingency	14,475	24,388	43,496

	Sub-Total	125,610	246,138	411,943
2. Consulting Service				
	Base Cost	5,980	15,577	23,471
	Physical Contingency	379	842	1,343
	Sub-Total	6,360	16,419	24,814
Total		131,970	262,557	436,757
B. Borrower Portion				
	a. Civil Works and Procurement of Equipment			
	Base Cost	0	0	0
	b. Panel of Experts	0	19	19
	c. Land Acquisition			
	Base Cost	15,768	0	20,814
	Physical Contingency	1,733	0	2,288
	d. Local Administration	20,145	0	26,591
	e. Tax			
	VAT	12,758	0	16,840
	Import Tax	60,971	0	80,482
	Other Taxes	27,936	0	36,875
Total		139,311	19	183,909
A+B				
	Base Cost	153,028	237,345	439,342
	Physical Contingency	16,588	25,231	47,126
	VAT	12,758	0	16,840
	Import Tax	60,971	0	80,482
	Other Taxes	27,936	0	36,875
Grand Total		271,281	262,575	620,666

Source：JICA Study Team

O&M cost is provided in the process of cost estimation and summarised in Table 6.2.5. While Table 6.1.3 shows O&M cost in economic price, the table below shows its financial price used for financial analysis.

Table 6.2.5 O&M Cost of the Project (Financial Price)

Unit：million

Year	Train Operation	Staff Salary	O&M Cost	Rollingstock Maintenance	General / O&M Administration	Additional Car	Reinvestment/ Replacement Cost	Total
2026	135	103	183	76	166	0	0	662
2027	1,617	1,234	2,191	911	1,992	0	0	7,945
2028	1,617	1,234	2,191	911	1,992	0	0	7,945
2029	1,617	1,234	2,191	911	1,992	0	0	7,945
2030	1,617	1,234	2,191	911	1,992	0	0	7,945
2031	1,855	1,512	2,191	1,044	2,284	8,448	0	17,334
2032	1,855	1,512	2,191	1,044	2,284	0	0	8,886
2033	1,855	1,512	2,191	1,044	2,284	0	0	8,886
2034	1,855	1,512	2,191	1,044	2,284	0	0	8,886
2035	1,855	1,512	2,191	1,044	2,284	0	0	8,886
2036	2,093	1,663	2,191	1,178	2,577	10,560	6,980	20,262
2037	2,093	1,663	2,191	1,178	2,577	0	0	9,702
2038	2,093	1,663	2,191	1,178	2,577	0	0	9,702
2039	2,093	1,663	2,191	1,178	2,577	0	0	9,702
2040	2,093	1,663	2,191	1,178	2,577	0	0	9,702
2041	2,093	1,829	2,191	1,178	2,577	0	4,053	13,921

2042	2,093	1,829	2,191	1,178	2,577	0	0	9,868
2043	2,093	1,829	2,191	1,178	2,577	0	0	9,868
2044	2,093	1,829	2,191	1,178	2,577	0	0	9,868
2045	2,093	1,829	2,191	1,178	2,577	0	0	9,868
2046	2,093	2,012	2,191	1,178	2,577	0	0	10,051
2047	2,093	2,012	2,191	1,178	2,577	0	6,980	17,031
2048	2,093	2,012	2,191	1,178	2,577	0	0	10,051
2049	2,093	2,012	2,191	1,178	2,577	0	0	10,051
2050	2,093	2,012	2,191	1,178	2,577	0	0	10,051
2051	2,093	2,213	2,191	1,178	2,577	0	0	10,252
2052	2,093	2,213	2,191	1,178	2,577	0	0	10,252
2053	2,093	2,213	2,191	1,178	2,577	0	0	10,252
2054	2,093	2,213	2,191	1,178	2,577	0	0	10,252
2055	2,093	2,213	2,191	1,178	2,577	0	0	10,252
Total	57,735	51,180	63,723	32,501	71,097	19,008	18,014	306,278

Source : JICA Study Team

6.2.5 Result of Financial Analysis

Based on the estimated revenue and cost, the cost-benefit analysis done and calculated results are summarized in Table 6.2.6. The details of cash flow of the cost-benefit analysis are shown in Table 6.2.7. The value of FIRR is lower than the opportunity cost of capital in Bangladesh; thus, financial assistance is necessary to implement the project.

Table 6.2.6 Summary Result of Cost Benefit Analysis

Indicator	Value
FIRR	3.8%
B/C (at discounted rate of 15%)	0.26
NPV (Million Yen at discounted rate of 15%)	-208,107

Source: JICA Study Team

Table 6.2.7 Cash flow of Financial Analysis

unit: million Yen

	Cost			Revenue		Revenue
	Investment	O&M	Total	Revenue	Total	- Cost'
2018	451	0	451	0	0	-451
2019	9,854	0	9,854	0	0	-9,854
2020	15,302	0	15,302	0	0	-15,302
2021	67,044	0	67,044	0	0	-67,044
2022	143,700	0	143,700	0	0	-143,700
2023	101,375	0	101,375	0	0	-101,375
2024	102,219	0	102,219	0	0	-102,219
2025	102,066	0	102,066	0	0	-102,066
2026	49,830	662	50,492	2,126	2,126	-48,366
2027	19,093	7,945	27,038	27,601	27,601	563
2028	9,695	7,945	17,640	29,691	29,691	12,051
2029	36	7,945	7,981	31,781	31,781	23,800
2030	0	7,945	7,945	33,871	33,871	25,927
2031	0	17,334	17,334	35,961	35,961	18,627
2032	0	8,886	8,886	38,051	38,051	29,165
2033	0	8,886	8,886	40,141	40,141	31,255

2034	0	8,886	8,886	42,231	42,231	33,345
2035	0	8,886	8,886	44,321	44,321	35,435
2036	0	20,262	20,262	44,764	44,764	24,503
2037	0	9,702	9,702	46,737	46,737	37,035
2038	0	9,702	9,702	48,709	48,709	39,007
2039	0	9,702	9,702	50,681	50,681	40,980
2040	0	9,702	9,702	52,654	52,654	42,952
2041	0	13,921	13,921	54,626	54,626	40,705
2042	0	9,868	9,868	56,598	56,598	46,730
2043	0	9,868	9,868	58,570	58,570	48,702
2044	0	9,868	9,868	60,543	60,543	50,675
2045	0	9,868	9,868	62,515	62,515	52,647
2046	0	10,051	10,051	64,487	64,487	54,436
2047	0	17,031	17,031	66,460	66,460	49,428
2048	0	10,051	10,051	68,432	68,432	58,381
2049	0	10,051	10,051	70,404	70,404	60,353
2050	0	10,051	10,051	72,376	72,376	62,326
2051	0	10,252	10,252	74,349	74,349	64,097
2052	0	10,252	10,252	76,321	76,321	66,069
2053	0	10,252	10,252	78,293	78,293	68,041
2054	0	10,252	10,252	80,266	80,266	70,014
2055	0	10,252	10,252	82,238	82,238	71,986
Total	620,666	306,278	926,944	1,595,801	1,595,801	668,857
PV	264,277	18,631	282,909	74,802	74,802	-208,107
				B/C : 0.26	IRR :	3.8%

Source: JICA Study Team

6.2.6 Sensitivity Analysis

Estimation of benefit for this project is based on the assumed 30 years project life. Although future forecast is made on the premises presumed most suitable at the time of estimation, the actual benefit might be either larger or smaller than the estimation. Technical progress beyond assumption, occurrence of unforeseen technical objection, and fluctuation of foreign exchange may be expected. If these unpredicted cases happen, figures in the previous result should have changed. For these unpredicted cases, sensitivity study is made when the demand (revenue) and the project cost vary between -20% and +20%. As shown in Table 6.2.8, FIRR goes up to 6.5% when the demand (revenue) increases by 20% and the project cost decreases by 20%. On the other hand, FIRR goes down to 1.3% in the worst case of 20% decrease in the demand (revenue) and 20% increase in the project cost.

Table 6.2.8 Result of Sensitivity Analysis（Financial Analysis）

		Project Cost				
		20% Decrease	10% Decrease	Base Case	10% Increase	20% Increase
Traffic Demand (Revenue)	20% Increase	6.5%	5.8%	5.2%	4.6%	4.1%
	10% Increase	5.9%	5.1%	4.5%	4.0%	3.5%
	Base Case	5.1%	4.4%	3.8%	3.3%	2.8%
	10% Decrease	4.3%	3.7%	3.1%	2.6%	2.1%
	20%Decrease	3.4%	2.8%	2.2%	1.7%	1.3%

Source: JICA Study Team

6.3 Risk Management Framework

6.3.1 Stakeholder Risk

1) Possibility of Regime Change

The serious traffic congestion in Dhaka Metropolitan Area (DMA) caused by the growth of cities pushed the Government of Bangladesh to give the MRT Line 6 a high priority status of “First-Track Project.”

It is expected that MRT Lines 1 and 5 will be given the same high priority status because of the current serious traffic condition.

The Government of Bangladesh formulated the Strategic Transport Plan for Dhaka (STP) in 2005 in cooperation with the World Bank. The transport improvement project in DMA will be a high priority project by whichever government term.

2) Consistency of necessity of nation

There are some opposition on the construction of elevated station of the on-going MRT Line 6 project at Shahbag Station by Bangladesh Sheikh Mujib Medical University (BSMMU) and TSC Station by University of Dhaka. The reason for the opposition is because of the lack of knowledge on the MRT construction. There is no other opposition movement.

MRT Lines 1 and 5 projects will be given the high priority by the government and the probability of less commitment for this project is low.

6.3.2 Executing Agency Risk

1) Capacity Risk

(1) Resource of implementation organization

The implementation organization of MRT Line 6 is Dhaka Mass Transit Company Limited (DMTCL), which was established on 26 May 2013 according to the Company Act 1994.

At present, the only staff of DMTCL is the Managing Director who assumed position on 26 October 2017.

Contract for the consultant and tender invitation for the construction works were done under the name of DMTCL.

The temporary organization, Dhaka Mass Rapid Transit Development Project (DMRTDP), was established for the MRT Line 6 project. Its officers work for the management of MRT Line 6 project implementation and they are considered staff of DMTCL. These officers come from Road and Highway Department, Public Works Department, Bangladesh Railway, and so on. They are called “admin kadre” and are high level elite with high capability for their work.

Their capabilities seem enough for the management of MRT Line 6 at present, but when the construction work of MRT Line 6 is in full capacity, it will be necessary to increase the officers.

There is no problem and no delay of their works caused by lack of knowledge, and they accept advice from the General Consultant.

However, there is some delay in the treatment of documents, such as monthly payment, caused by the strictness of the officers. They do the Bangladesh handling method of payment document, so they often request to modify the payment documents. That causes the payment delays.

It is desirable to nominate these officers as officers of DMTCL at the earliest as preparation for the organization of MRT operations.

(2) Procurement process

The procurement procedure was studied and reported as by the consultants as the Institutional Development Consultancy Services (IDC). The proposal is based on the actual procurement method of Government of Bangladesh for smooth procurement treatment and no new laws were proposed.

The procurement for the contracts of MRT Line 6 is based on public procurement Regulation (PPR). At present, there has been no significant problem.

Should there be an inconsistency between PPR and JICA Procurement Guidelines, the JICA Guide Line is accepted.

(3) Funds

In the case of the MRT Line 6 project, most of the construction cost comes from Japanese Yen Loan. The rest are local funds from the government budget. This government budget is well-allocated to the MRT Line 6 project.

The advance payment for a contract of MRT Line 6 was delayed once. In this case, the budget allocation was not prepared within the fiscal year but was allocated budget in the next fiscal year. So, the start of the construction work was delayed.

(4) Delay of payment for contractor

The delay of payment for the MRT Line 6 was caused by the delayed arrangement of budget and the necessity of long time for the treatment of payment document by the strict work, but not happened caused by lack of budget.

During the works for MRT Line 6, the work method will be improved and the next project of MRT Line 1 and MRT Line 5, the management works of DMTCL will be smooth.

The probability of risk caused by the capability of DMTCL for MRT Lines 1 and 5 will be low.

2) Government Risk

(1) Cooperation with other organizations

The implementation organization of MRT Lines 1 and 5 is expected to be DMTCL. They also managed and implemented the MRT Line 6 project.

The highest organization of DMTCL is Road Division, Ministry of Road Transport and Bridges (MORTB). The Secretary of Road Division of MORTB holds 99.99% of the stock of DMTCL.

Decision-making of DMTCL is done through board meetings. There are 11 members in the board:

1. Secretary, Road Division, Ministry of Communication
2. Executive Director, Dhaka Transport Co-ordination Authority
3. Representative from Prime Minister Office
4. Additional Secretary, Local Government Division
5. Additional Secretary, Ministry of Finance
6. Representative from Ministry of Railway

7. Joint Secretary, Power Division, Ministry of Power, Energy & Mineral Resources
8. Professor, Department of Civil Engineer, Bangladesh University of Engineering and Technology
9. Qualified Chartered Accountant from Institute of Chartered Accountants, Bangladesh
10. Learned Advocate specializing in company laws
11. Managing Director (MD), DMTCL

The delegation of authority to MD has not been done, so all decision-making has to be through board meetings that also cause delays.

Authorization to approve the monthly payments is done by the project director of DMTCL.

The organization and capability of DMTCL will be improved through the experience of MRT Line 6 project, and the probability of insufficient managing capability is expected to be low.

3) Fraud and Corruption Risk

The important decisions, such as approval of bidding and contract and payment, are done by the board. The board members and the officers are strict when it comes to regulations.

Political pressure has not been applied on works of the general consultant (GC) of MRT Line 6.

There is a low probability of fraud and corruption in the MRT Line 1 and MRT Line 5 projects.

6.3.3 Project Risk

1) Design Risk

(1) Technical specification

The design condition and specification of MRT Line 1 and MRT Line 5 were based on MRT Line 6.

The O&M of the MRT system of Dhaka will be easier and assured of when the technical conditions of all the MRT are the same. O&M will be done by the respective group of each line. The interaction of staff and exchange of machine and spare parts will also be easy. Sharing new technology learned through their experience of operation and maintenance will be easy. A more effective operation and saving in expenses will be possible by commonly using rolling stock, maintenance machine, and spare parts at all the MRT lines. Therefore, technical risks in the operation of MRT Line 1 will be low.

(2) Project scope

The project scope of MRT Lines 1 and 5 is based on MRT Line 6. The additional scope of MRT Lines 1 and 5 is the study of area development and redevelopment plan of station area. The area development along MRT line and redevelopment of station area will be for the convenience for MRT passengers and to increase the number of passengers.

The scope of MRT Lines 1 and 5 projects is appropriate.

(3) Monitoring

The employment of GC for the management of MRT Lines 1 and 5 with the client DMTCL is included in the scope of the project same as MRT Line 6.

In the case of MRT Line 6 project, the GC manages and advises the bidding, contract, and supervision of construction works for DMTCL, so MRT Line 6 is progressing well but only with some payment delay because of strict control.

(4) Package of construction works

The number of packages is 10. Contents of the eight packages are as follows.

- CP01,02,03,04,05: Underground Civil
- CP06,07: Elevated Civil
- CP08: Depo Civil
- CP09: System
- CP10: Rolling Stock

There have been no significant problems occurred during bidding except system package, contract, and supervision of construction works in MRT Line 6.

Regarding system packages, there are cases where all the system lines are made as one package and a case where the system package is divided some packages.

Although there are advantages and disadvantages to each. (1) It can minimize the impact on other packages due to delay in bidding, (2) It can secure the proper competition by many bidders.

For these reasons, it is desirable to subdivide the system package.

(5) Vulnerability

The construction work and most construction materials were planned to be procured in Bangladesh, while the coarse aggregate (stone) for concrete was planned to be imported. Most E&M materials will be imported. Since there are many suppliers of E&M material, the escalation of price will be likely low. However, there is a probability of change of price with the coarse aggregate because the international market of coarse aggregate is not large.

(6) Vulnerability of demand

The traffic congestion in Dhaka is a lingering problem and the significant fall of traffic demand is not predicted in the study report of the Strategic Transport Plan for Dhaka 2015–2035 (STP).

There is a possibility of change of transport demand of MRT due to fare level, but the fare of MRT can adjust to the traffic demand.

The probability of risk of technical problems for MRT Lines 1 and 5 will be low.

2) Program/Donor Risk

(1) Related project

DMTCL and Rajdhani Unnayan Kartripakkha (RAJUK) are the authority in the planning and implementation of the development plan along MRT and station area.

In MRT Line 6, there is no positive action for the development for the station areas, although Uttara North, Uttara Central, and Uttara South are suitable for the redevelopment of the station areas.

(2) Policy and institution

The decision and modification procedures of fare are provided by Metrorail Act.

IDC report proposed the method of setting the fare; however, DMTCL has not yet started the study to setting the fare for MRT Line 6.

The fare level was studied and proposed in the study report of STP and its result is applied to the financial analysis of MRT Lines 1 and 5.

The proposed fare level is higher than the fare of BR and bus/minibus.

In the STP report, the fares of MRT and BR in 2014 and the fares of bus and minibus in 2015 are shown as follows.

Table 6.3.1 Comparison of Fare

	MRT (2014)	BR (2014)	Bus (2015)	Mini Bus (2015)
Standard	16.0+2/km	0.5/km	1.7/km (minimum fare:7.00)	1.6/km (minimum fare:5.00)
5km	26.0	2.5	8.5	8.0
10km	36.0	5	17.0	16.0

Unit : BDT

Source : MRT, BR:STP

Bus, Mini Bus: Fare of public Transport Services in Case of Dhaka City and Comparison with Neighbouring Countries, by Shajia Sultana and Md. Aminul Islam,

From: BRTA Gazette Notification Ref. No.35.020.006.00.00.019. 2013-417, dated on 16 September 2015

The fare of MRT at a 10 km base is about 7 times more than BR and twice more than bus as shown on Table 6.3.1.

The number of passengers may fluctuate due to the fare level.

The fare of MRT Line 6 has not yet been decided, but the fare will be adjusted through trial after start of operation. The fare of MRT Lines 1 and 5 will be applied with the adjusted fare level of MRT Line 6.

There is a probability of high risk that the area of development along MRT line and station area will not be done as proposed.

The probability of risk of unsuitable fare level will be low.

3) Delivery Quality Risk

(1) Analysis of development effect

The AFC (Automatic Fare Collection) system including IC ticket, ticket vending machine, automatic gate, station control unit, and line control unit, is planned for use on the MRT Lines 1 and 5 same as MRT Line 6.

The number of vended tickets, number of passengers with travelling section, and income by ticket vended will be collected automatically through this AFC system. Analyzation of the effects of operation of the MRT system using these data would be easy and studies on future operation and improvement plan of operation would be possible.

The connection between the AFC and accounting systems is not proposed in this study. There is a big possibility to connect the AFC system, accounting system, clearing system, procurement management system, and maintenance management system including inventory control system by IT technology. It will also be possible to grasp the situation of operation and management to improve the whole system.

(2) Monitoring of sub-project

The development of station area and adjacent area of MRT line has the large impact on the railway operation business. DMTCL and RAJUK have the authority to develop the area along MRT line, but there is no cooperation nor coordination until now.

The commercial use of free space inside the MRT stations is profitable and efficient for MRT operations, but no clear plan has been proposed.

The area improvement plan around the MRT station shall be considered the change of operation pattern of public transportation such as bus and mini-bus. The change of operation pattern of public transportation is not clear and so are the improvement plan of the space around MRT station and the implementation organization and method.

A clear redevelopment plan around the MRT station, implementation organization, and implementation method are not proposed.

There is low probability of implementation of a good, coordinated development of MRT line area.

(3) Sustainable development

DMTCL is expected to be the implementation, operation, and management organization of MRT Lines 1 and 5 same as with MRT Line 6.

The detailed implementation, operation, management, and staff recruitment for MRT Line 6 was studied and proposed by IDC report.

The staff training plan of DMTCL for MRT Line 6 consists of:

a) Training abroad for the leading member by GC,

b) Technical training for the key staff by contractors,

c) Technical training of E&M and rolling stock by contractors, and

d) Training other technician and staff by the leading members and key staff trained by GC and contractors.

Additionally, the training for the leading member through the technical assistance of JICA program is expected.

The training of staff for MRT Lines 1 and 5 is proposed to be based on the training of MRT Line 6. The training is expected to be improved based on the results of training and operation of MRT Line 6.

(4) Possibility of natural disaster

The construction of underground track and stations of MRT Lines 1 and 5 were planned for the first time in Dhaka City where flood and inundation occur frequently. The measurement for high water by flood and inundation is important for the underground structure.

The highest water level recorded is 8.35 m. The height of the entrance to the underground station and the transition section from underground to elevated section and depot area of MRT line was proposed to be higher than 8.5 m.

Measurement of flood done in Japan is explained in this report. A more detailed specific measurement and design based on the detailed survey will be at the implementation stage.

The measurement for high water level by flood and inundation of MRT Lines 1 and 5 is very much in this report.

(5) Possibility of improper use

The possibility of illegal development and unplanned development of MRT line area shall be studied.

(6) Possibility of rise of maintenance cost

The AFC system is planned to be installed in MRT Lines 1 and 5 same as MRT Line 6. Free riders can be prevented through the AFC system without additional cost. It is possible to avoid profit losses due to free riding, keep the fare profits based on the number of passengers, and keep the O&M as planned based on the planned fare income.

Control of excessive issue of complimentary IC cards for the soldier, retired person, and other supposedly eligible persons for the MRT is necessary.

(7) Possibility of benefit for limited class

There is a possibility to limit the fare level by passenger class. A careful study on setting the fare level is necessary.

The Metro in Cairo, Egypt has a low fare level. Its passengers are from the lower income group, such as students. Since are no of car owners or users, there is no shift of use from car to Metro.

The Blue Line Subway and Bangkok Mass Transit System in Bangkok, Thailand have fairly high fare levels. Both have few passengers from the low-income group.

The probability of risk is estimated low because the MRT system is planned based on MRT Line 6.

6.3.4 Overall Risk Rating

The MRT system, civil structure, E&M, rolling stock, project implementation, and operation organization of MRT Lines 1 and 5 projects were planned based on MRT Line 6 that is currently under construction. When the problems of MRT Line 6 becomes clear through its implementation and operation, it is expected that the problems will be solved.

The experience and results of MRT Line 6 will be reflected on MRT Lines 1 and 5, and the MRT system, organization, and operation of MRT Lines 1 and 5 are expected to be better, more stable, and have a more reliable system.

There is a low probability of risk during implementation of MRT Lines 1 and 5 projects.

Table 6.3.2 Evaluation Sheet of Risk Management

Potential project risks	Assessment
1. Stakeholder Risk	Probability: L
(Commitment of Government) The MRT Line 6 project is given a high priority status of "First-track Project." The MRT Lines 1 and 5 projects will be given the same status. From this record, the status of MRT construction projects in Dhaka City is high priority for Government of Bangladesh.	Impact: L
	Analysis of probability and impact:
	There is high probability of high priority of MRT Projects.
	Mitigation measures:
	Action during the implementation:
	Contingency plan (if applicable):
No remarkable opposition to the construction of MRT has occurred at present.	Analysis of probability and impact:
	There is low probability of opposition to MRT projects.
	Mitigation measures:
	Action during the implementation:
	Contingency plan (if applicable):

	Analysis of probability and impact:
2. Executing agency risk	Probability: L
2.1 Capacity risk	Probability: L
(Competency and resource of DMTCL) As the executing agency for MRT line 6, DMTCL was established on 26 May 2013 according to the Company Act 1994. DMTCL will be the executing agency for MRT Lines 1 and 5.	Impact: L Analysis of probability and impact: There is high probability of enough capacity of executing agency. Mitigation measures: Action during the implementation: Contingency plan (if applicable):
The executing agency is DMTCL and 99.99% share of DMTCL belongs to the Secretary of Road Division or Ministry of Road Transport and Bridges. The decisions of DMTCL, such as the approval of bidding and contract, monthly payment, and so on, is done by the Board of DMTCL. The staff of DMTCL is only one as of 31 October 2017. It is only Managing Director who was nominated on 26 October 2017. The other 40 PIU officers belong to the temporary organization DMRTDP and they come from Road and Highway Department, Public Works Department, Bangladesh Railways, and so on. These officers are called as "admin kadre" and are highly capable and strict. The capability of MRTCL is enough for the management work of the implementation of MRT Line 6 at present.	Impact: L Analysis of probability and impact: There is low probability of problems. Mitigation measures: Action during the implementation: Contingency plan (if applicable):
The laws and regulations related to the procurement were studied and proposed on the IDC report. In the case of MRT line 6, Public Procurement Regulation (PPR) was applied and when there was a discrepancy with JICA Guidelines, the latter was given priority over PPR.	Impact: L Analysis of probability and impact: There is low probability of problem. Mitigation measures: Action during the implementation: Contingency plan (if applicable):
(Delay of payment to contractor) Main part of the funds for the construction of MRT comes from the Japanese Yen Loan for MRT Line 6, and the rest of the funds is from government budget. Until now, necessary budget has been allocated. The payment to the contractors were delayed because of the rigid and strict document procedure of MRTCL.	Impact: L Analysis of probability and impact: There is low probability of non-payment but delay. Mitigation measures: Prepare the required documents for payment. Action during the implementation: Contingency plan (if applicable):
2.2 Governance risk	Probability: L
(Coordination of organizations) The highest organization of DMTCL is Road Division, Ministry of Road Transport and Bridges (MORTB). Decision-making of MRTCL is done by board meetings. The members of the board are the Secretary, Road Division of Ministry of Communication, Executive Director of Dhaka Transport Co-ordination Authority, Representative from Prime Minster Office, Additional Secretary of Local Government Division of Government, Additional Secretary of Ministry of Finance, Representative from Ministry of Railway, Managing Director of DMTCL, and four representatives from other organizations.	Impact: L Analysis of probability and impact: There is probability of delay of decision making in DMTCL. Mitigation measures: Action during the implementation: Contingency plan (if applicable):
2.3 Fraud & corruption risk	Probability: L
(Financial management and procurement management) The important decisions such as approval of bidding and contract and payments are done by the board members. Board members and officers are strict, and this is reason of delay in the procedure of decision and payment. The advanced and monthly payments of MRT Line 6 were delayed because	Impact: L Analysis of probability and impact: There is probability of delay of decision making in DMTCL. Mitigation measures:

of document treatment, but the budget was secured. There was no probability of fraud and corruption on the MRT Line 6 Project even until now.	
	Action during the implementation:
	Contingency plan (if applicable):
3. Project risk	Probability: L
3.1 Design risk	Probability: L
(Engineering design) The design conditions and specifications of MRT Lines 1 and 5 are based on the MRT Line 6. The technical conditions and specifications of all MRT in Dhaka will have an easy maintenance and operation of railway system.	Impact: L
	Analysis of probability and impact:
	There will be low probability of problems.
	Mitigation measures:
	Action during the implementation:
	Contingency plan (if applicable):
(Scope of Project) The scope of the projects includes whole the necessary component of MRT operation based on the results of MRT Line 6. The additional components of this study are the area of development of MRT Lines 1 and 5, which components to target for better service to the passenger, and increase number of the passengers.	Impact: L
	Analysis of probability and impact:
	There will be a low probability of problems for MRT and there is medium probability of problems in the implementation of area development project as the proposed plan.
	Mitigation measures:
	Action during the implementation:
	Contingency plan (if applicable):
(Monitoring of project) General consultants are planned to be employed for the project implementation management together with DMTCL, similar with MRT Line 6. The general consultant under DMTCL manages and tenders contract and supervision of construction works of MRT Line 6, and until now the project has been implementing well with only some payment delay.	Impact: L
	Analysis of probability and impact:
	In general, there will be low probability of problems.
	Mitigation measures:
	Action during the implementation:
	Contingency plan (if applicable):
(Packaging of procurement) The contract packaging of MRT Lines 1 and 5 were planned same as MRT Line 6. For system packages, it is desirable to divide them from the viewpoint of improving procurement quality and ensuring a proper competitive.	Impact: L
	Analysis of probability and impact:
	In general, there will be low probability of problems.
	Mitigation measures:
	Action during the implementation:
	Contingency plan (if applicable):
(Risk of cost increase) The construction work and most construction material were planned to be procured in Bangladesh, while the coarse aggregate for concrete is planned to import. Most of the E&M material will be imported. There is the possibility of change of the import price of the coarse aggregate.	Impact: L
	Analysis of probability and impact:
	In general, there will be low probability of problems. There is medium probability of change of cost of coarse aggregate.
	Mitigation measures:
	Action during the implementation:
	Contingency plan (if applicable):
(Risk of lower traffic demand) Change of traffic demand is not predicted in general, but there will be some	Impact: L
	Analysis of probability and impact:

fluctuation in the fare level.	There will be low probability of change of traffic demand.
	Mitigation measures:
	Action during the implementation:
	Study the access plan to MRT station.
	Contingency plan (if applicable):
3.2 Program/donor risk	Probability: L
(Related project) Both DMTCL and RAJUK handle the planning and implementation organization of the area development.	Impact: H
	Analysis of probability and impact:
	There is high probability of no implementation of area development.
	Mitigation measures:
	Action during the implementation:
	Propose the area development plan as a part of consultancy service.
	Contingency plan (if applicable):
(Policy and system for operation of MRT) The decision and modification procedures of fare is provided by Metrorail Act. IDC report proposed the method of setting the fare. MRT Line 6 has not yet started doing so. The fare for MRT Lines 1 and 5 will be the same level as MRT Line 6 that will be decided before the commencement of their operation. The number of the passengers will substantially change caused by the level of fare. The fare shall be set in consideration to the number of passengers corresponding the fare. There is no action by DMTCL until now.	Impact: L
	Analysis of probability and impact:
	Mitigation measures:
	Action during the implementation:
	Contingency plan (if applicable):
3.3 Delivery quality risk	Probability: L
(Evaluation of effectiveness) MRT Lines 1 and 5 plan to adopt the AFC2 system including IC ticket, ticket vending machine, automatic gate, station control unit, and line control unit same as MRT Line 6. Using this AFC system, the data of number of passengers with travelling section and income by tickets are automatically collected.	Impact: L
	Analysis of probability and impact:
	There is high probability of efficient operation.
	Mitigation measures:
	Action during the implementation:
	Contingency plan (if applicable):
(Sub-project) The implementation of the area development and commercial use of free space in the stations are not clear at present.	Impact: H
	Analysis of probability and impact:
	Low probability of efficient development of MRT station area and good commercial use of free space of station.
	Mitigation measures:
	Propose the clear development plan
	Action during the implementation:
	Study and prepare the area development plan and assist the implementation.
	Contingency plan (if applicable):
(Continuation) The operating organization proposed on the F/S, which depends on the IDC study, is the same organization in MRT Line 6.	Impact: L
	Analysis of probability and impact:
	There is low probability of problems of operation.
	Mitigation measures:
	Action during the implementation:
	Check and evaluate the results of operating organization of MRT Line 6 and if necessary, improve the organization and system.
	Contingency plan (if applicable):

(Natural disaster) The inflow of water caused by flood at underground section of MRT Lines 1 and 5 is predicted. The highest water level by flood is well-studied on the F/S, and the protection method such as high level of entrance to the underground stations is proposed.	Impact: L Analysis of probability and impact: There is low probability of problems caused by flood. Mitigation measures: The entrance of the underground stations is situated at high level enough to protect inflow of flood water. Action during the implementation: Apply the design to protect inflow of flood water. Contingency plan (if applicable):
(Improper and illegal use) The area development and commercial use of free space in the stations are probable.	Impact: L Analysis of probability and impact: There is low probability of unplanned development of the studied area. Mitigation measures: Appropriate management of area and station space. Action during the implementation: Contingency plan (if applicable):
(Improper use) The AFC system including automatic gate will be applied in MRT Lines 1 and 5 same as MRT Line 6. This system will protect to enter the passengers without ticket.	Impact: L Analysis of probability and impact: There is middle probability of over issue of complimentary ticket. Mitigation measures: Action during the implementation: Contingency plan (if applicable):
(Unbalance benefit) There is the possibility of limitation of passenger class depending on the fare system.	Impact: L Analysis of probability and impact: There is low probability of problems when the fare will be fixed depend on the proposal of IDC study report. Mitigation measures: Action during the implementation: Contingency plan (if applicable):
4. Overall Risk Rating	Probability: L
(Overall comments) The same system and same organization of MRT Line 6 will be applied for MRT Lines 1 and 5. Depending on the implementation experience in MRT Line 6, there is high possibility of improvement of system and implementation and operation organization. Good implementation and operations are to be expected.	

Source： JICA Study Team

Appendix 1

Plan & Profle

PLAN AND PROFILE

DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)

DATE PRINTED
2017/04/25

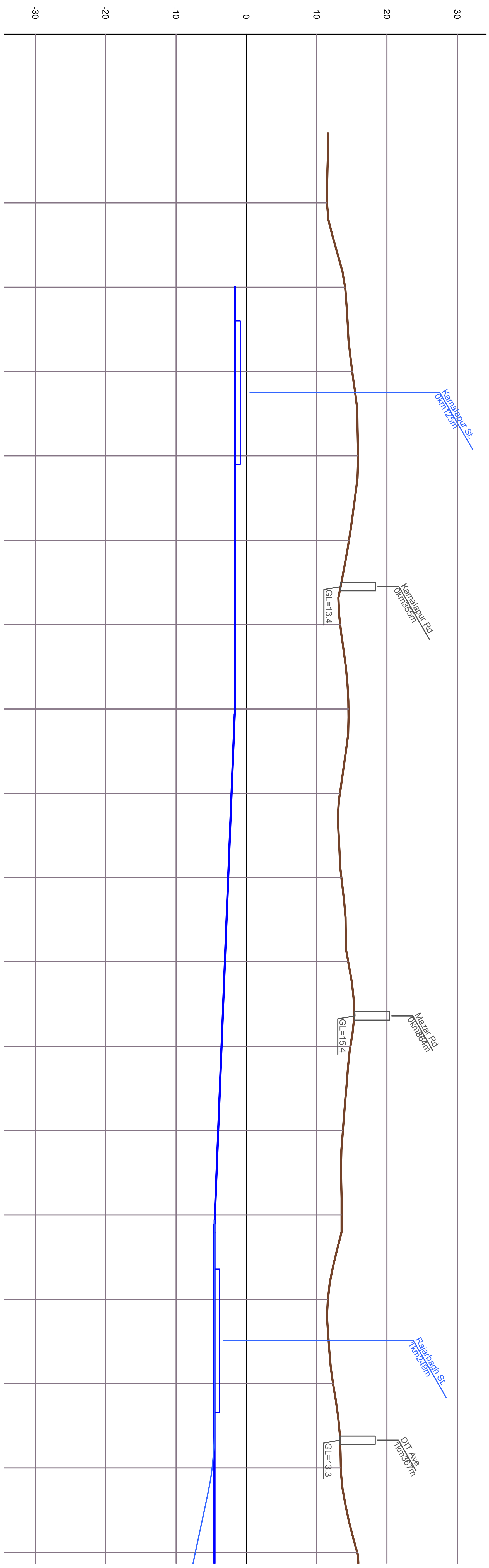
SCALE
H : 1/5000 V : 1/600

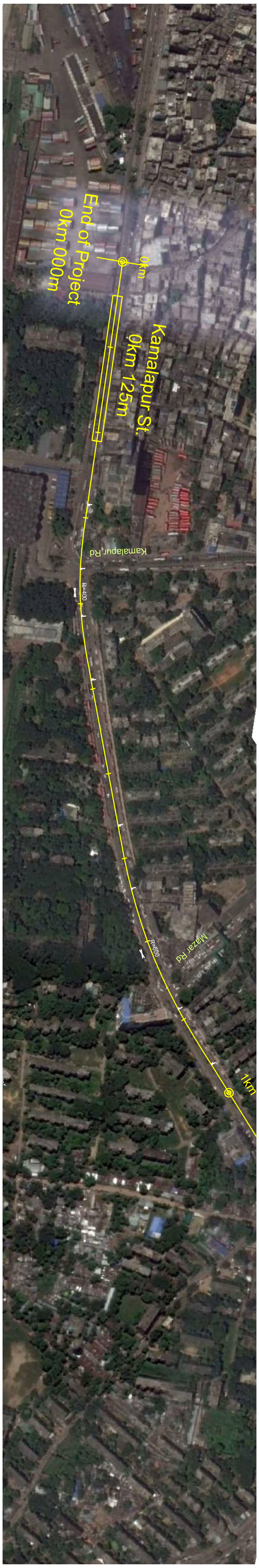
DRAWING NAME
KAMALAPUR TO NOTUN BAZAR (1)

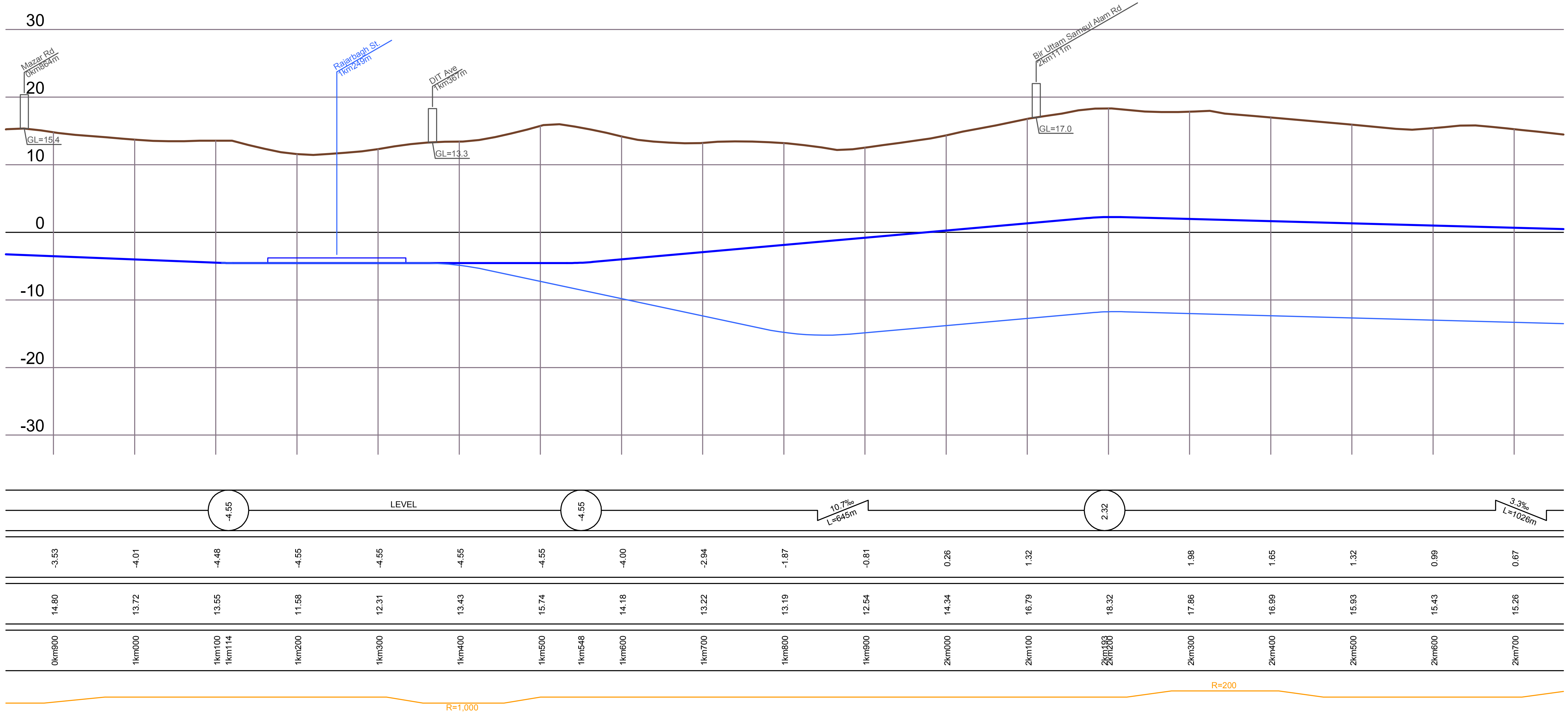
DRW NO.
ALIGN-205.DWG

PAGE
1 / 23

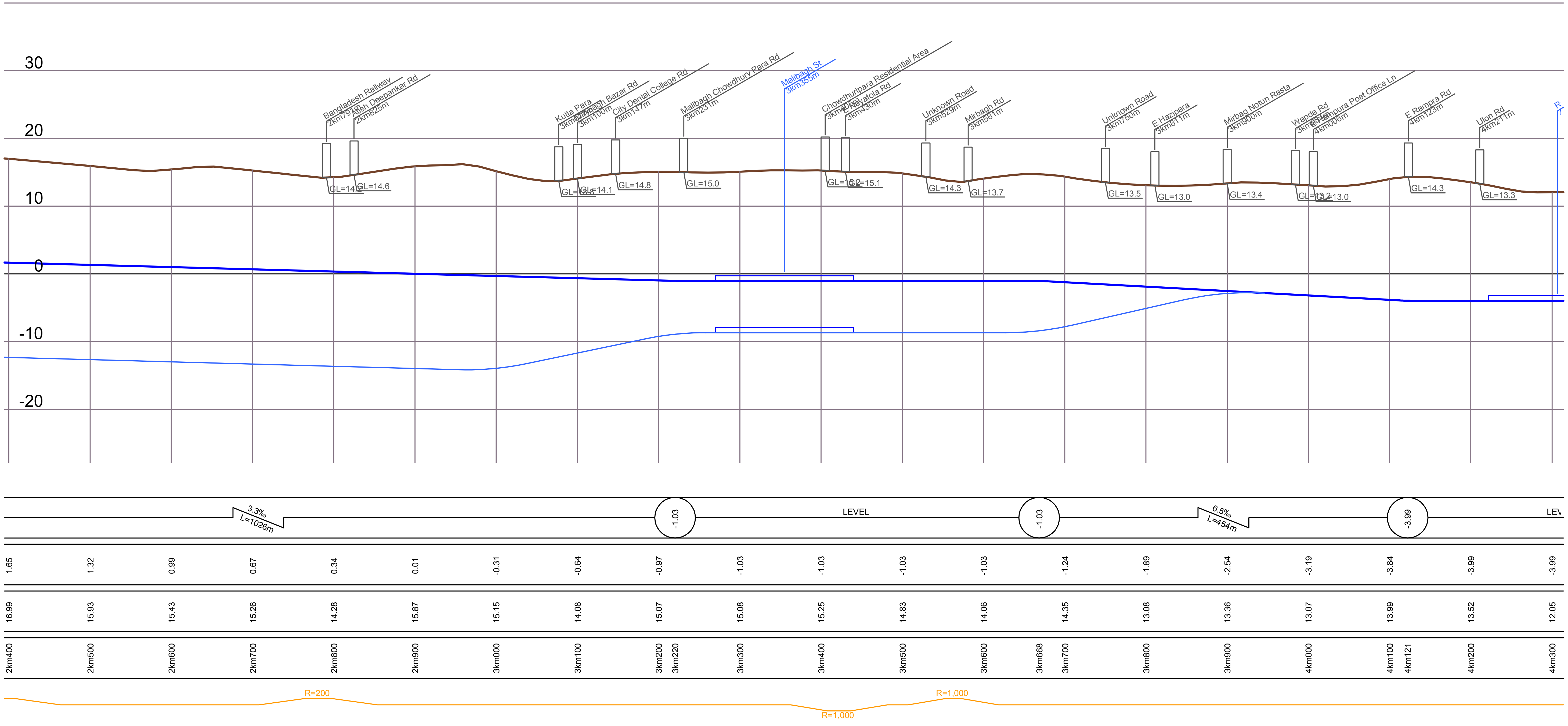
Curve	Chainage	Ground	Rail	Gradient
	-0km300			
	-0km200			
	-0km100	11.46		
	0km000	14.03		-1.63
	0km100	15.06	-1.63	
	0km200	15.87	-1.63	LEVEL
	0km300	14.58	-1.63	
R=400	0km400	13.34	-1.63	
	0km500 0km499	14.52		-1.63
	0km600	13.30	-2.11	
	0km700	13.51	-2.58	
R=600	0km800	14.49	-3.06	4.7‰ L=614m
	0km900	14.80	-3.53	
	1km000	13.72	-4.01	
	1km100 1km114	13.55	-4.48	-4.55
	1km200	11.58	-4.55	
	1km300	12.31	-4.55	LEVEL
R=1,000	1km400	13.43	-4.55	
	1km500	15.74	-4.55	





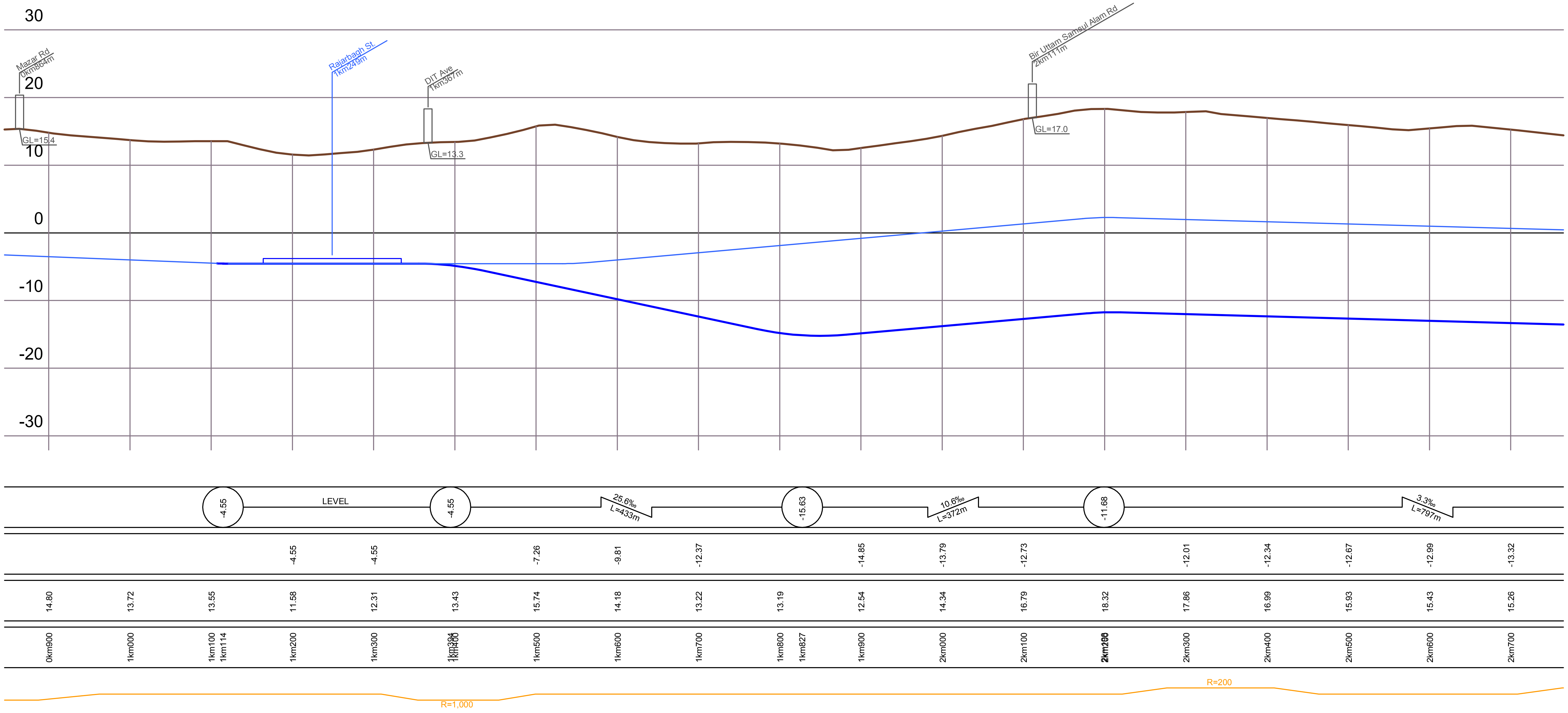


PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : $\frac{1}{5000}$ V : $\frac{1}{600}$	KAMALAPUR TO NOTUN BAZAR (2) UPPER TRACK	ALIGN-205.DWG	2 / 23

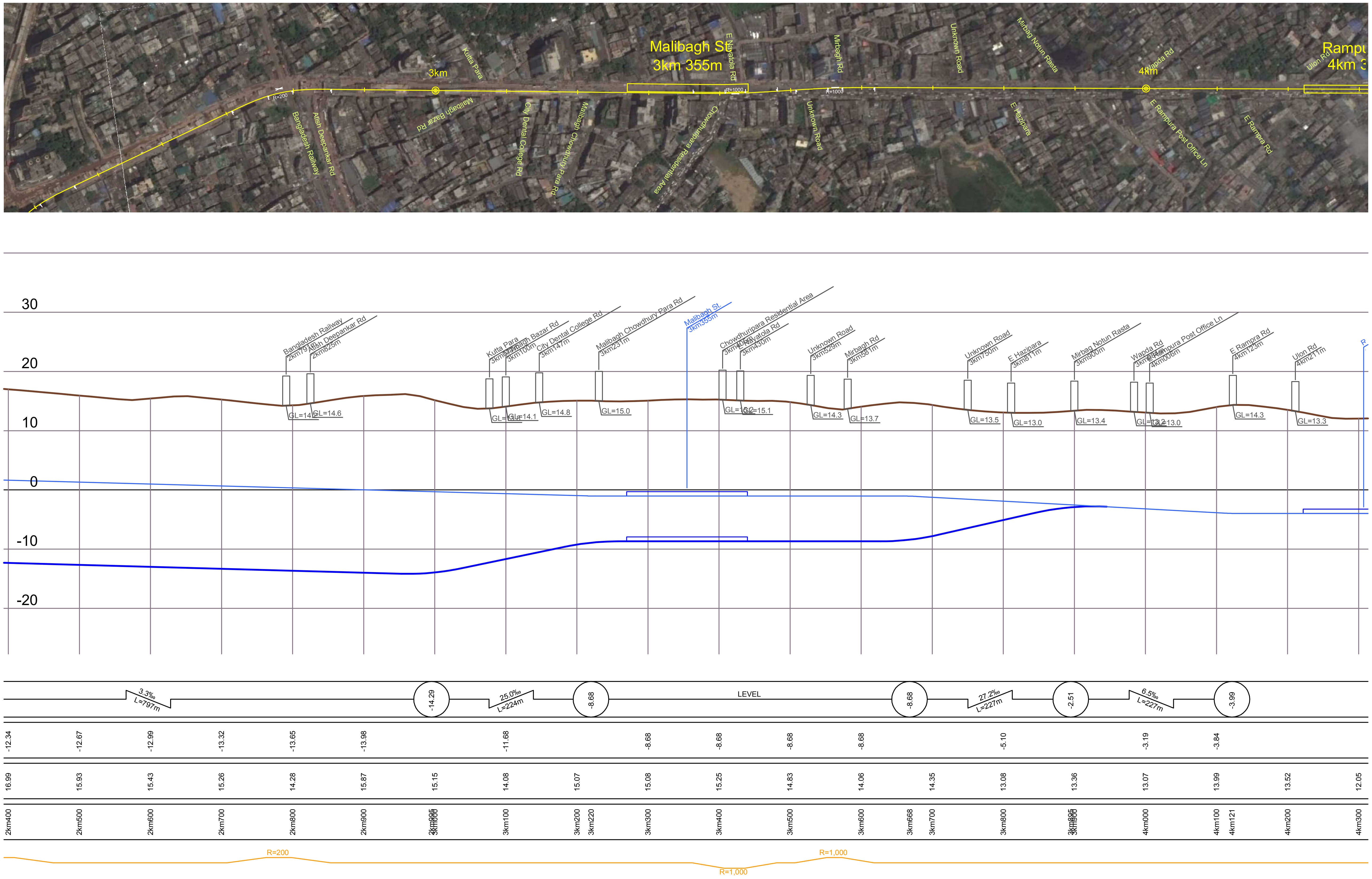


2km400	16.99	1.65
2km500	15.93	1.32
2km600	15.43	0.99
2km700	15.26	0.67
2km800	14.28	0.34
2km900	15.87	0.01
3km000	15.15	-0.31
3km100	14.08	-0.64
3km200	15.07	-0.97
3km220		
3km300	15.08	-1.03
3km400	15.25	-1.03
3km500	14.83	-1.03
3km600	14.06	-1.03
3km668		
3km700	14.35	-1.24
3km800	13.08	-1.89
3km900	13.36	-2.54
4km000	13.07	-3.19
4km100	13.99	-3.84
4km121		
4km200	13.52	-3.99
4km300	12.05	-3.99

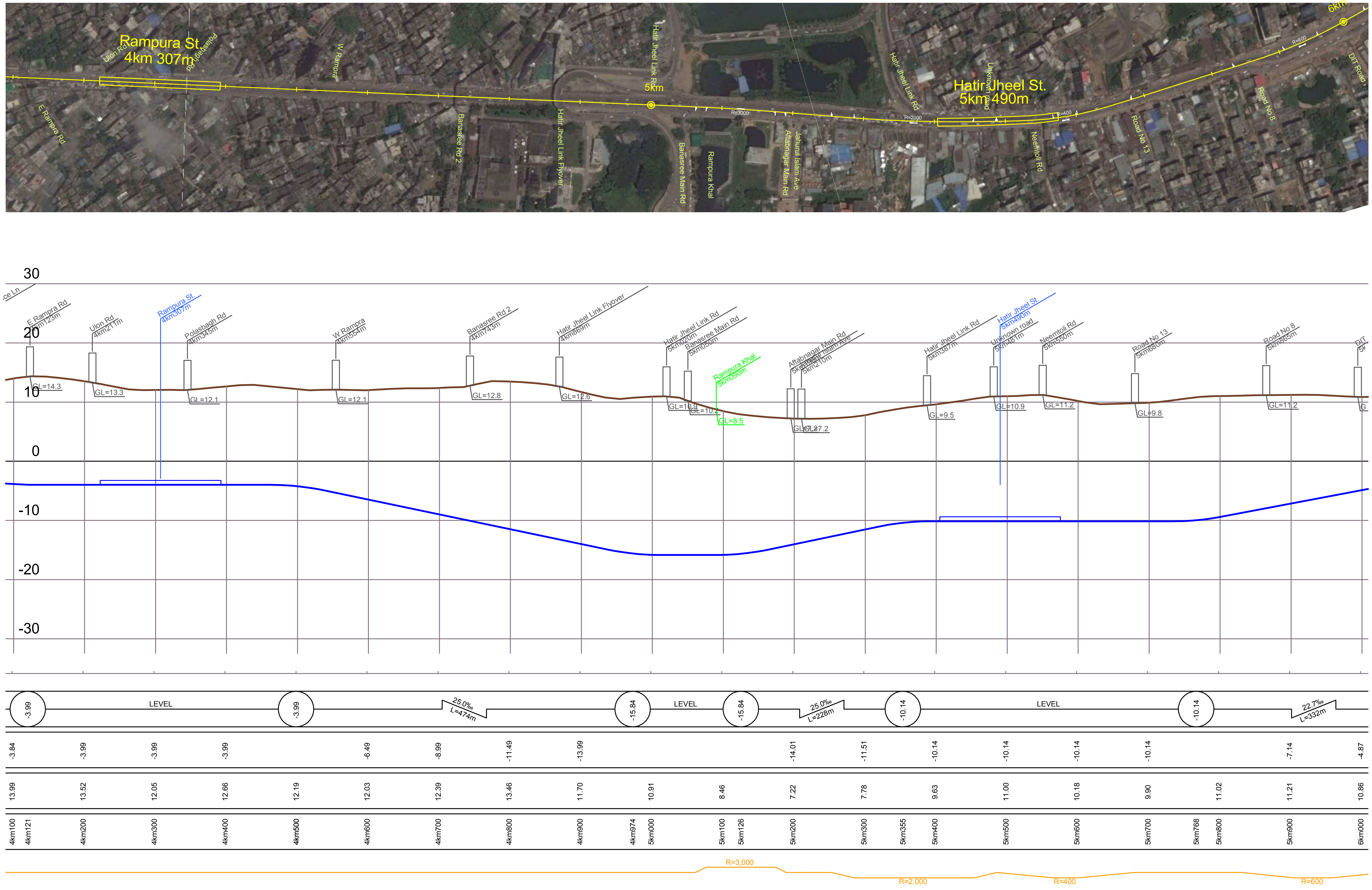
PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : $^1/_{5000}$ V : $^1/_{600}$	KAMALAPUR TO NOTUN BAZAR (3) UPPER TRACK	ALIGN-205.DWG	3 / 23



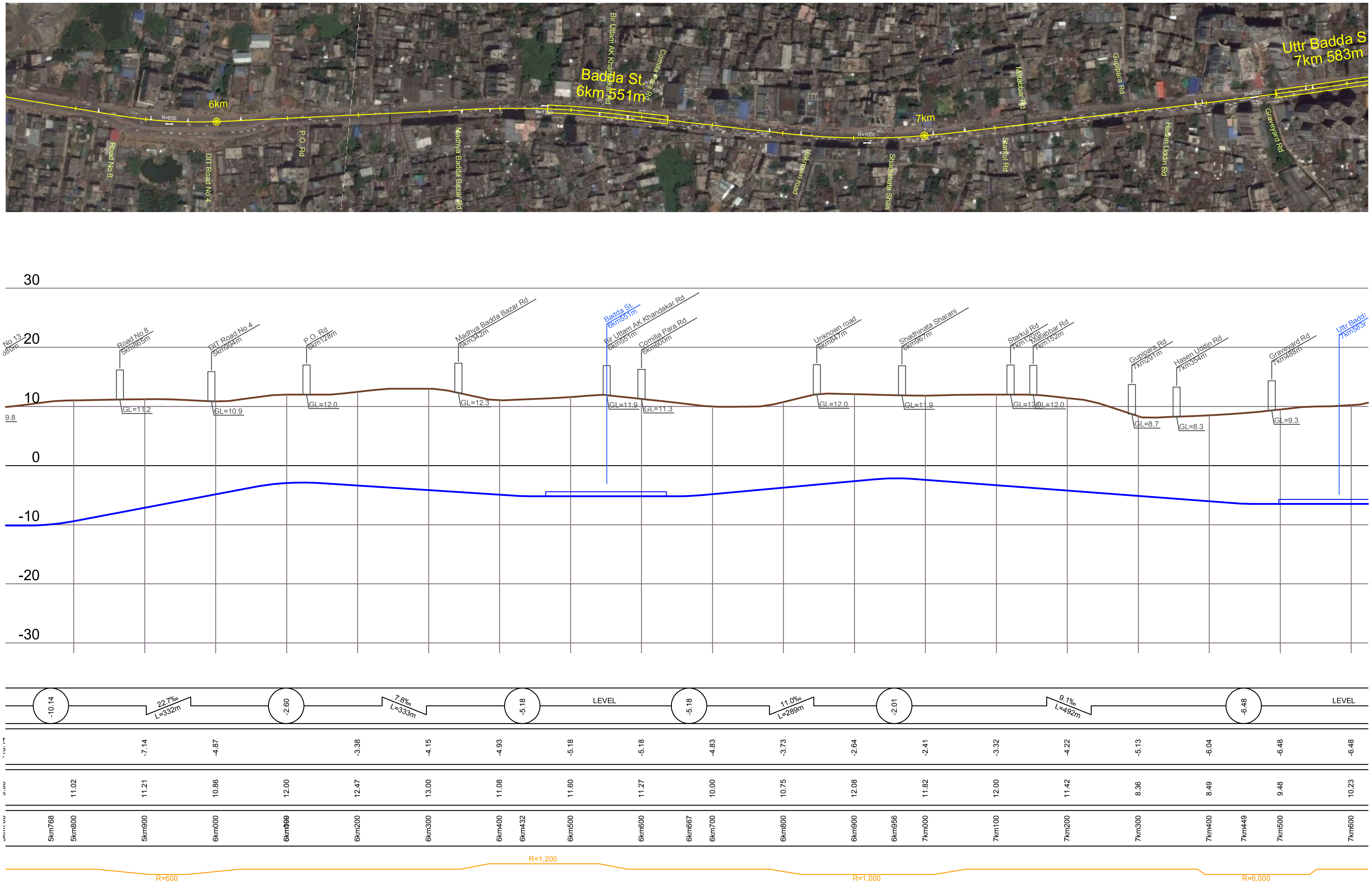
PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : $\frac{1}{5000}$ V : $\frac{1}{600}$	KAMALAPUR TO NOTUN BAZAR (2) LOWER TRACK	ALIGN-205.DWG	4 / 23



PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : $\frac{1}{5000}$ V : $\frac{1}{600}$	KAMALAPUR TO NOTUN BAZAR (3) LOWER TRACK	ALIGN-205.DWG	5 / 23

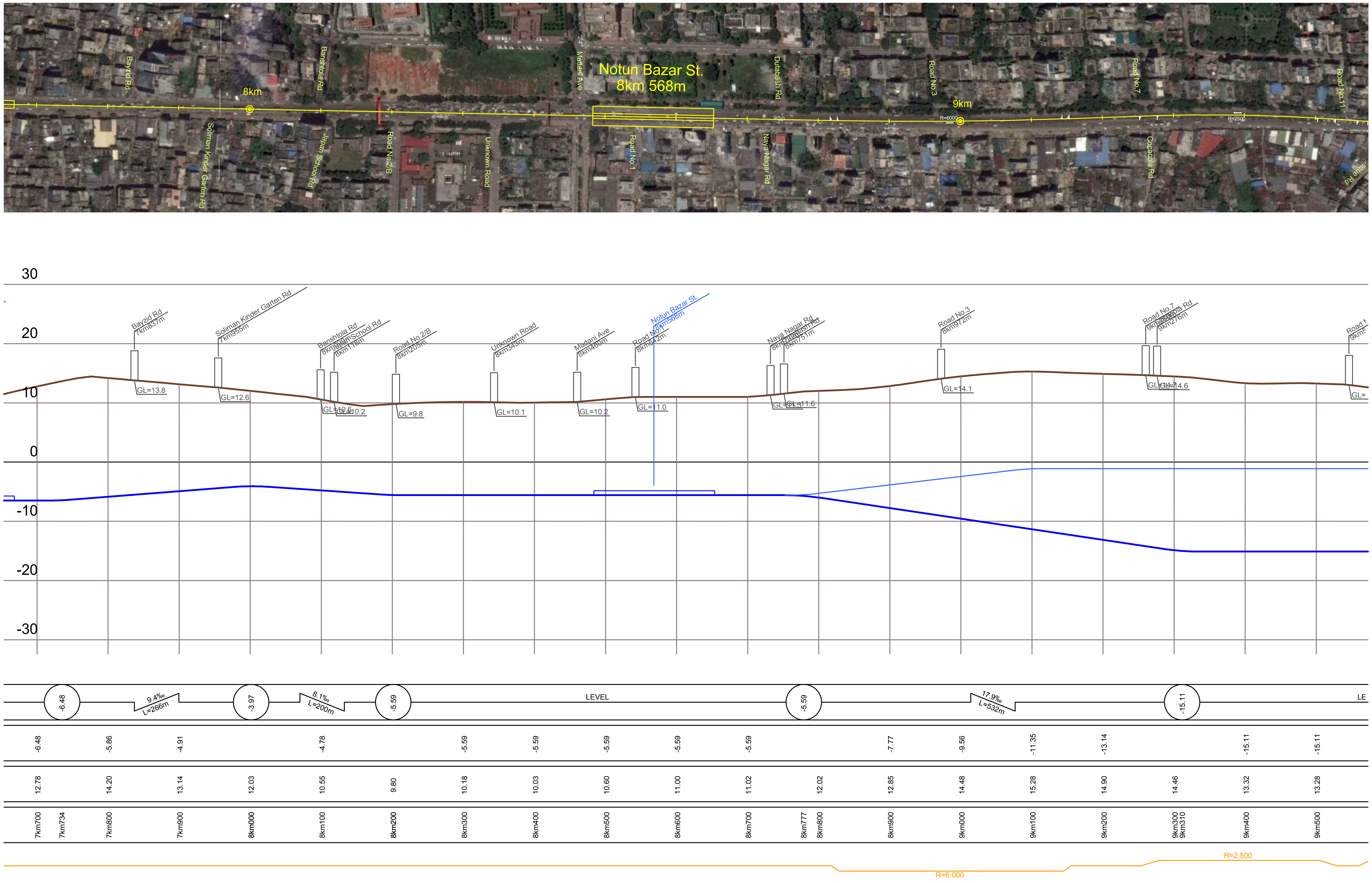


PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : 1/5000 V : 1/600	KAMALAPUR TO NOTUN BAZAR (4)	ALIGN-205.DWG	6 / 23

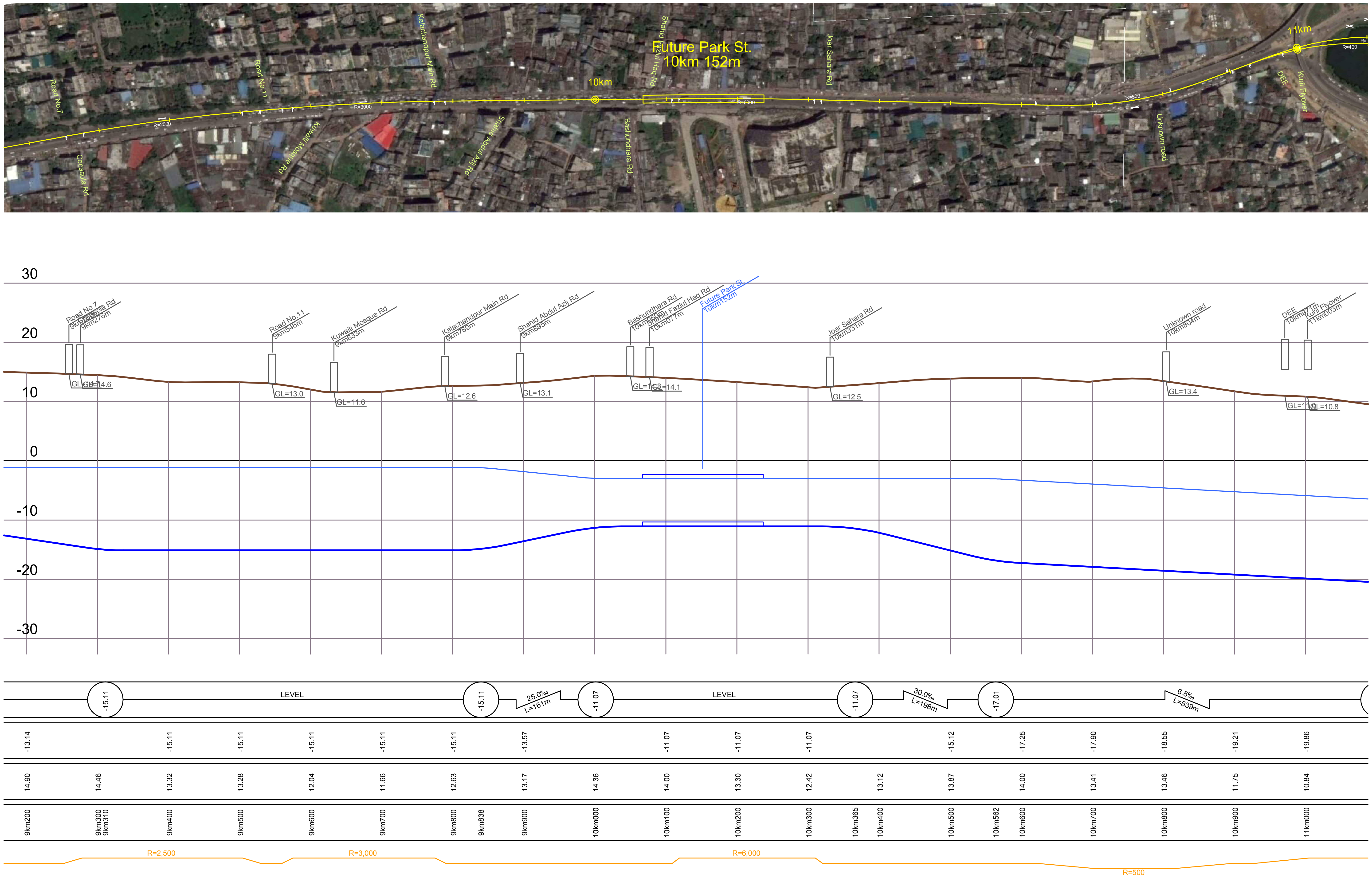


5km768		
5km800	11.02	
5km900	11.21	-7.14
6km000	10.86	-4.87
6km100	12.00	
6km200	12.47	-3.38
6km300	13.00	-4.15
6km400	11.08	-4.93
6km432		
6km500	11.60	-5.18
6km600	11.27	-5.18
6km667		
6km700	10.00	-4.83
6km800	10.75	-3.73
6km900	12.08	-2.64
6km956		
7km000	11.82	-2.41
7km100	12.00	-3.32
7km200	11.42	-4.22
7km300	8.36	-5.13
7km400	8.49	-6.04
7km449		
7km500	9.48	-6.48
7km600	10.23	-6.48

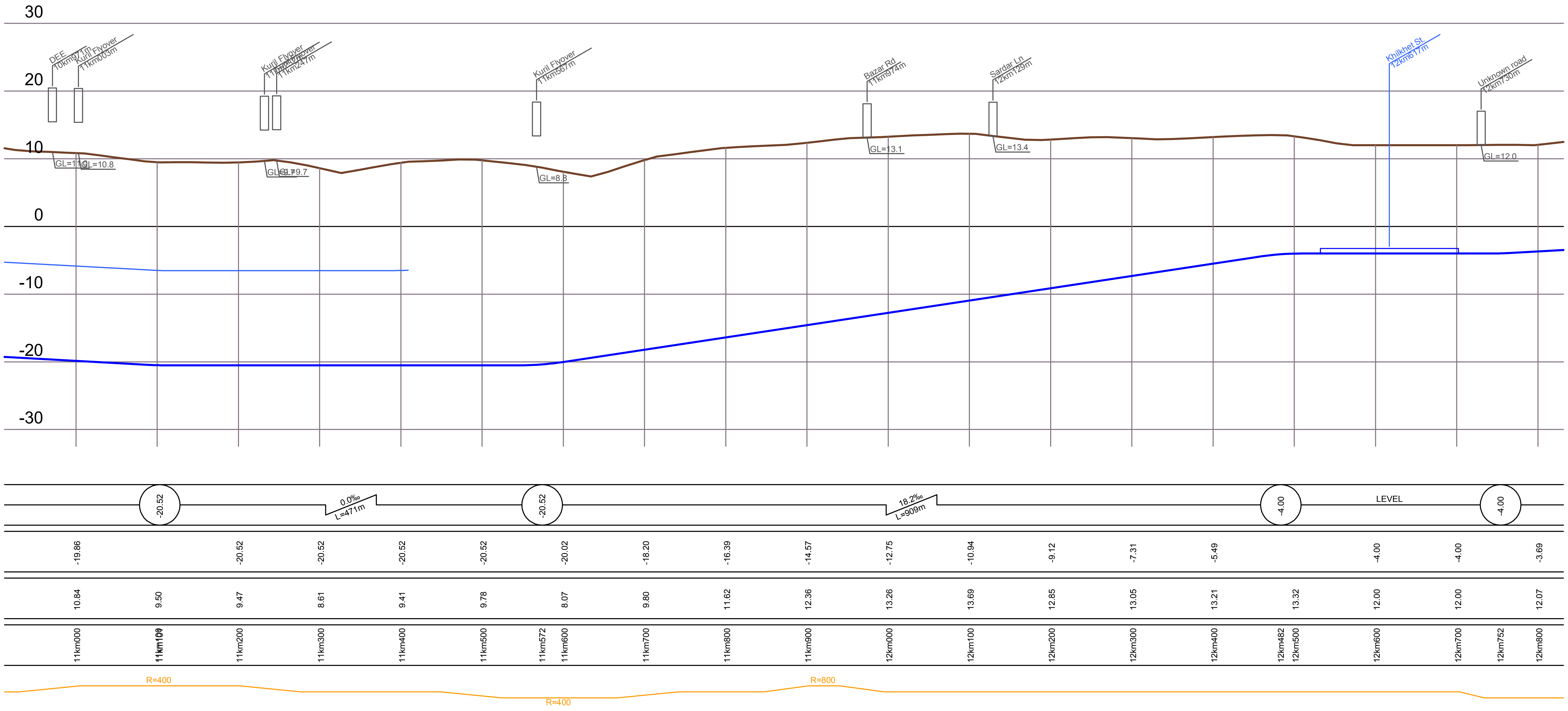
PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : 1/5000 V : 1/600	KAMALAPUR TO NOTUN BAZAR (5)	ALIGN-205.DWG	7 / 23



PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : 1/5000 V : 1/600	NOTUN BAZAR TO AIRPORT (1)	ALIGN-205.DWG	8 / 23



PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : $\frac{1}{5000}$ V : $\frac{1}{600}$	NOTUN BAZAR TO AIRPORT (2)	ALIGN-205.DWG	9 / 23



PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
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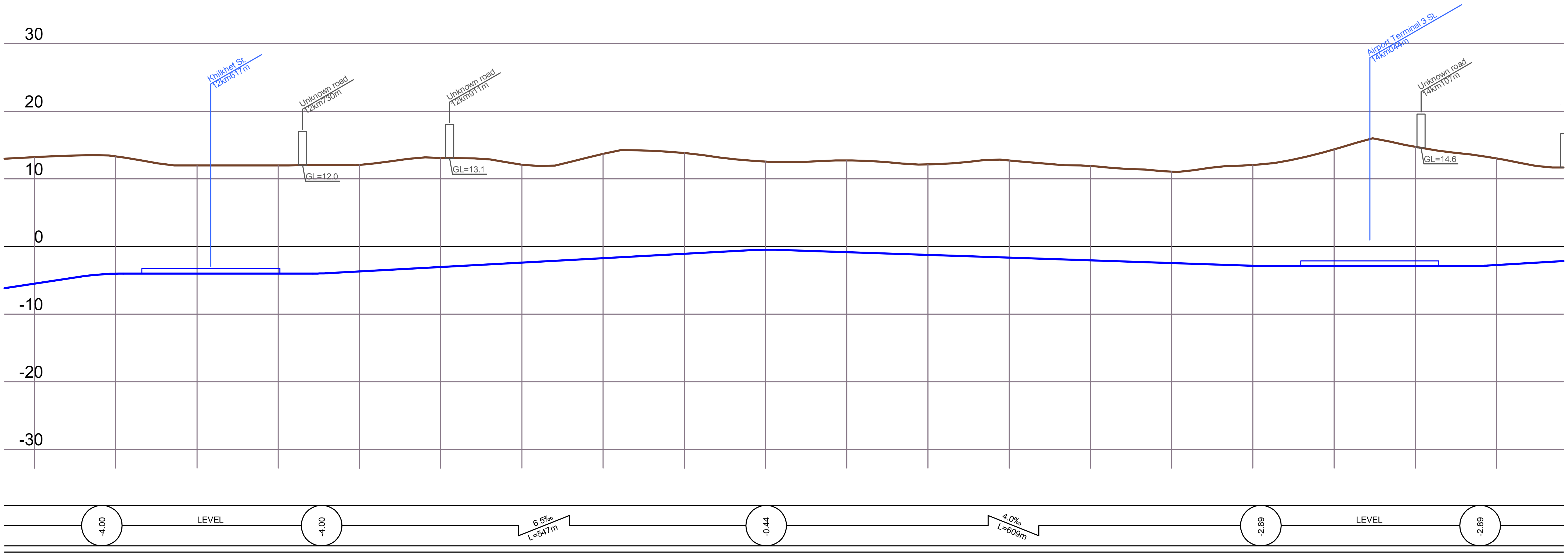
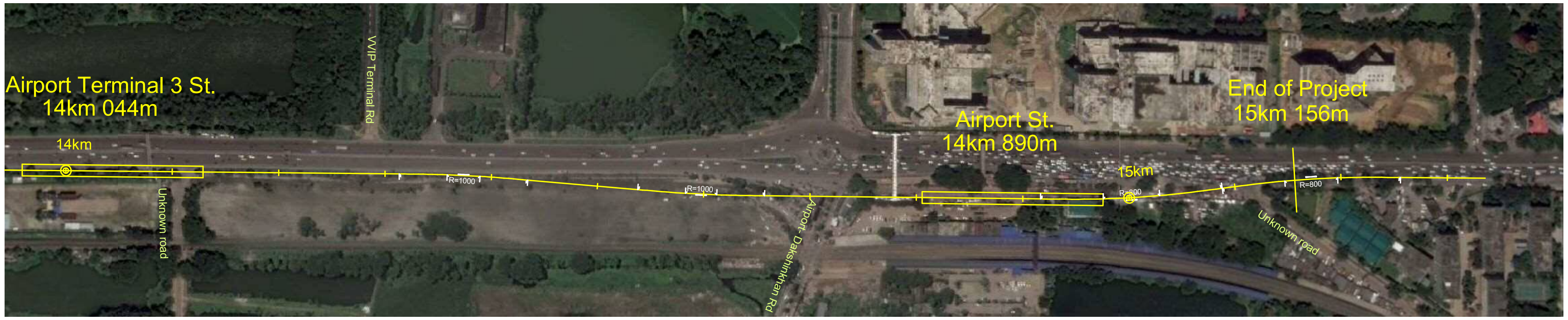
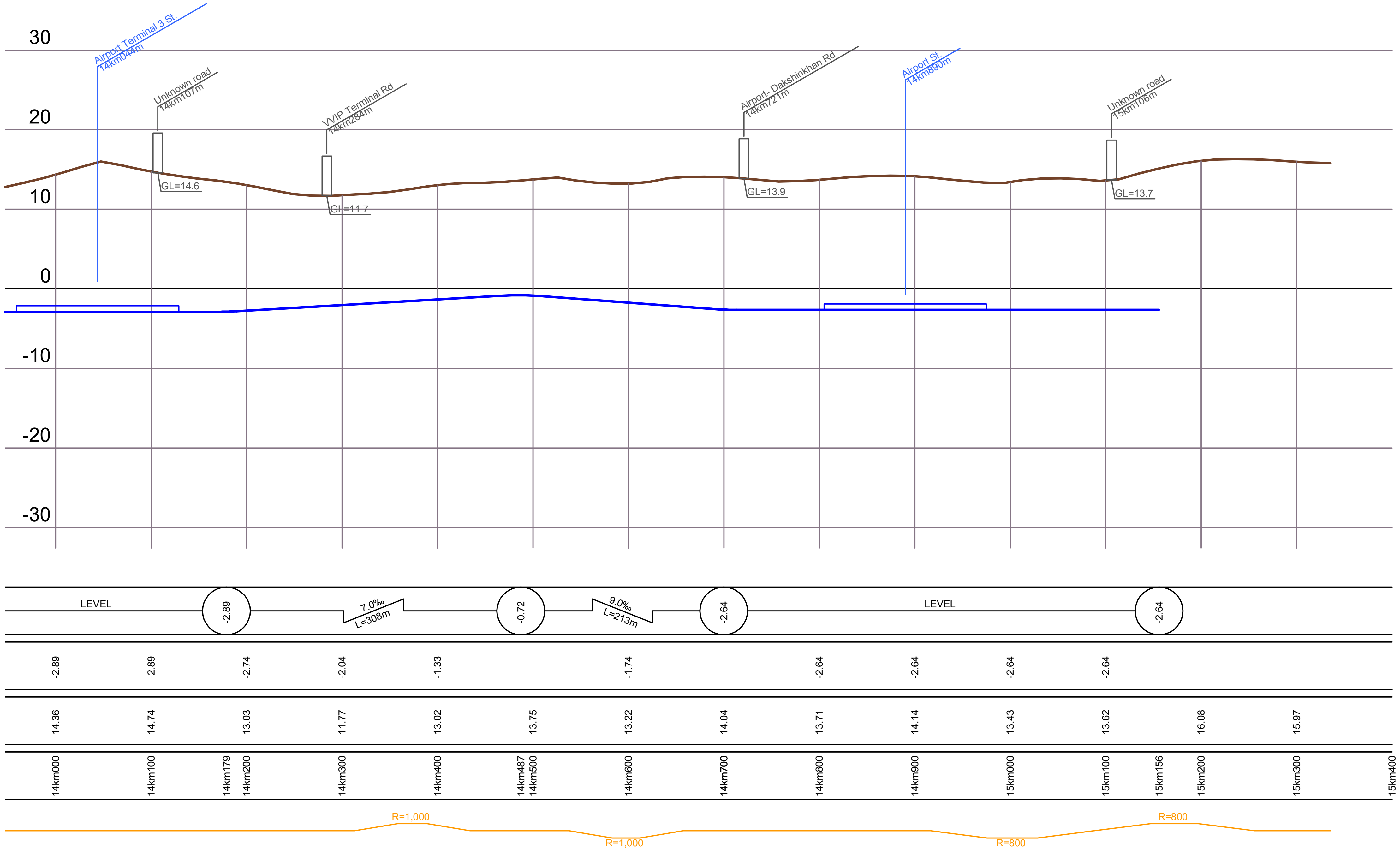


12km400	13.21	-5.49
12km482 12km500	13.32	
12km600	12.00	-4.00
12km700	12.00	-4.00
12km752		
12km800	12.07	-3.69
12km900	13.10	-3.04
13km000	12.09	-2.39
13km100	13.71	-1.74
13km200	13.83	-1.09
13km300	12.56	
13km400	12.73	-0.84
13km500	12.16	-1.24
13km600	12.72	-1.64
13km700	11.90	-2.05
13km800	11.07	-2.45
13km900 13km909	12.07	-2.85
14km000	14.36	-2.89
14km100	14.74	-2.89
14km179 14km200	13.03	-2.74

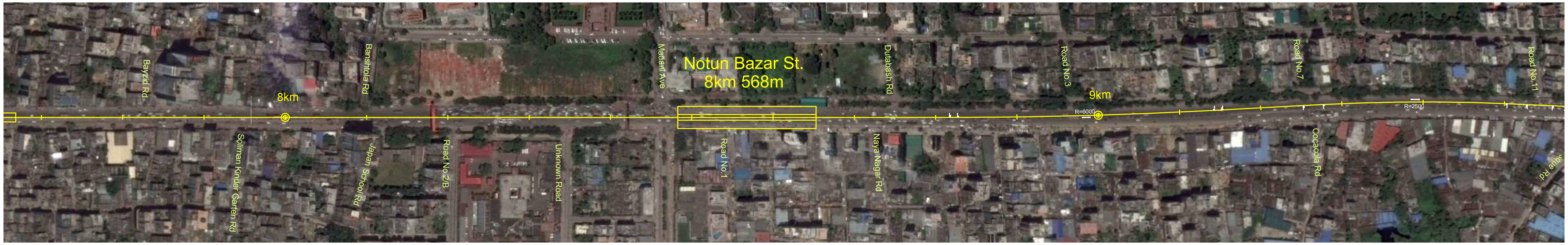
R=1,400

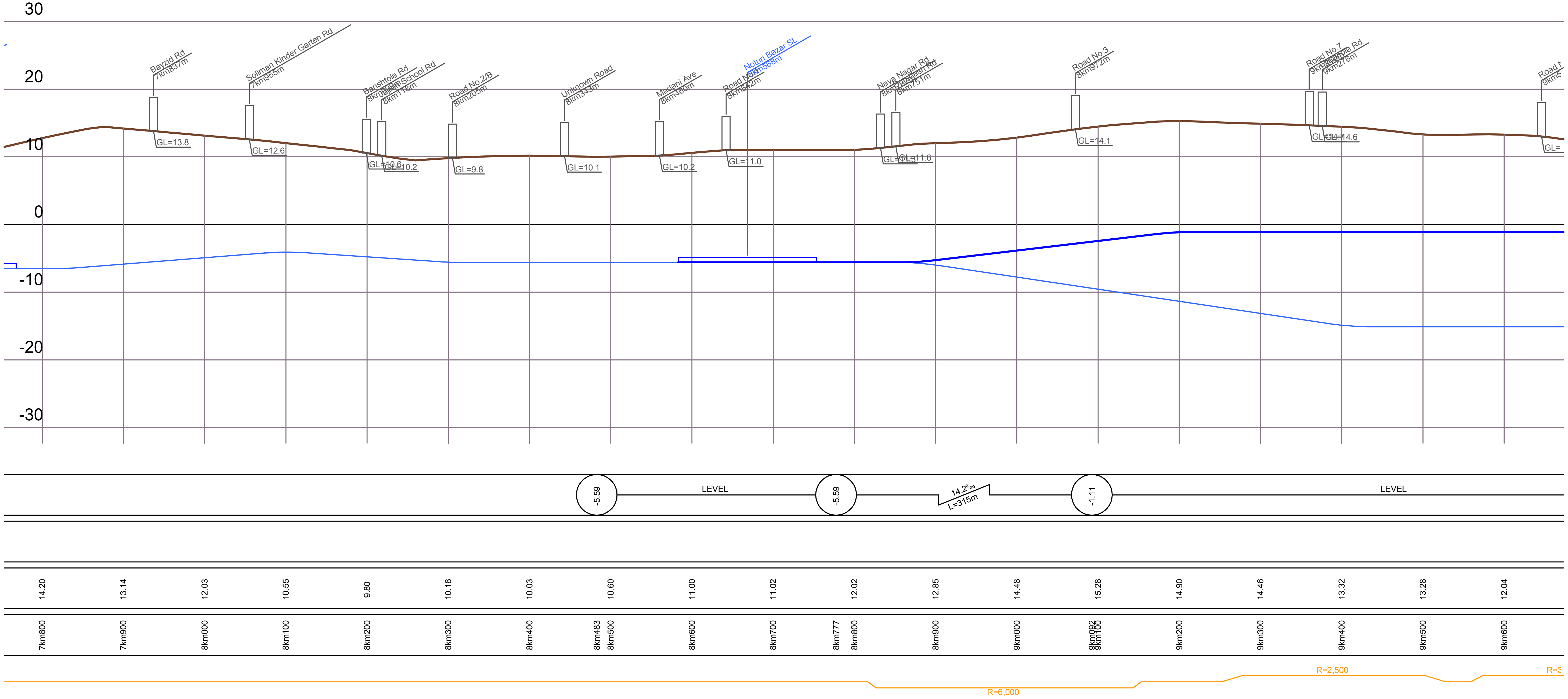
PLAN AND PROFILE DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
	2017/04/25	H : $\frac{1}{5000}$ V : $\frac{1}{600}$	NOTUN BAZAR TO AIRPORT (4)	ALIGN-205.DWG	11 / 23



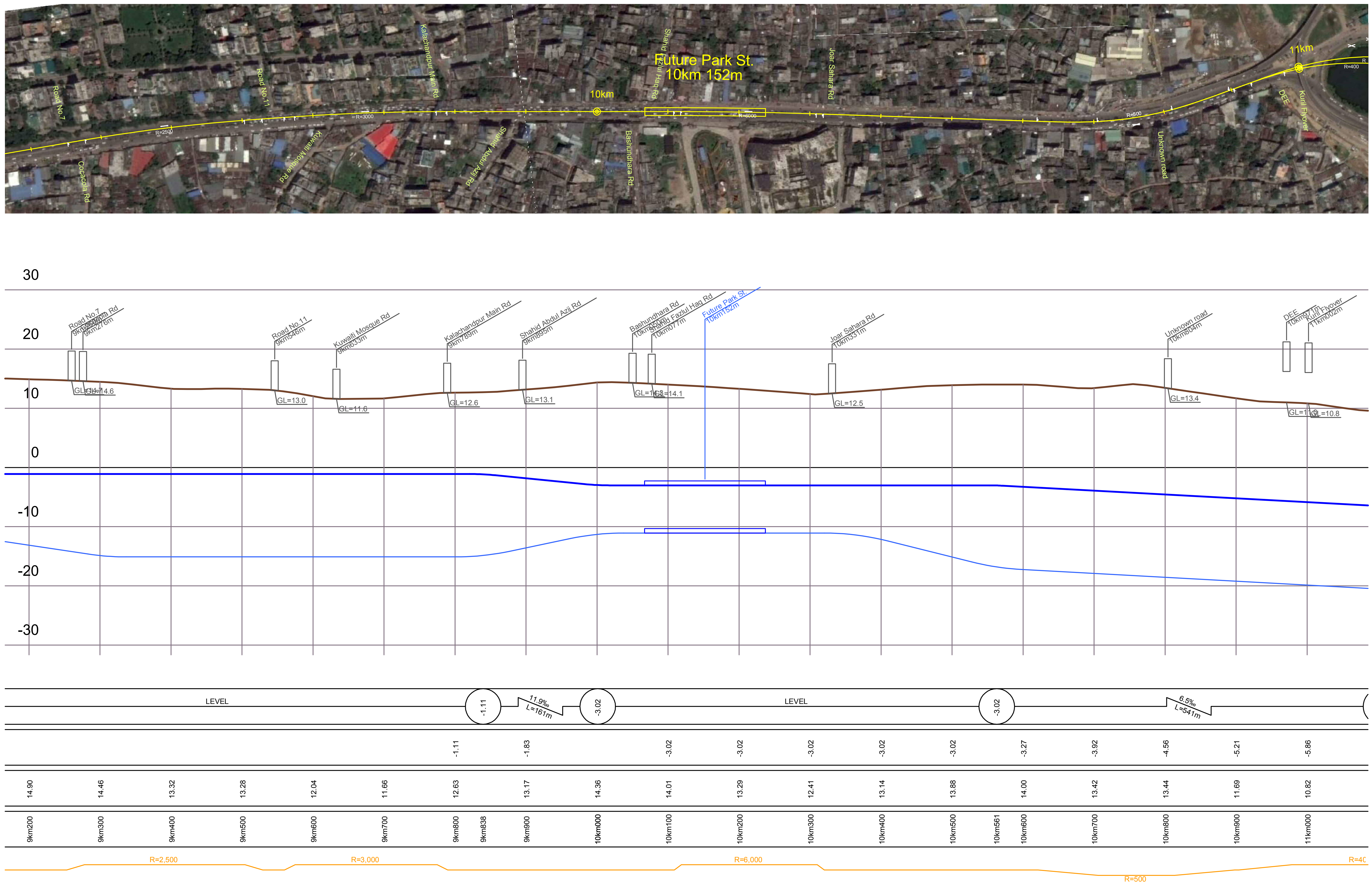


PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : 1/5000 V : 1/600	NOTUN BAZAR TO AIRPORT (5)	ALIGN-205.DWG	12 / 23





	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : 1/5000 V : 1/600	NOTUN BAZAR TO PURBACHAL (1)	ALIGN-205.DWG	13 / 23



9km200	14.90	
9km300	14.46	
9km400	13.32	
9km500	13.28	
9km600	12.04	
9km700	11.66	
9km800	12.63	-1.11
9km838		
9km900	13.17	-1.83
10km000	14.36	
10km100	14.01	-3.02
10km200	13.29	-3.02
10km300	12.41	-3.02
10km400	13.14	-3.02
10km500	13.88	-3.02
10km561		
10km600	14.00	-3.27
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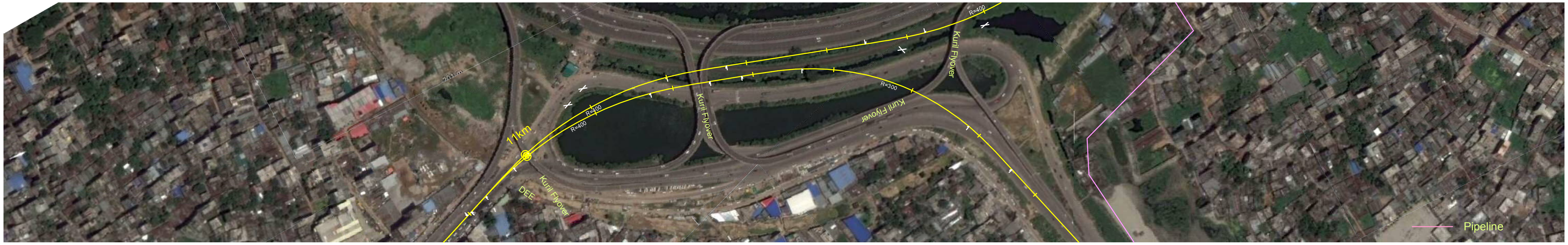
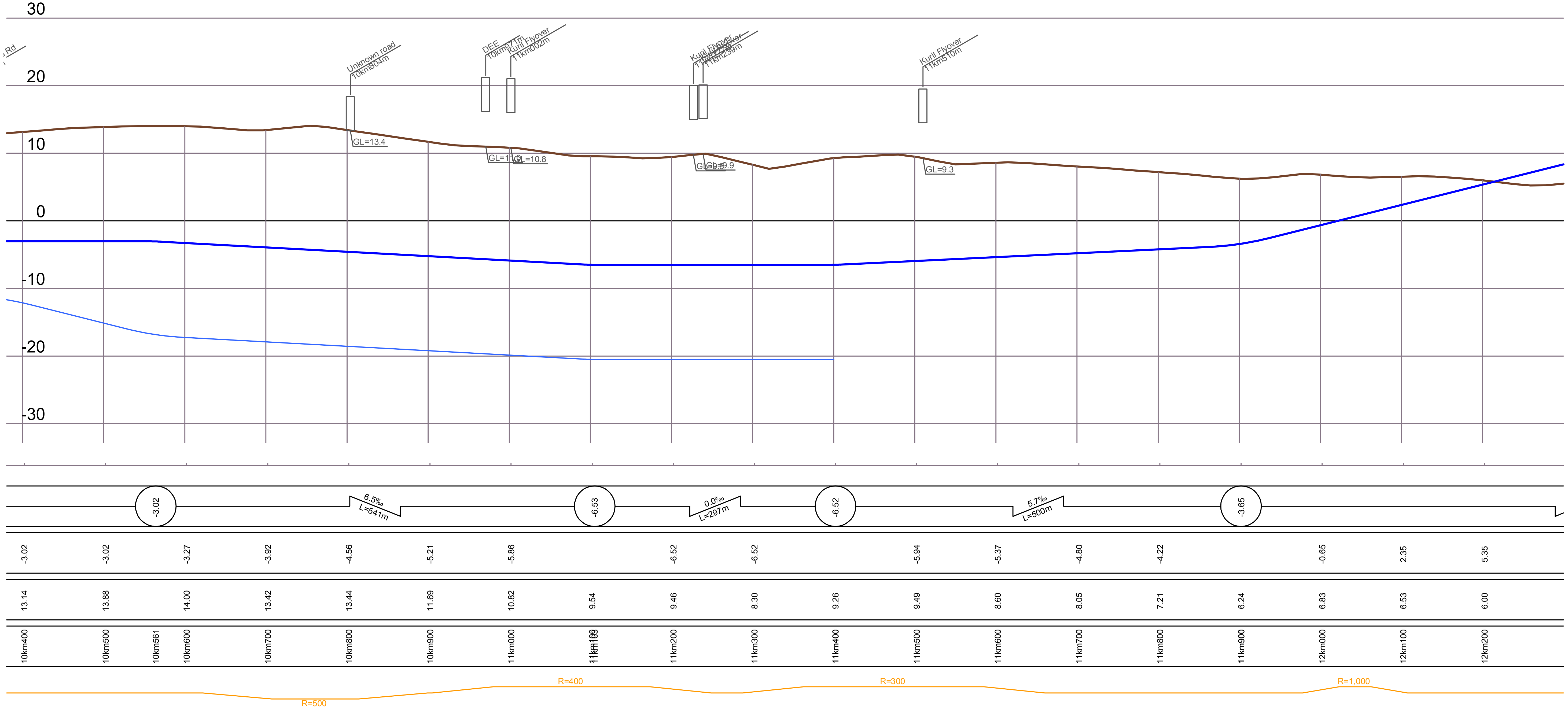
10km800	13.44	-4.56
10km900	11.69	-5.21
11km000	10.82	-5.86

PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : 1/5000 V : 1/600	NOTUN BAZAR TO PURBACHAL (2)	ALIGN-205.DWG	14 / 23





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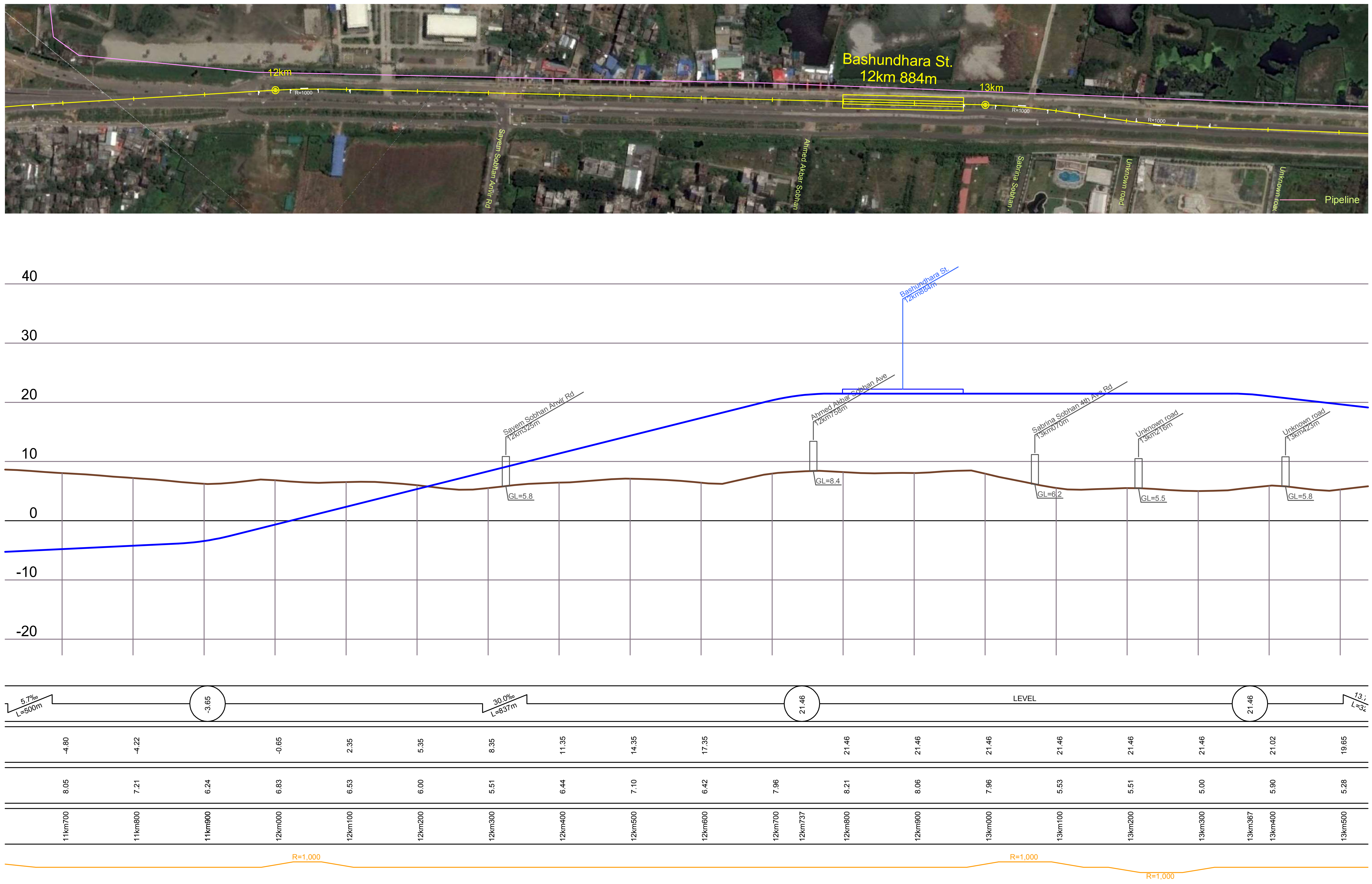
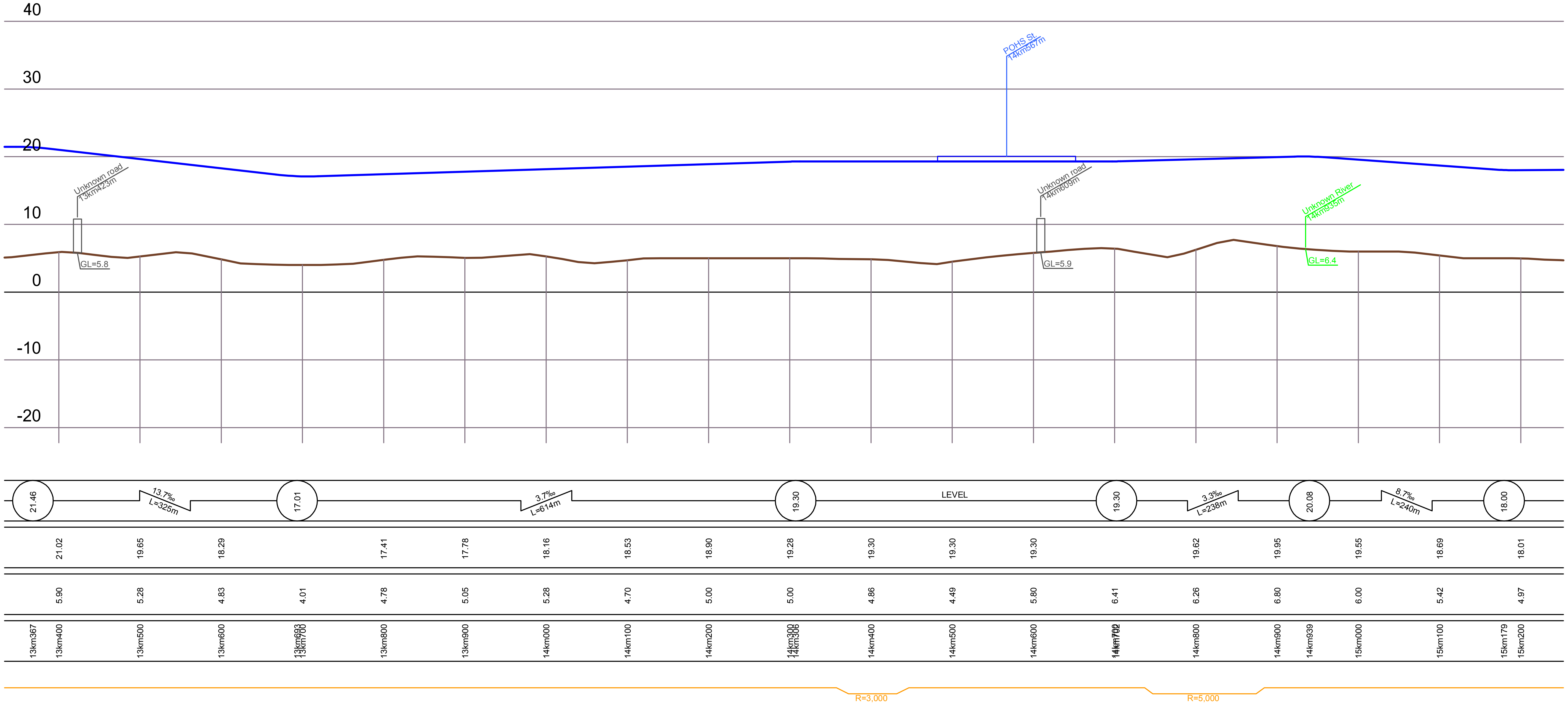
10km500	13.88	-3.02
10km561		
10km600	14.00	-3.27
10km700	13.42	-3.92
10km800	13.44	-4.56
10km900	11.69	-5.21
11km000	10.82	-5.86
11km100	9.54	
11km200	9.46	-6.52
11km300	8.30	-6.52
11km400	9.26	
11km500	9.49	-5.94
11km600	8.60	-5.37
11km700	8.05	-4.80
11km800	7.21	-4.22
11km900	6.24	
12km000	6.83	-0.65
12km100	6.53	2.35
12km200	6.00	5.35

PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : $\frac{1}{5000}$ V : $\frac{1}{600}$	NOTUN BAZAR TO PURBACHAL (3)	ALIGN-205.DWG	15 / 23

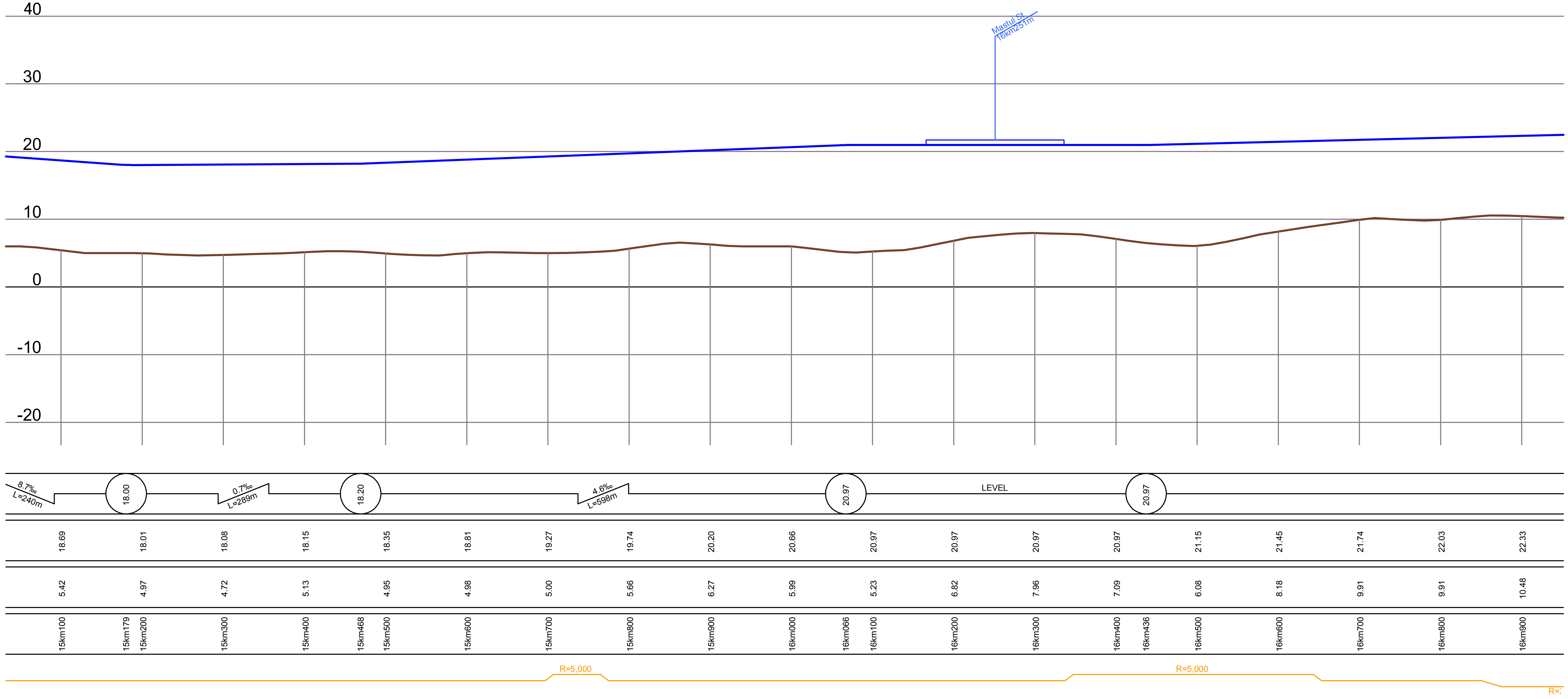


-4.80	-4.22		-0.65	2.35	5.35	8.35	11.35	14.35	17.35			21.46	21.46	21.46	21.46	21.46	21.46		21.02	19.65
8.05	7.21	6.24	6.83	6.53	6.00	5.51	6.44	7.10	6.42	7.96		8.21	8.06	7.96	5.53	5.51	5.00		5.90	5.28
11km700	11km800	11km900	12km000	12km100	12km200	12km300	12km400	12km500	12km600	12km700	12km737	12km800	12km900	13km000	13km100	13km200	13km300	13km367	13km400	13km500

PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : $\frac{1}{5000}$ V : $\frac{1}{600}$	NOTUN BAZAR TO PURBACHAL (4)	ALIGN-205.DWG	16 / 23

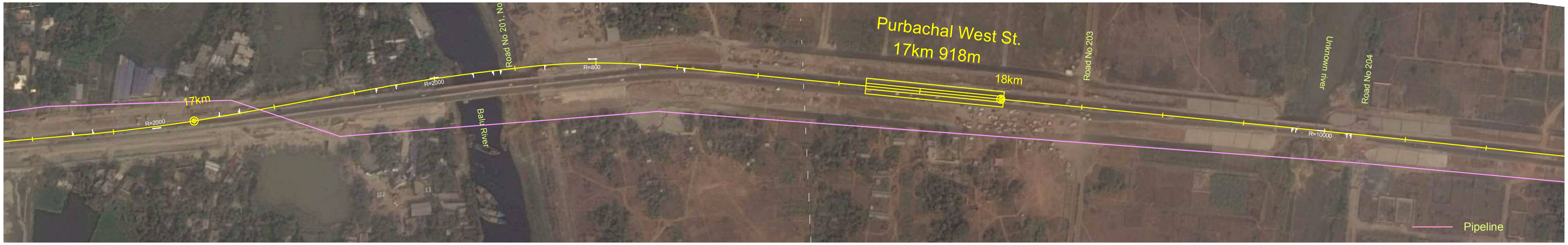


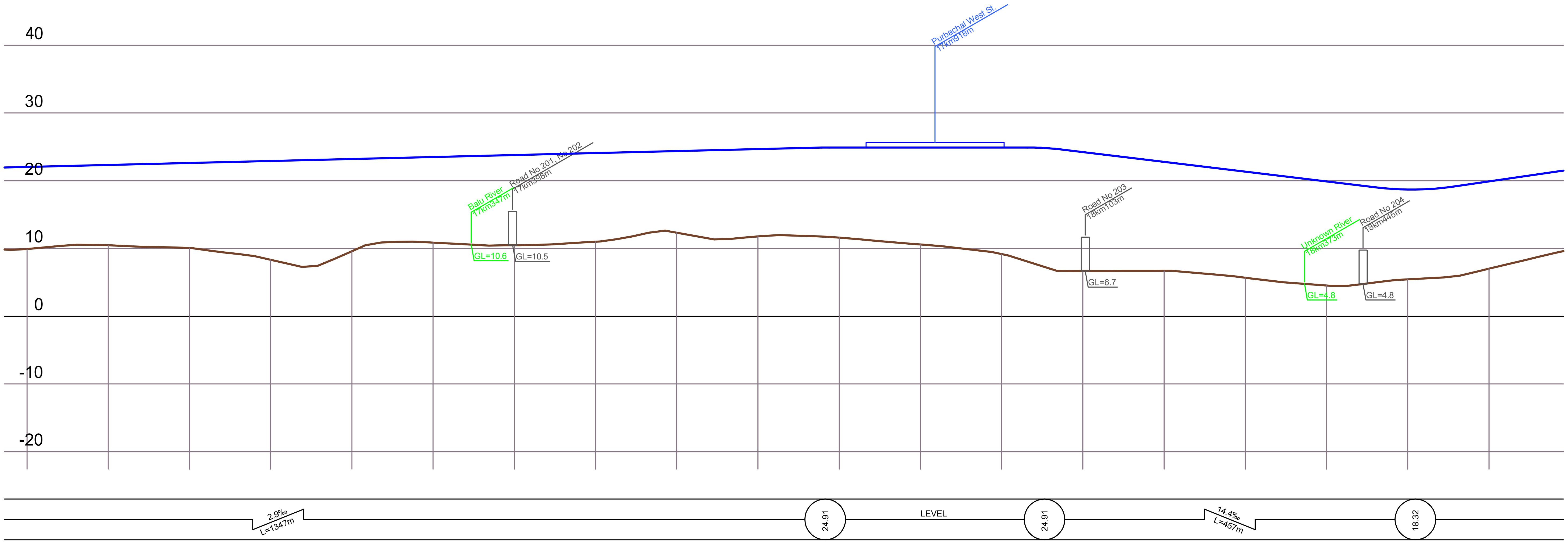
PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : $^1/_{5000}$ V : $^1/_{600}$	NOTUN BAZAR TO PURBACHAL (5)	ALIGN-205.DWG	17 / 23



15km100	5.42	18.69
15km179		
15km200	4.97	18.01
15km300	4.72	18.08
15km400	5.13	18.15
15km468		
15km500	4.95	18.35
15km600	4.98	18.81
15km700	5.00	19.27
15km800	5.66	19.74
15km900	6.27	20.20
16km000	5.99	20.66
16km066		
16km100	5.23	20.97
16km200	6.82	20.97
16km300	7.96	20.97
16km400	7.09	20.97
16km436		
16km500	6.08	21.15
16km600	8.18	21.45
16km700	9.91	21.74
16km800	9.91	22.03
16km900	10.48	22.33

PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : $\frac{1}{5000}$ V : $\frac{1}{600}$	NOTUN BAZAR TO PURBACHAL (6)	ALIGN-205.DWG	18 / 23





22.03	9.91	16km800
22.33	10.48	16km900
22.62	10.08	17km000
22.91	8.33	17km100
23.20	9.59	17km200
23.50	10.88	17km300
23.79	10.48	17km400
24.08	11.01	17km500
24.38	12.32	17km600
24.67	11.79	17km700
		17km783
24.91	11.61	17km800
24.91	10.59	17km900
24.91	9.17	18km000
		18km053
24.23	6.67	18km100
22.79	6.71	18km200
21.35	5.69	18km300
19.90	4.54	18km400
	5.45	18km500 18km509
19.89	7.02	18km600

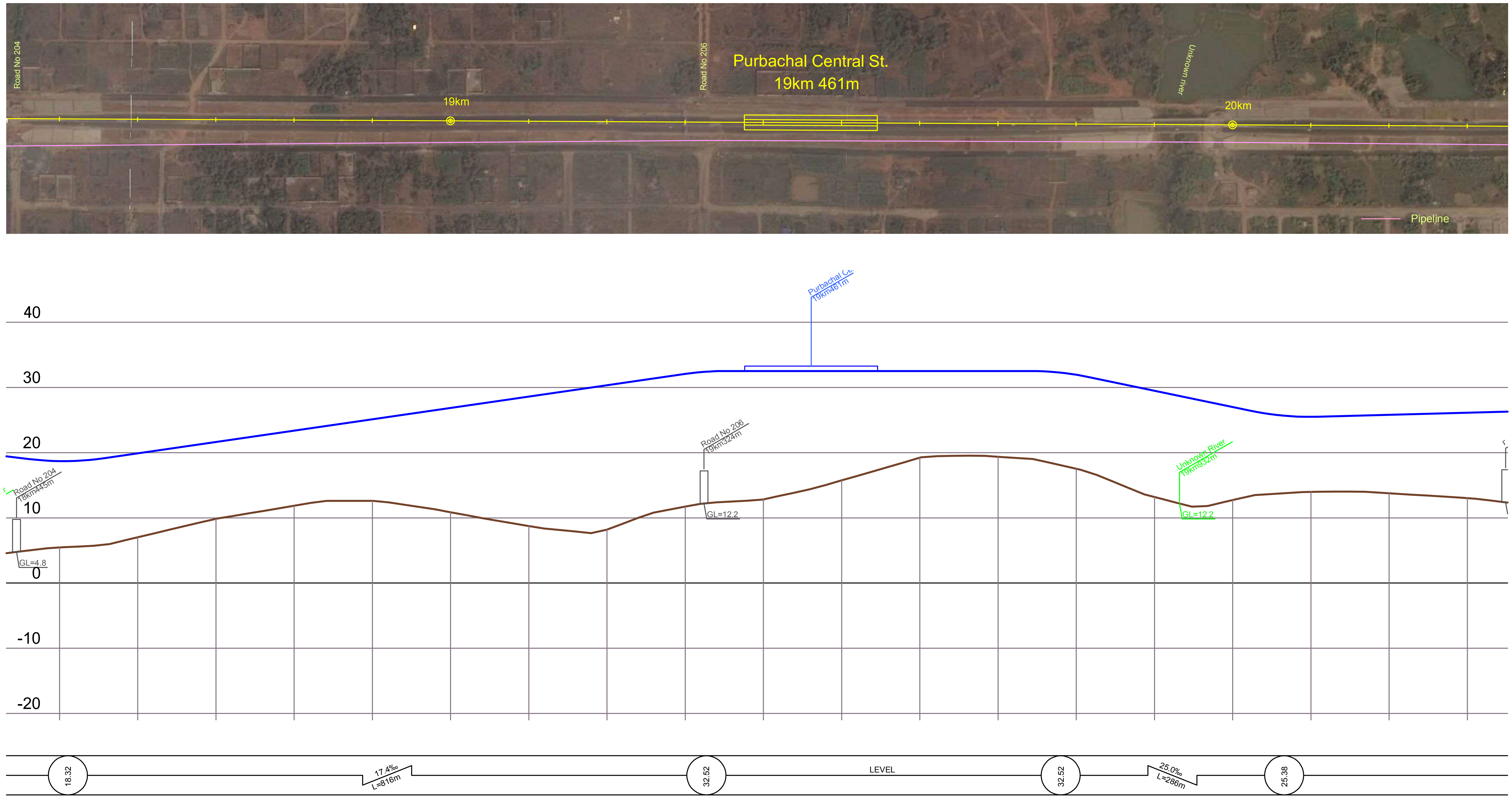
R=2,000

R=2,000

R=800

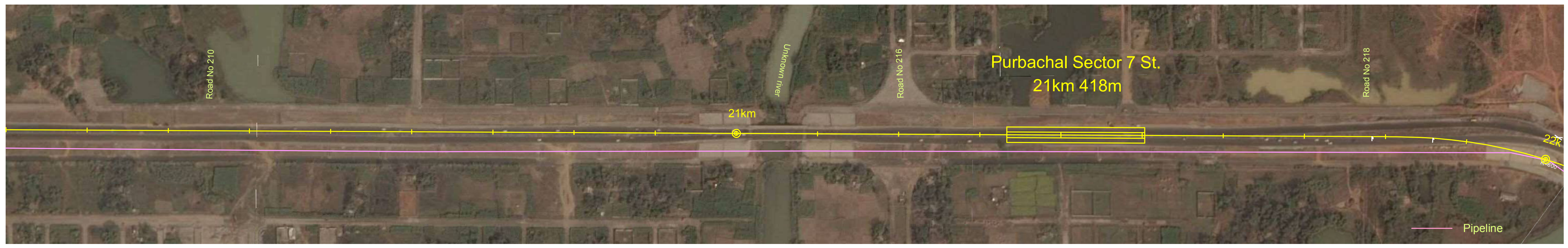
R=10,000

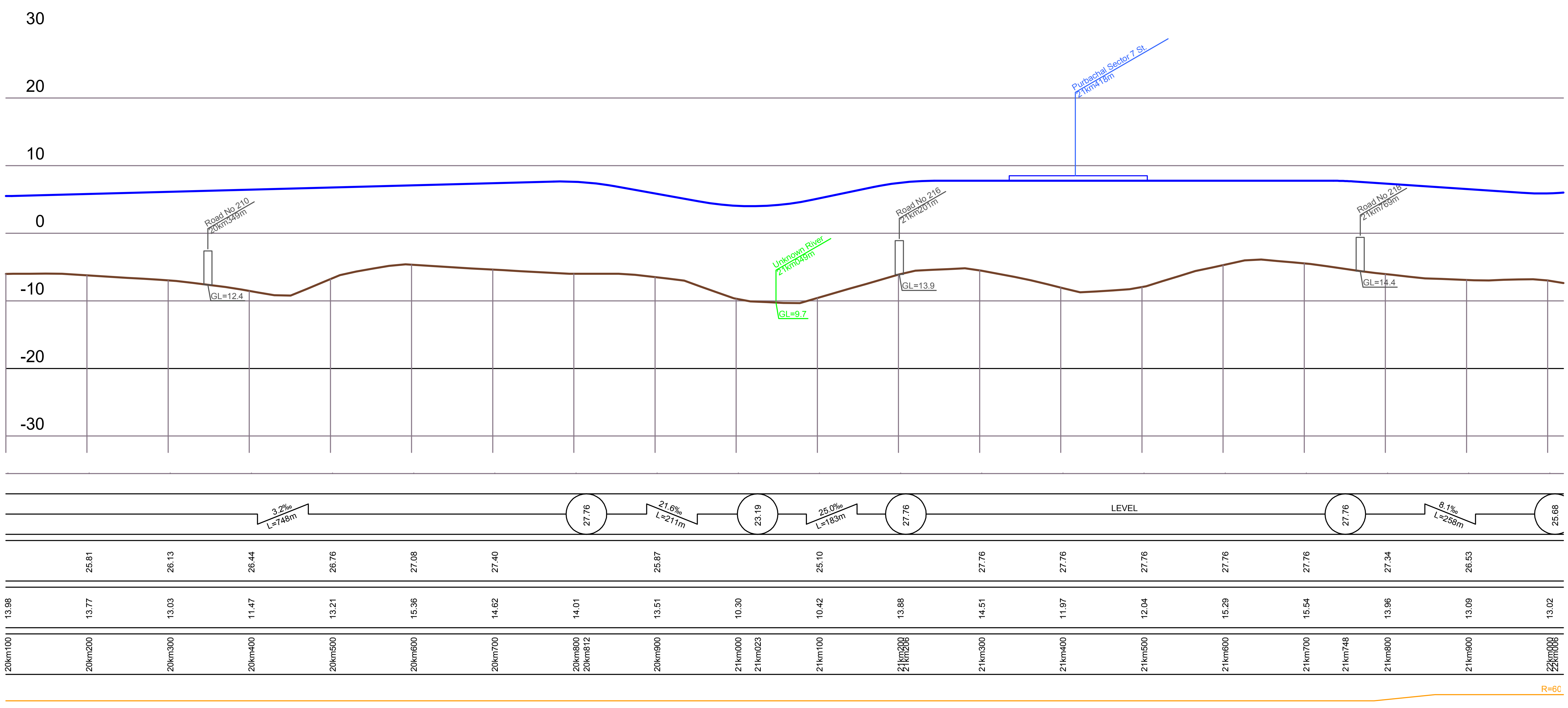
PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : $\frac{1}{5000}$ V : $\frac{1}{600}$	NOTUN BAZAR TO PURBACHAL (7)	ALIGN-205.DWG	19 / 23



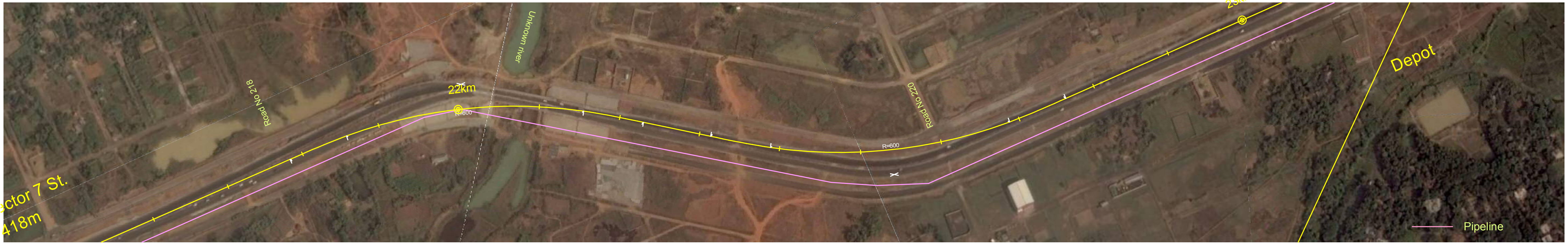
18km500	5.45	
18km509		18.32
18km600	7.02	19.89
18km700	9.84	21.63
18km800	11.85	23.37
18km900	12.61	25.11
19km000	10.85	26.85
19km100	8.75	28.59
19km200	8.20	30.33
19km300	11.72	
19km326		32.52
19km400	12.82	32.52
19km500	15.74	32.52
19km600	19.23	32.52
19km700	19.36	32.52
19km778		32.52
19km800	17.53	
19km900	13.19	29.49
20km000	12.73	26.99
20km064		25.38
20km100	13.98	
20km200	13.77	25.81
20km300	13.03	26.13

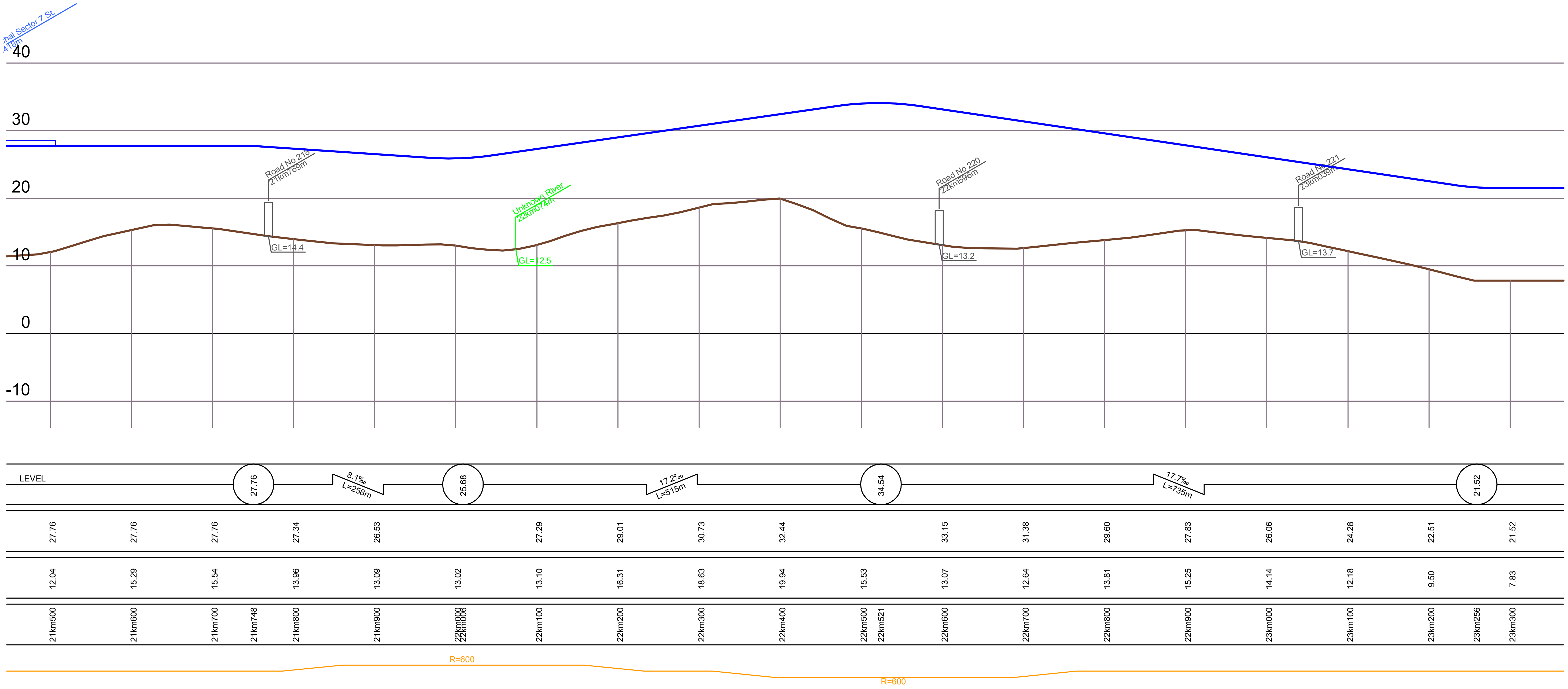
PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : $\frac{1}{5000}$ V : $\frac{1}{600}$	NOTUN BAZAR TO PURBACHAL (8)	ALIGN-205.DWG	20 / 23





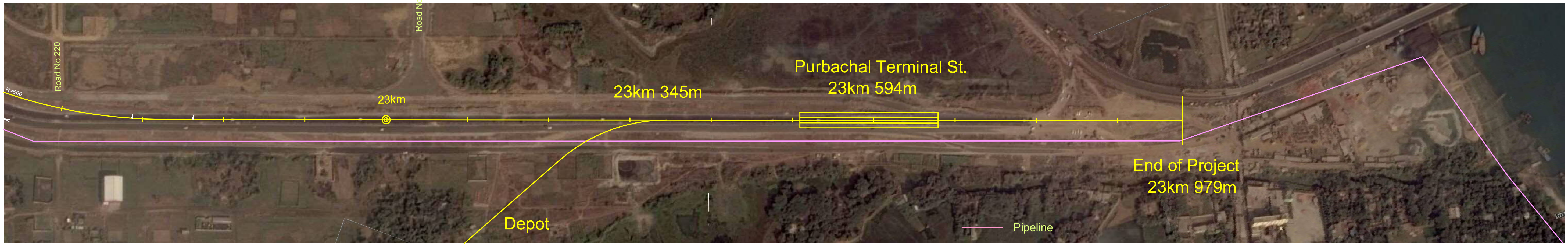
PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : ⅟5000 V : ⅟600	NOTUN BAZAR TO PURBACHAL (9)	ALIGN-205.DWG	21 / 23

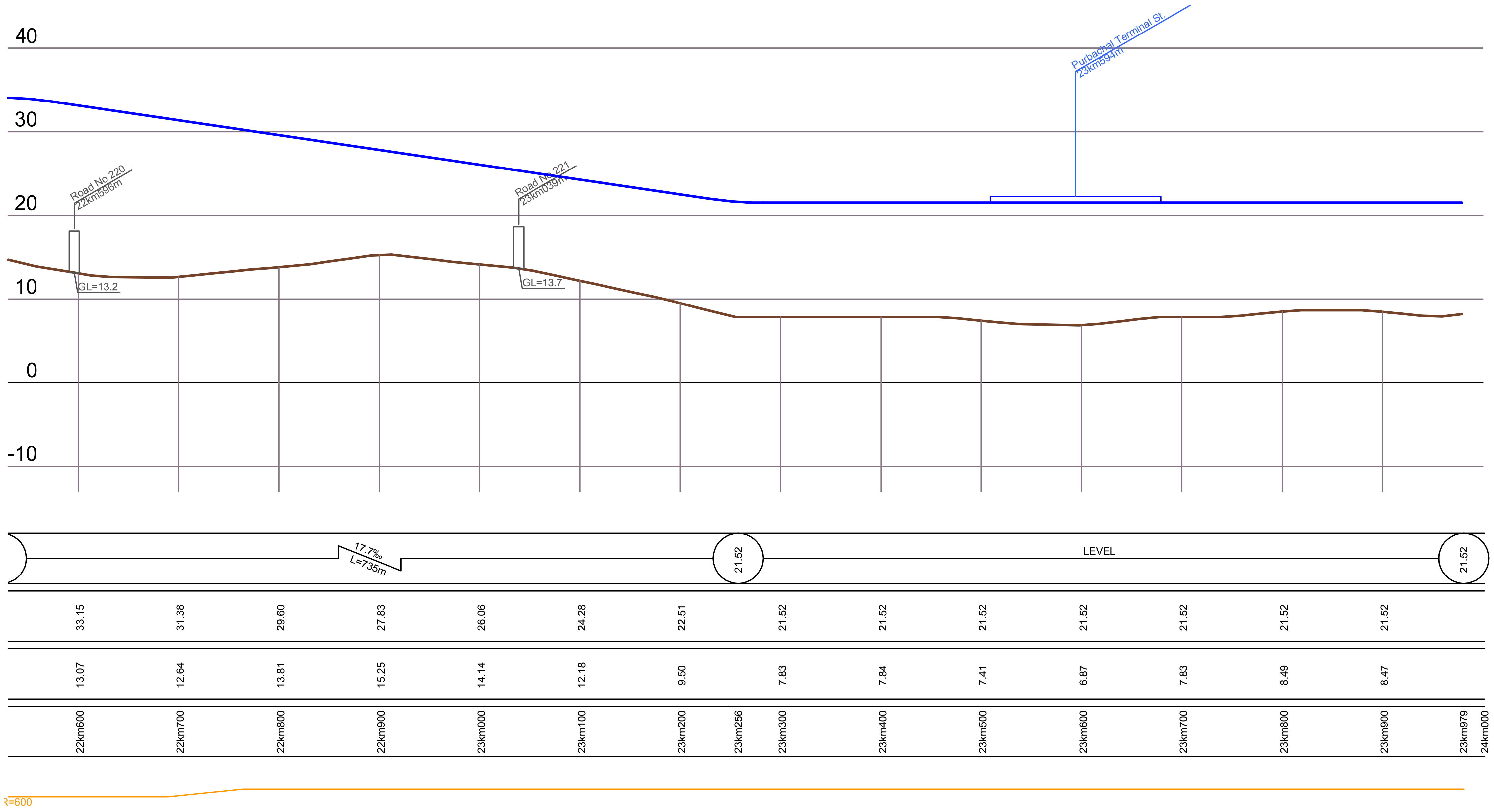




21km500	12.04	27.76
21km600	15.29	27.76
21km700	15.54	27.76
21km748		
21km800	13.96	27.34
21km900	13.09	26.53
22km000 22km000	13.02	
22km100	13.10	27.29
22km200	16.31	29.01
22km300	18.63	30.73
22km400	19.94	32.44
22km500	15.53	
22km521		
22km600	13.07	33.15
22km700	12.64	31.38
22km800	13.81	29.60
22km900	15.25	27.83
23km000	14.14	26.06
23km100	12.18	24.28
23km200	9.50	22.51
23km256		
23km300	7.83	21.52

PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : $^1/_{5000}$ V : $^1/_{600}$	NOTUN BAZAR TO PURBACHAL (10)	ALIGN-205.DWG	22 / 23





22km600	13.07	33.15
22km700	12.64	31.38
22km800	13.81	29.60
22km900	15.25	27.83
23km000	14.14	26.06
23km100	12.18	24.28
23km200	9.50	22.51
23km256		
23km300	7.83	21.52
23km400	7.84	21.52
23km500	7.41	21.52
23km600	6.87	21.52
23km700	7.83	21.52
23km800	8.49	21.52
23km900	8.47	21.52
23km979		
24km000		

PLAN AND PROFILE	DATE PRINTED	SCALE	DRAWING NAME	DRW NO.	PAGE
DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 1)	2017/04/25	H : $^1/_{5000}$ V : $^1/_{600}$	NOTUN BAZAR TO PURBACHAL (11)	ALIGN-205.DWG	23 / 23

Appendix 2

Comparison of Fire Prevention Standards

Appendix 2 Comparison of Fire Prevention Standards

(1) Comparison between Article 29 of MLIT and NFPA 130

In section 6.1.2, it is mentioned about “Article 29 of Ministerial Ordinance of the Ministry of Land Infrastructure, Transport and Tourism” (hereinafter referred to as “Article 29 of MLIT). In this section, it is described about “NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail (hereinafter referred to as “NAPA 130”)issued by National Fire Protection Association (NFPA)comparing with Article 29 of MLIT, which is widely adopted in Metros in South and South East Asia such as India, Thailand, Singapore and Vietnam etc.

The main differences between Article 29 of MLIT and NFPA 130 are summarized in the following table.

Table 6.1.3-1 Comparison between Article 29 of MLIT and NFPA130

Items	Article 29 of MLITI	NFPA 130, 2017 Edition
Tunnel section at between stations	Tunnel is not used for evacuation passage of passengers except for emergency case.	Tunnel can be used for evacuation passage of passengers.
Fire control at between stations	Generally, train made of non-combustible material runs to next station.	It specifies evacuation method for passengers in case of tunnel fire to evacuate to outside of the burned tunnel on foot based on the concept that train has the potential to burn.
Tunnel structure	No requirement for cross passageways for twin bores and no requirement for fire walls for double line-single bore	-Cross passageways at 244m maximum interval are installed for twin bores having station distance is more than 762m. - A minimum 2-hr rated fire walls are installed for double line-single bore.
Emergency exit signs	Mention	No mention
Smoke control equipment	It is required to install smoke control equipment except that sufficient flue gas is expected by natural ventilation opening. It can be used for mechanical ventilation equipment.	-A mechanical emergency ventilation system is installed to make provisions for the protection of passengers, employees, and emergency personnel from fire and smoke during a fire emergency. -An engineering analysis to determine the need for the mechanical emergency ventilation system is conducted where the length of the underground is greater than 61m.
Emergency facility design	• It is divided into an ordinary fire and a large fire (arson with 4 litres of gasoline). • In case of an ordinary fire at platform level, smoke density Cs shall be less than 0.1 (1/m).	• The platform occupant load is specified. • Platform Evacuation Time: It is designed for sufficient egress capacity to evacuate the platform occupant load from the station platform in 4

	- In case of an ordinary fire at platform level, smoke diffusion volume shall be greater than the value derived from the evacuation time. - In case of a larger fire at platform and concourse levels, evacuation time shall be less than smoke descending time that is time for smoke descending to 2.0 (m) higher of the floor.	minutes or less. - Evacuation Time to a Point of Safety: The station is designed to permit evacuation from the most remote point on the platform to a point of safety in 6 minutes or less. - Travel Distance: The maximum travel distance on the platform to a point at which a means of egress route leaves the platform is not exceed 100 m.

Source: Summarized by study team based on Article 29 of MLIT and NFPA130 2017 edition

Design philosophies for both standards are vastly different as mentioned the above table. While Article 29 of MLIT specifies rolling stocks to be made of non-combustible material and basically the tunnel between stations is not permitted to use for evacuation passage, NFPA130 allows to use the tunnel as evacuation passage considering possibility of burns.

Therefore, although Article 29 of MLIT does not specify for cross passageways for twin bores, NFPA130 stipulates cross passageways at 244m maximum interval for twin bores where station distance is more than 762m. The presence of cross passageways is often focused on as a difference for both standards.

(2) Cross passageways specified by NFPA 130

NFPA 130 was often revised and details of cross passageways were also revised following the revisions as shown in Table 6.1.3-2, Figure 6.1.3-1 and 2.

In more details, in 2007 edition, cross passageways was specified as “cross passageways shall not be farther than 244 m from the station or portal of the enclosed trainway.”, meaning it became restrictive compared to the previous revision.

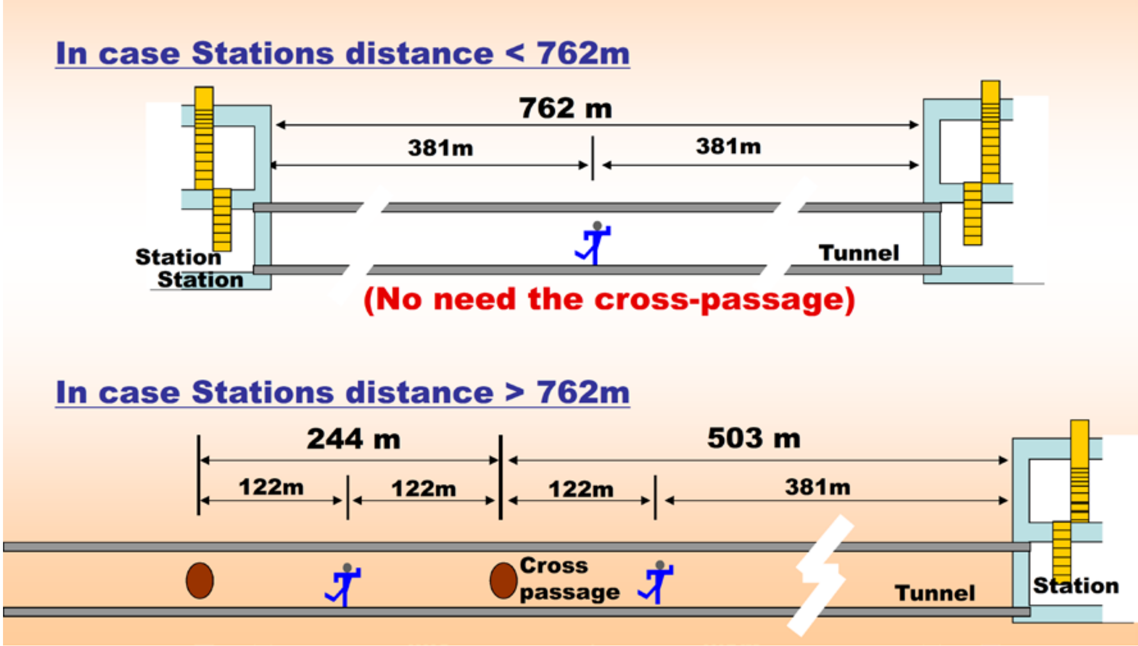
However, the details of cross passageways have not been revised since the above revision.

Table 6.1.3-2 Standards for Emergency Exit for Underground Trainways by NFPA 130

	Emergency Exit Details	Cross passageways utilized for emergency exit
1997 edition 2000 edition	3.2.4.2 Distance to an emergency exit <381m	3.2.4.3 Cross passageways <244m apart
2003 edition	3.2.4.2 Maximum distance between exits <762m	3.2.4.3 Cross passageways <244m apart
2007 edition 2010 edition	6.2.2.2.1 Maximum distance between exits < 762m	6.2.2.3.2(1) Cross passageways < 244m apart 6.2.2.3.2(2) Cross passageways from the station or tunnel portal <244m
2017 edition	6.3.1.4 Maximum distance between exits	6.3.1.6 (1) Cross passageways

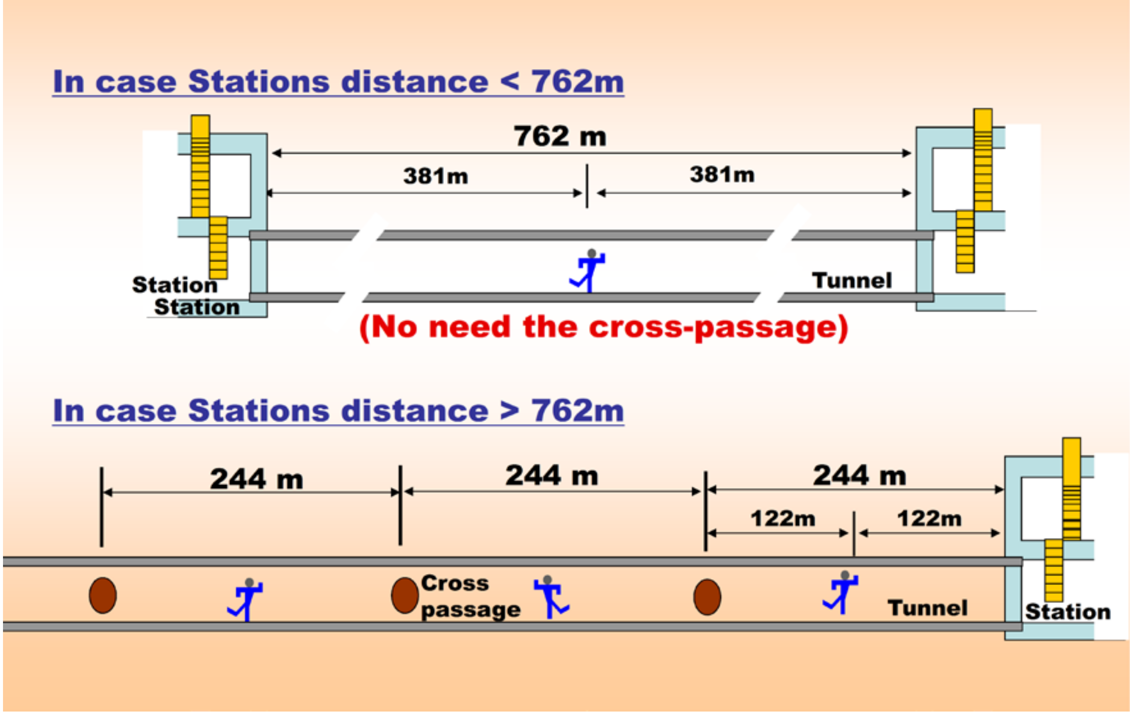
	< 762m	< 244m apart 6.3.1.6 (2) Cross passageways from the station or tunnel portal <244m

Source: Summarized by study team based on NFPA130 1997, 2000, 2003, 2007, 2010 and 2017 edition



Source: Study team

Figure 6.1.3-1 NFPA130 1997 Edition



Source: Study team

Figure 6.1.3-2 NFPA130 2010&2017 Edition

(3) Considerations and Recommendations

It is often described differences between Article 29 of MLIT and NFPA130 as just focusing on the presence of cross passageways and concluded that NFPA130 is safer standard compared to Article 29 of MLIT.

However, since NFPA 130 is overall standard for railway fire protection and therefore it is described less information regarding station equipment compared with Article 29 of MLIT. For instance, it is not mentioned about emergency exit signs and less information for smoke control equipment, although Article 29 of MLIT describes details of these issues.

It should be noted again that both standards are different design philosophies as mentioned in (1) Comparison between Article 29 of MLIT and NFPA 130. Hence, it should be discussed which standard is adopted considering whole railway system including rolling stocks not focusing on specific items and discuss which standard is superior or safer.

This study recommends adopting excellent Japanese railway system. Therefore, it is highly recommended using the standard for railway fire protection by Article 29 of MLIT.

ANNEXURE-1

STRUCTURED QUESTIONNAIRE AND INVENTORY OF LOSSES

MRT Line				
Station/Depot				
Form No				

MRT Line-1 and 5
Socioeconomic and IOL Survey

Organized by: BCL Associates Ltd.

A. INFORMATION OF HOUSEHOLDS /CBES t

1.	Name of head of HHs /CBEs	t			
2.	Cell No	t			
3.	Father's / Husband's Name	t			
4.	Mother's Name	t			
5.	Sex	t	1. Male	2. Female	3. Third Gender
6.	Holdings Number	t			
7.	Street	t			
8.	Village / Mohalla	t			
9.	Thana/Upazilla	t			
10.	District	t			
11.	Length of Stay	t			
12.	Main Occupation	t			
13.	Caste	t			
14.	Total yearly Income	t			
15.	Total yearly Income	t			
16.	Type of loss	t			

Investigator:_______________ Date t ___________________________

Verified by________________ Date t _____________________

MRT Line
Station/Depot
Form No

B. HOUSEHOLD MEMBERS :

SL. No.	Name of household members	Relation with HHs	Age	Sex	Educational Qualification	Primary Occupation	Location of Job or business	Monthly Income	Vulnerability	Length of Services	Secondary Occupation
01.											
02.											
03.											
04.											
05.											
06.											
07.											
08.											
09.											

C. INFORMATION OF LAND

Sl. No.	Category of land	Total own land (Dec.)	Affected in the Project			Remaining Land (Dec)	Ownership type
			Mouza	Plot No.	Qty. (Dec)		
01.							
02.							
03.							
04.							
05.							
06.							
07.							
08.							

D. LAND USE

i	Existing use of land	:	
ii.	Areas under different land usages, where applicable	:	
iii.	Total and affected area of land with breakdown by usages, if applicable	:	
iv.	Estimate whether the remaining area is viable for continued use	:	
v.	Total area of land by type for compensation purposes		

MRT Line				
Station/Depot				
Form No				

E. NON-TITLE HOLDERS (Squatters)

Sl. No.	Category of Land	Name and address of owners of the land	Nature of use right	Nature of Agreement	Years of used	Rent/month (If rented)	It leases (Years of Leases)	Deposit made by Leases
01.								
02.								
03.								

F. AFFECTED STRUCTURE

SL. No.	Type of Structure	Description of Building materials	Use of structure	Area of structure	Area of structure affected	Unit	Remaining Structure (if any) is viable	Year of structure constructed	Area of building for compensation purposes	Special feature (if any)
01.										
02.										
03.										
04.										
05.										
06.										
07.										

G. UTILITY CONNECTIONS STATUS

Sl No.	Name of utility	Connection(Yes/No.)	Charge/Month	Remarks
01.	Electricity			
02.	Water Supply			
03.	Land Phone			
04.	Sewerage Connection			

H. TREES

SL. No. 01.	Trees	Large		Medium		Small		Sapling		Species of trees (Timber / Fruits bearing)	Average yield of fruit bearing trees	Average yearly income from fruit trees	Name of Owners
		Affected No.	Value	Affected No.	Value	Affected No.	Value	Affected No.	Value				
02.													
03.													

MRT Line				
Station/Depot				
Form No				

04.													
05.													

I. INFORMATION ON AFFECTED BUSINESS

SL. No.	Type of Business Affected	Owner's of Business	Business Registration	Yearly Income from Business	Average monthly expenditure	Number of Permanent Employee	Number of Temporary Employees	Income reported for Income Tax	Whether Business needs to be relocation
01.									
02.									
03.									
04.									
05.									
06.									

J. EMPLOYEE AFFECTED IN THE BUSINESS

SL. No.	Name of Employee	Designation	Nature of work	Type of employment (Permanent / Temporary)	Monthly Salary
01.					
02.					
03.					
04.					
05.					
06.					
07.					

K. PREFERENCE FOR RELOCATION

SL. No.	Need of Relocation or Reorganization (Yes /No)	Mode of Compensation for Affected land (Cash / Kind)	Mode of Compensation for Affected land (Cash / Kind)	Preference type of assistance for income rehabilitation
01.				
02.				
03.				

MRT Line				
Station/Depot				
Form No				

04.				

L. HOUSEHOLD LOAN AND SAVINGS

Sources of Loan (if / any)		Amount (Tk.) of Savings (if any)	
	Amount (Tk.)		Remarks
Bank			
Friends			
Relatives			
Others			
Total		Total	

M. CHOISE OF OCCUPATIONAL AND LIVELIHOOD RESTORATION PATTERNS

Name of Household members	Present Occupation	Option of training for livelihood restoration

N. USE OF COMMON PROPERTY RESOURCES

Access to electricity (Yes /No)	Sources of water Supply	Sanitation facilities	Distance of Educational Institution	Distance of Health Centre	Distance of market

MRT Line				
Station/Depot				
Form No				

O. AVAILABILITY OF SOCIAL ORGANIZATION :

Sl. No.	Type of Social Organization	Availability (Yes/No.	Distance
1.	Mosque		
2.	Temple		
3	Church		
4.	Graveyard		
5.	Others (Specify)		

P. AVAILABILITY OF COMMUNITY ORGANIZATION :

Sl. No.	Type of Community Organization	Availability (Yes/No.	Distance
1.	Clues		
2.	Community Center		
3	Play Ground		
4.	Park		
5.	Others (Spicily)		

Q. INFLUENCE OF LEADERSHIP

1	How your inter-family and social issues are resolved? (Beyond court)		
2	What are your complaints/ problems are resolved through Ward Commissioner /Union Parisad Chairman /Member?		
3	Do the member/Ward Commissioners consult with the local political leader in taking decision to solve your demands? Or the leaders of their own initiative influence the Chairman/Members in taking decision in these respects.	Yes	No
4	Do the Members/Chairman can resolve local problems/complaints of local people independently?	Yes	No

R. ROLE OF WOMEN IN FAMILY AFFAIRS/EMPOWERMENT OF WOMEN

1	1. Can the women place their opinions in financial/social/ religions matters to their husbands?	Yes	No
1.1	If, Yes, then are their opinions effective in decision making?	Yes	No
2	Do the women preserve the income or earned money of the family?	Yes	No
2.1	If yes, then can the women expend money from the family income to meet daily necessities?	Yes	No
3	Do their opinions get importance in expending money for the family or in implementation of other matters?	Yes	No
4	Are the opinions of the women are accepted in respect of family matters (including financial matters)?	Yes	No

MRT Line			
Station/Depot			
Form No			

5	Do the women can spend their earned money without the consent of their husbands?	Yes	No
6	Are the opinions of the women given due importance in taking family planning?	Yes	No
7	Do the women can preserve or use the sail proceeds of their own properties?	Yes	No
8	If any property is purchased with the income of the family, in that case whether the property is registered in the name of wife or both wife and husband?	Yes	No
9	Is there any disparity in getting education /higher education between male and female members of the family?	Yes	No
10	Are they daughters given marriage in appropriate age as per law?	Yes	No
11	Are the family members conscious of procreation health of female child?	Yes	No

Signature and Name of Interviewee

ANNEXURE-2

STRUCTURED QUESTIONNAIRE FOR SURVEYS FOR PROPERTY VALUATION AND OTHER ASSETS

Area No. ☐

Form No. ☐☐☐☐☐

Mass Rapid Transit Line 1 and 5 (MRT 1 and 5)

Dhaka Transport Coordination Authority (DTCA)

Land valuation Survey Form

Only for land affected Mouza

1. Identity of Respondent

Name ____

Name of Father/Husband______________________________,**Occupation**_______________

Village:____, **P.S:**_____________________________,

2| Have you purchased land during last one year? **Yes** ☐ No ☐
If answer is yes:

a) Date________________________

b) Location of land (Mouza, Plot No.) and Category__________

c) Amount of land (Decimal) d) Purchase value of land (Except stamp and other expenditure)

3| Have you sold any land during last one year? **Yes** ☐ No ☐
If answer is yes:

a) Date________________________

b) Location of land (Mouza, Plot No.) and Category__________

c) Amount of land (Decimal) d) Sale value of land (Except stamp and other expenditure)

4| What are the market price of different category of land mentioned below according to your knowledge?

Sl#	Description of categories	Location of land (Mouza)	Current market price (Per decimal)	Comments
1.	Homestead			
2.	**Vita/High land**			
3.	**Single crop**			
4.	**Double crop**			
5.	**Multi crop**			
6.	**Orchard**			
7.	**Pond (Under cultivated)**			
8.	**Pond (Non cultivated)**			
9.	**Fallow land**			
10.	**Road**			
11.	Nayanjuli			
12.	**Others(Please mention)**			

Name & Signature of Respondent____

Area No. ☐

Form No. ☐☐☐☐☐

Mass Rapid Transit Line 1 and 5 (MRT 1 and 5)

Dhaka Transport Coordination Authority (DTCA)

Tree Valuation Survey Form

What are the present market prices of the following trees according to your knowledge?

Sl#	Name of tree	Market price of tree (as per age)				Comments
		Big	Medium	Small	Sapling	
1.	**Mango**					
2.	**Jackfruit**					
3.	**Black berry**					
4.	**Litchi**					
5.	**Guava**					
6.	**Tamarind**					
7.	**Koroi**					
8.	**Segun**					
9.	**Mehagini**					
10.	**Neem**					
11.	**Paya**					
12.	**Debdaru**					
13.	**Silk cotton plant**					
14.	**Rain tree**					
15.	**Akasmoni**					
16.	**Baynna**					
17.	**Krishnachura**					
18.	**Ucapliptus**					
19.	**Banana**					
20.	**Marmeloes**					
21.	**Hog plum**					
22.	**Bamboo**					
23.						
24.						
25.						
26.						
27.						
28.						

Name & Signature of Respondent____

Area No.					
Form No.					

Mass Rapid Transit Line 1 and 5 (MRT 1 and 5)

Dhaka Transport Coordination Authority (DTCA)

Structure Replacement Value Survey Form

SL	**Particular of Structure**			**Measurement of Structure**		Replacement value	Comments
	Roof	Fence	Floor	Quantity	Code*		
1	**Pucca**	**Pucca**	**Pucca**				
2	**Pucca**	**Pucca**	**Pucca**				
3	**Tin**	**Pucca**	**Pucca**				
4	**Tin**	**Pucca**	**Pucca**				
5	**Tin**	**Tin**	**Pucca**				
6	**Tin**	**Tin**	**Pucca**				
7	**Tin**	**Soil**	**Katcha**				
8	**Tin**	**Straw**	**Katcha**				
9	**Straw**	**Straw**	**Katcha**				
10	**Straw**	**Soil**	**Katcha**				
11							
12							
13	**Latrine (Katcha)**						
14	**Latrine (Slab)**						
15	**Latrine (Pucca)**						
16	**Tubewell**						
17	**Draw well**						
18	**Well**						
19	**Drain**						
20	**Fencing by straw**						
21	**Fencing by Tin**						
22	**Boundary Wall (Brick) “**						

*Infrastructure Unit Code **1. Sft, 2. Rft 3.Cft 4. Number**

Name & Signature of Respondent ____

ANNEXURE-3

REPUBLIC ACT NO 10752 OF PHILIPPINES AND “CIRCULAR37/2014/TT-BGTVT REGULATING ON PROTECTION AREA OF WORKS, SAFETY CORRIDOR OF URBAN RAILWAY TRANSPORTATION（1ST OF NOVEMBER, 2014）”IN VIETNAM.

Annex Ⅲ - Republic Act No 10752 of Philippines and "Circular37/2014/TT-BGTVT Regulating on Protection Area of Works, Safety Corridor of Urban Railway Transportation（1st of November, 2014）"in Vietnam.

The followings are extracted from the Republic Act No. 10752", "Implementing Rules and Regulations of Republic Act (IRR) 10752, An Act Facilitating the Acquisition of Right-of-Way, Site or Relocation for National Government Infrastructure Projects" in Philippine, and "Circular37/2014/TT-BGTVT Regulating on Protection Area of Works, Safety Corridor of Urban Railway Transportation（1st of November, 2014）"in Vietnam.

In Philippine

Section 4 of the Republic Act: Modes of Acquiring Real Property

The Government may acquire real property needed as right-of-way sire or location for any national government infrastructure project through donation, negotiated sale, expropriation, or any other mode of acquisition as provided by law.

In case of lands granted through Commonwealth Act No. 141, as amended, otherwise known as "The Public Land Act", the implementing agency shall:

(a) Follow the other modes of acquisition enumerated in the Act, if the landowner is not patent holder and any previous acquisition of said land is not through a gratuitous title; or

(b) The implementation agency may utilize donation or similar mode of acquisition if the landowner is a government-owned or government-controlled corporation.

When it is necessary to build, construct, or install on the subsurface or subterranean portion of private and government lands owed, occupied, or leased by other persons, such infrastructure as subways, tunnels, underpasses, waterways, floodways, or utility facilities as part of the government or any of its authorized representatives shall not be prevented from entry into and use of the subsurface or subterranean portions of such private and government lands by surface owners or occupants, if such entry and use are made more than fifty (50) meters from the surface.

Section 11 of the IRR: Acquisition of Subsurface Right-of-Way

As provided in Section 4 of the Act, when it is necessary to build, construct, or install on the subsurface or subterranean portion of private and government lands owed, occupied, or leased by other persons, such infrastructure as subways, tunnels, underpasses, waterways, floodways, or utility facilities as part of the government or any of its authorized representatives shall not be prevented from entry into and use of the subsurface or subterranean portions of such private and government lands by surface owners or occupants, if such entry and use are made more than fifty (50) meters from the surface.

The IA shall duly consult with and notify the affected property owners of any acquisition of subsurface right of way needed for the infrastructure projects.

If the national government project involves undrground works within a depth of fifty (50) meters from the surface, the IA may undertake the mode of acquisition in the following order:

(a) Negotiate with the property owner a perpetual easement of RoW for the subterranean portions of his property required by the project; and

(b) Offer to acquire from the property owner the affected portion of the land, including the affected structure, improvements, crops and trees therein in accordance with the provisions of the Act.

To assist the IA in determining (a) the appropriate price offer for perpetual easement of the RoW under Section 11 (a) of this IRR or (b) the appropriate price offer for the entire affected land including structure, improvement, crops and trees under Section 11 (b) of this IRR, the IA may engage the services of a GFI (Government Financial Institutions) or an IPA (Independent Property Appraisers), in accordance with the procedure provided in Section 6 of this IRR. The easement price under Section 11 (a) of this IRR shall be twenty percent (20%) of the market price of the land.

The IA shall follow the other rules for negotiated sale provided in Section 6 of this IRR.

In Vietnam

Item 7 and 8 of Article 3: Interpretation of Terms in Chapter 1: General Provison mention as follows;

Protection Zone means the area surrounding the tunnel to protect railway works in which construction of other works impacting on stability, duration and safety of the urban railway works prohibited.

*Restriction Zone*means the area above and outside the protection zone in which new construction, rehabilitation or improvement of existing buildings must be strictly controlled to avoid any impacts on stability, duration and safety of the urban railway works.

It is illustrated as follows.

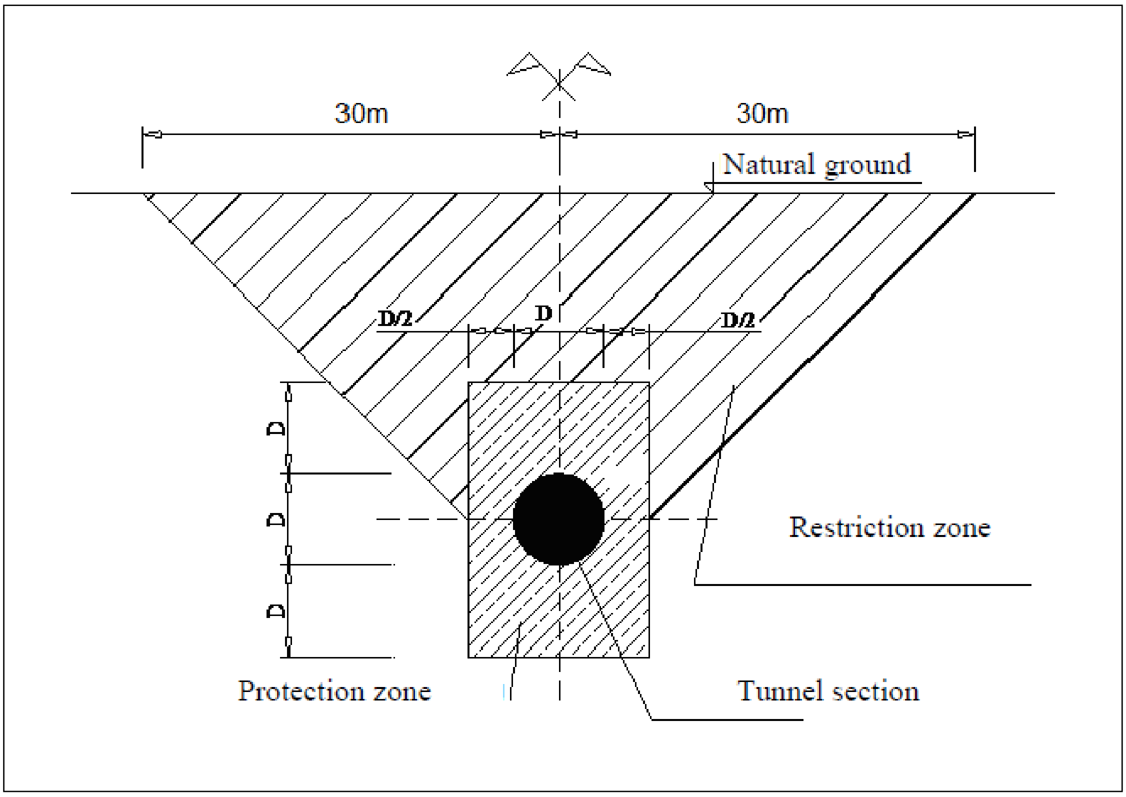


Figure-2 For Round Tunnels

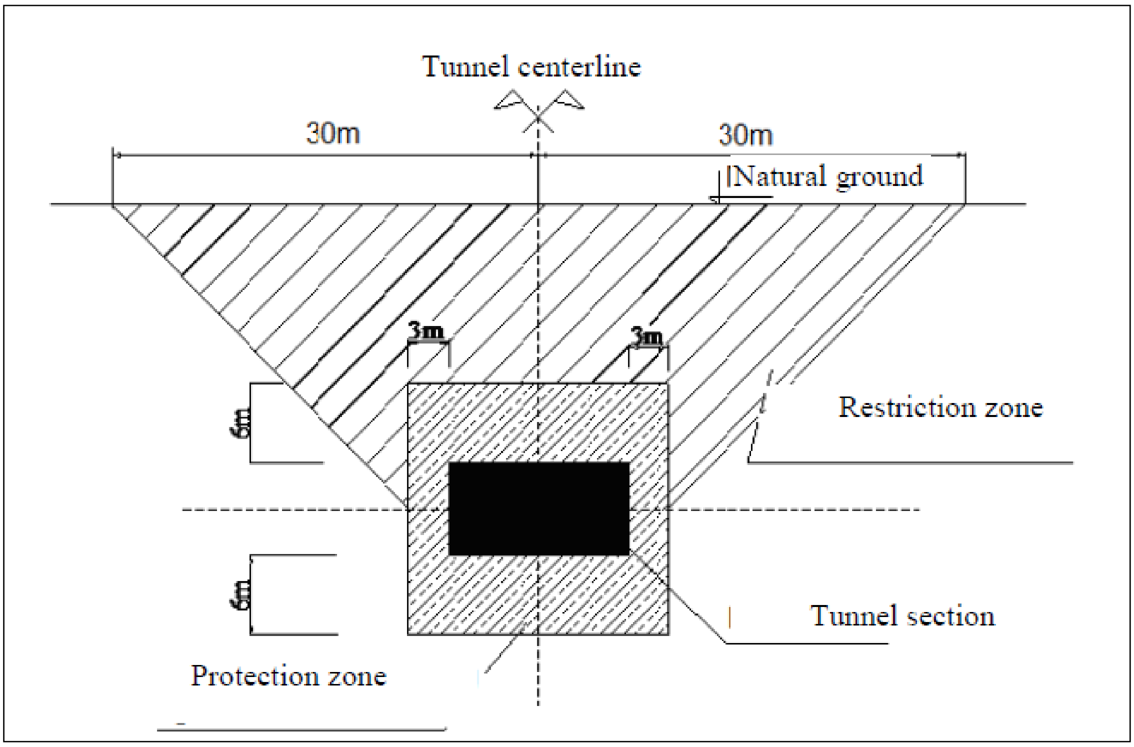


Figure-3 For Square and Rectangular Tunnel

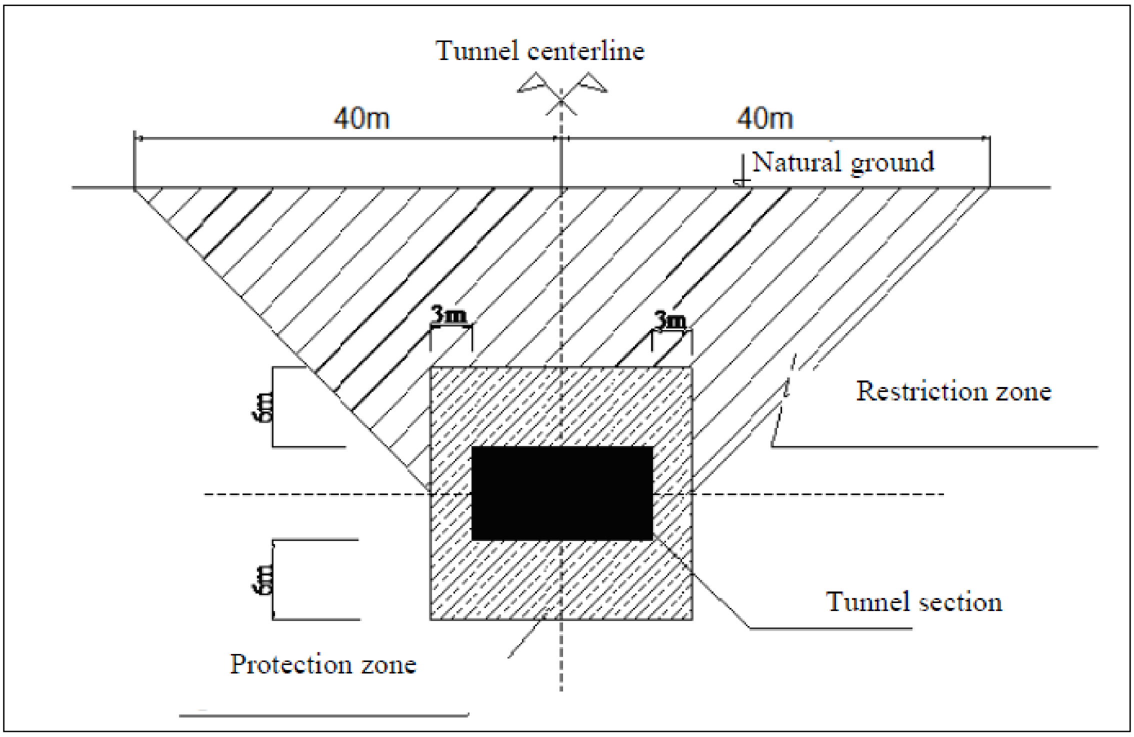


Figure-4 For Underground Station

Estimation on Sub-surface easement is conducted based on the following conditions.

① Compensation is 20% of present market price.

② Outer diameter D=7m

③ Main structure on stations will be built within present RoW excluding lateral protection zone

④ Standard length of station is 300m

For Line 1

	Name of Station	Length（m）	Affected Width（m）	Affected Area（ha）	Market Price（million BDT/ha）	Unit of Compensation（million BDT/ha）	Amount of Compensation（million BDT）
1	Kamalapur	1,000	6	0.6	5,243	1,049	629.16
2	Rajabagh	300	6	0.18	5,243	1,049	188.75
3	Malibagh	300	6	0.18	3,370	674	121.32
4	Rampura	300	6	0.18	1,498	300	53.93
5	Hatir	300	6	0.18	1,648	330	59.33
6	Badda	300	6	0.18	1,648	330	59.33

7	Utta Badda	300	6	0.18	1,648	330	59.33
8	Nortun Bazar	300	6	0.18	2,621	524	94.36
9	Future Park	300	6	0.18	2,996	599	107.86
10	Khilet	300	6	0.18	4,119	824	148.28
11	Airport	1,000	6	0.6	5,243	1,049	629.16
9	Future Park						
		1,000	14	1.4	2,996	599.20	838.88
1'	Bashundhala						
Sub-total							**2,989.68**
Others：20% of the Above							**597.94**
Total							**3,587.61**

For Line 5

	Name of Station	Length（m）	Affected Width（m）	Affected Area（ha）	Market Price（ million BDT/ha）	Unit of Compensation（ million BDT/ha）	Amount of Compensation（million BDT）
1	Gabtoli	300	6	0.18	1,273	255	45.83
		240	14	0.336	1,273	255	85.55
2	Dar-Us-Salam	300	6	0.18	2,996	599	107.86
		120	14	0.168	2,996	599	100.67
3	Mirpur 1	300	6	0.18	3,745	749	134.82
4	Mirpur 10	300	6	0.18	3,745	749	134.82
5	Mirpur 14	300	6	0.18	1,648	330	59.33
6	Kochukhet	300	6	0.18	1,648	330	59.33
		1,350	14	1.89	1,648	330	622.94
7	Banani	300	6	0.18	12,732	2,546	458.35
8	Gulshan 2	300	6	0.18	17,975	3,595	647.10
9	Notun Bazar	300	6	0.18	2,631	526	94.72
Sub-total							**2,551.30**
Others：20% of the Above							**510.26**
Total							**3,061.56**

Total (**3,587.61+3,061.56**)=**6,649.17 million BDT** is estimated as compensation on sub-surface easement.

ANNEXURE-4

TERMS OF REFERENCE FOR RAP IMPLEMENTING AGENCY (IA) (NGO OR CONSULTING FIRM WITH EXPERIENCE ON SOCIAL ISSUES).

Annex-4: TOR for RAP Implementing Agency

Government of the People's Republic of Bangladesh

Dhaka Mass Transit Company (DMTC)

Mass Rapid Transit (MRT) Line 1

TERMS OF REFERENCE FOR RAP IMPLEMENTING NGO (INGO)

1. Introduction

The Government of Bangladesh with the financial loan from Japan International Cooperation Agency (JICA) has undertaken a project in order to alleviate traffic congestion and reduce air pollution in Dhaka City by constructing mass rapid transit system, thereby contributing to the economic and social development of Greater Dhaka Region and of the MRT Line 1 was prioritized as high priority project by Revised Strategic Transport Plan (RSTP) for Dhaka. The length of the MRT line 1 will be 27 km with 19 stations and one depot in Purbachal area. The stations are located both on the surface and underground and there is a depot area. The depot for this MRT line will be constructed in Purbachal and the stations are in Airport, Airport Terminal-3, Khilkhet, Bashundhara, POHS, Mastul, Purbachal West, Purbachal Central, Purbachal Sector-7, Purbachal Terminal, Jamuna Future Park, Notun Bazar, Uttar Badda, Badda, Hatir Jheel, Rampura, Malibag, Rajarbag and Kamalapur. Among these stations seven are on elevated surface and rest twelve are underground.

The average outer diameter of the tunnel is 7m and standard length of station is 300m. The metro tunnels will range from 20m to 50m below the ground in different locations with average dept of 30 meter. In some areas, the tunnels and underground stations will need to pass underneath existing homes and businesses which will restrict the expansion and extension particularly in height for the future construction, extension or utilization of the underground as well as surface of their inhabited area. In these cases DMTC will purchase or compensate the inhabitants (owners) for this imposed restriction. This can be termed as purchasing a subsurface easement from the property owner without affecting the existing infrastructures on the surface. The subsurface area for easement for all the stations depends on the area and location of the stations. The status of these stations and potential area for easement for the tunnel and underground stations and potential affected area for the elevated stations are shown in the Table 1.

Table 1 Status of the Stations and Potential Affected Area for Easement for underground Stations and Potential Affected area for elevated Stations of MRT Line 1

Sl No	Name of the Station	Tunnel passing under the Settlements (Residential and Commercial area)	Status of the Station	Length (m)	Affected Width (m)	Total Affected Area (ha)
				Potential Affected Area for Easement for Underground Stations and Tunnel (length X width= Total Area)		
a)		Future Park -- Basundhara		1,000	14	1.4

1	Kamlapur		Underground	1,000	6	0.60
2	Rajarbag		Underground	300	6	0.18
3	Malibagh		Underground	300	6	0.18
4	Rampura		Underground	300	6	0.18
5	Hatir Jheel		Underground	300	6	0.18
6	Badda		Underground	300	6	0.18
7	Uttar Badda		Underground	300	6	0.18
8	Nortun Bazar		Underground	300	6	0.18
9	Future Park		Underground	300	6	0.18
10	Khilkhet		Underground	300	6	0.18
11	Airport Terminal-3		Underground	300	6	0.18
12	Airport		Underground	1,000	6	0.60
				Potential Affected Area for Elevated Stations (length X width= Total Area)		
13	Basundhara		Elevated	245	25	0.61
14	POSH		Elevated	250	30	0.75
15	Mastul		Elevated	250	30	0.75
16	Purbachal Central		Elevated	250	30	0.75
17	Purbachal West		Elevated	250	30	0.75
18	Purbachal Sector-7		Elevated	250	30	0.75
19	Purbachal Terminal		Elevated	250	30	0.75

This Resettlement Action Plan (RAP) for the project that complies with the Resettlement Framework (RF) prepared, based on relevant national law of the Government of Bangladesh (GoB) Acquisition and Requisition of Immovable Property Ordinance 1982 (ARIPO), amended in 1993 and 1994 and with the policy of the JICA Guidelines for Environmental and Social Considerations and the World Bank OP 4.12. A RAP Implementing NGO (INGO) or Social Consulting Firm i.e. IA will be engaged by Dhaka Mass Transit Company (RAP) for implementation of the RAP.

2. Description of the Project

The project area extends in both Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC) and Rupganj Upazila of Narayanganj district. The users would be able to use other lines like line 1 and line 6 through junction facilities Total length of the MRT line 1 is 27 Km with one depot in Purbachal in Rupganj Upazila. There are 19 stations and seven of them will be on the surface and rest will be underground. The project needs to acquire 18.78 hectare of private land, mainly for the depot are and 4.82 ha of land will be needed for subsurface easement. Rest of the components will be mostly on the government land along the existing road network of the city. However, it is estimated that additional 0.23 ha of land will be required in different pockets along the route, mainly in the station areas. A total of 525 people in 115 (PAUs) that include HHs, CBEs and CPRs have been identified in the RoW of the project to be affected

.

3. SCOPE OF WORK- GENERAL

The general scope of work shall include i) dissemination of information as described in the policy framework regarding RAP implementation procedure; ii) conducting public consultations, iii) assisting Project Directors and his/her staff in implementation of the Resettlement Action Plan (RAP) and iv) maintain close co-ordination with National Resettlement Specialist (NRS)& RAP (Executing Agency) staff. Displacement and other impacts due to the project are shown in the table below-

Table 2 Displacement of PAHs and Impacts by Location

Station Name	**Location wise Number of PAHs**						**Total**
	Loss of Residence	**Loss of Business**	**Loss of Business and Residence**	**Loss of Residence by Rented**	**Vendors on Govt. land**	**Others**	
Airport	0	0	0	0	0	0	**00**
Airport Terminal-3	0	0	0	0	0	0	**00**
Khilkhet	0	0	0	0	1	0	**01**
Basundhara	0	4	0	0	0	0	**04**
POHS	0	0	0	0	0	0	**00**
Mastul	0	0	0	0	0	0	**00**
Purbachal West	0	0	0	0	0	0	**00**
Purbachal Central	0	1	0	0	16	0	**17**
Purbachal Sector-7	0	0	0	0	0	0	**00**
Purbachal Terminal	0	14	0	0	0	0	**14**
Depot Area	0	0	0	0	0	0	**00**
Jamuna Future Park	1	2	0	1	3	0	**07**
Notun Bazar	0	4	0	0	1	0	**05**
Uttar badda	1	2	0	0	0	0	**03**
Badda	0	5	0	2	1	1	**09**
Hatir Jheel	0	4	0	0	0	1	**05**
Rampura	4	18	1	0	1	0	**24**
Malibag	1	10	0	0	1	0	**12**
Rajarbag	1	2	0	0	2	0	**05**
Kamalpur	0	6	0	0	3	0	**09**
Total	**08**	**72**	**1**	**3**	**29**	**02**	**115**

A list of the affected households with demographic and socioeconomic information will be provided to the implanting agency (IA) by RAP.

Key implementation issues in the delivery of the tasks includes: (i) consultation and stakeholder participation; (ii) dissemination of relevant information; (iii) assisting executing agency (RAP) in payment of compensation and other resettlement grants (iv) assisting affected persons (APs) in the process of resettlement.

4. SCOPE OF WORK- SPECIFIC TASKS

4.1 Information Campaign: The consultant will design, plan and implement an information campaign in the affected areas to facilitate the implementation of RAP. The campaign would include measures such as distribution of information booklets, leaflets, notices and other materials among the APs, carrying out community meetings, public announcements and any other measures necessary to provide information to all APs in the project area. The consultant will assist the APs during pre and post relocation period. The IA staff will also assist APs, where necessary, in preparing grievance redress cases for consideration by the GRCs. Assistance to DMTC in payment of Resettlement Benefits to APs. The selected Implementing agency will be responsible to assist DMTC in processing entitlements for the APs and making payment of resettlement benefits to them. The IA will compile and process data and develop & operate a menu driven computerized Management Information System (MIS) for preparation of entitled persons file and entitlement card for EPs.

4.2 Identification of Entitled Persons: Consult census/survey data and prepare final list of affected households, commercial business enterprises and community establishment now staying within the ROW from the list.

4.3 Assistance to APs during relocation: The IA will assist the APs during pre and post relocation period in close coordination with Resettlement Advisory Committee (RAC) and DMTC

4.4 Assistance to DMTC in Payment of Resettlement Benefits to APs: The selected Agency will assist DMTC in processing entitlements for the APs and making payment of resettlement benefits to them. The Agency will compile and process data and develop & operate a menu driven computerized Management Information System (MIS). The IA will prepare Entitled Person (EP) files with type and quantity wise losses and Entitlement Card (EC) mentioning amount of compensation/benefits for each of the EPs and prepare Indent mentioning category wise amount of compensation /benefits. The indent would be approved by the Project Director before making payment. The IA will prepare payment debit voucher on behalf of DMTC and assist DMTC in preparing Measurement Book. The debit voucher will be signed jointly by IA and EA representative and the cheque will be signed by IA and be issued in public place in presence of LGI representatives. The DMTC will place fund with Implementing Agency for making payment and the IA will submit vouchers with other documents on regular basis to the Project Director after making payment.

5. RAP Implementation Schedule and Tasks

The implementation of the RAP is scheduled to start from 1st January 2020 and expected to be completed by 31st December 2024. The IA will be deployed for a period of 60 (sixty) months and will be responsible to implement all resettlement activities stated in the TOR. The Project Director, in consultation with the National Resettlement Specialist (NRS) of the CSC will provide time schedule as per the requirement of the resettlement program. The Implementing Agency will assist DMTC but not necessarily limited to the following:

5.1 Information Campaign and RAP Disclosure: The IA will carry out consultation regarding policies and options and collection of legal documents required to claim compensation. Property owners require being advised/helped to gather all required documents. The affected people will be made aware of the GRC procedures for disputes over claims.

5.2 Disbursement of Compensation: Payment of compensation to titled and non-titled owners will be processed and paid by DMTC through implementing agency with assistance from NRS of the CSC. The Resettlement Specialist will supervise and monitor the process and the IA will keep record of the payments and report to the DMTC on monthly basis.

5.3 Notice for Encumbrance Free: Written notice will be given to individual affected persons at completion of payment of all compensation/entitlement from DMTC. The DMTC will keep records of issuance date of notice for making ROW encumbrance free signed by both DMTC and EPs.

5.4 Taking-over and handing-over sites: The IA will assist DMTC take-over acquired land from DC office and then hand-over to contractors. Contractors will move into sites the day following expiration of the encumbrance free notice.

6. Major Activities to be performed by Implementing Agency

The selected Agency will assist DMTC in implementing successfully all stipulations agreed in the RAP in their entirety, fairly and transparently. In this context, the major functions to be performed by the Implementing Agency are:

A: Information dissemination and feedback:

(i) Ensure dissemination of the project and resettlement policy related information to the project-affected persons and others (community groups, local administration, etc.) that might be considered instrumental in the effective and transparent implementation of the RAP. Even though the RAP recommends some dissemination mechanisms, the IA can suggest more in the process of its implementation and would gather information and disseminate it upward to the project authority.

(ii) During implementation of the project, extensive consultation and collaboration with key stakeholders on a continued basis is planned. The selected IA will be required to assist DMTC in organizing such consultation programs and facilitate consultation with local government representatives, local leaders, etc.

B. Assisting APs in resettlement process:

(i) The main purpose is to make the APs and entitled persons (EPs) aware of the project goals, importance, GRC procedures, compensation entitlement and receiving procedures, etc. Some of the major activities are: (a) Inform the EPs about the documents required for claiming compensation from DC office & resettlement benefit from DMTC (b) checking with the APs to make sure that they have all the required documents to claim compensation from DC and DMTC (c) whether or not there are usufruct rights of others on the properties within ROW and informing the people with such rights about the compensation policies.

(ii) Inform the AP households, especially the vulnerable ones, about the “compensation in cash and/or kind” option stipulated in the RAP and ensure fulfillment of the choices made by them.

(iii) Counseling and helping the households, whose previous incomes have been seriously affected, to find alternative source of income.

C. Grievances redress procedure

The selected IA will play vital role in the grievance redress process. The most important preconditions for doing this with maximum effectiveness are that the IA operatives will build personal rapport and confidence with the APs and will be fully aware of all socioeconomic problems/issues arising from the project. Among other things, the IA will:

(i) Ensure that the APs are fully aware of the grievance redress procedure and the process of bringing their complaints to the grievance redress committees (GRCs).

(ii) Assist the APs in any usual manner (e.g., preparing applications, accompanying them to the hearing and explaining the grievance to the GRCs and the like) to bring the complaints to the committee.

(iii) Impartially investigate the veracity of the complaints and try to settle them amicably, fairly and transparently before they go to the redress committee or the courts of law.

(iv) For more focused work in this area, the IA will prepare a list of problem cases in implementation of RAP. In doing so, the IA will pay special attention to the problems and needs of the vulnerable APs and recommend to the DMTC with probable mitigation measures.

D. Information management

The selected IA will collect computerized Census and SES data related to the pre-acquisition condition of the AP households and the nature and magnitude of all categories of losses as well as the compensation thereof determined by DMTC. All essential information will have to be generated by using one or more menu-driven MIS. Among other things, the IA will:

(i) Collect CCL from the DC office and prepare statement for assessing additional payment on the basis of quantity of affected properties and RAP PVAC rate.

(ii) Collect and computerize all information related to different types of payments and additional supports provided to the entitled person (EP) and update the EP file and EC.

(iii) Prepare ‘entitlement card’ for the individual EPs as per their types of losses and the amount of compensation due for each type of loss from legal title and the amount of additional compensation/resettlement benefits if any, to be paid by DMTC through IA.

(iv) Record and maintain details of the issues/disputes causing delay in the disbursement/receipt of compensation and the persons involved in them, including the cases brought to the courts of law, if there is any.

(v) Document information on the cases, with reasons, brought to and resolved by the GRC, with decisions going in favor of or against the complainants.

(vi) Collect and maintain relocation information on the homestead losers by categories of EP households such as legal owners, squatters, tenants and others.

E. Progress reports

The RAP requires that all APs are paid the stipulated compensations/entitlements before they are evicted from the properties and/or construction work begins. The selected IA will provide DMTC weekly report on the progress in RAP implementation, including any issue that might be hindering progress, separately for each bridge. The report will be brief consisting of both quantitative and qualitative information on:

(i) The IA in its report should reflect the status of total number of EPs identified by DC for compensation and progress of payment in a particular period and resettlement benefits paid against DC’s payment and other benefits as per RAP policy by zones and EP categories.

(ii) Number of focus groups formed and meeting held with the affected persons with issues discussed.

(iii) Number of vulnerable affected households male headed and female headed have received cheques and be deployed in project civil works according to their eligibility.

(iv) Number of cases received by the Grievance Redress Committee indicating the types of grievance made in favor of or against the complainants.

(v) Any other issues that are relevant to implementing the policies stipulated in the RAP.

F. Staff requirements

The IA is free to determine the number of members to be working in the team. A bar chart shall indicate the proposed timing of their input. The team members shall meet the following criteria:

(i) The Team Leader (Resettlement Specialist) is the spokesman for the Implementing Agency. He/she shall hold Masters in Social Science and have at least 10 years of relevant experience in implementation of RAP, report writing etc. He shall have conducted at least 5 trainings/ workshops in Resettlement Issues, and must be fluent in English.

(ii) The Deputy Team Leader (Resettlement Expert) will assist Team Leader in RAP Implementation process. He shall hold Masters in Social Science and have at least 10 years of relevant experience in implementation of RAP. He shall have conducted at least 5 trainings/ workshops in Resettlement Issues, and must be fluent in English.

(iii) MIS specialist shall hold a degree in Statistics, Mathematics or Computer Science having more than 10 years of relevant experience in Resettlement tools (EP/EC), and be fluent in English.

(iv) Gender and livelihood development specialist will have at least masters in any discipline with 7 years experience in the relevant field.

(v) Area Manager shall hold Masters in Social Science and have at least 5 years of relevant experience in implementation of RAP. He shall have conducted at least 3 trainings/ workshops in Resettlement Issues, and must be fluent in English.

(vi) Enumerators shall be graduates with at least two years relevant experience

G. Implementing Agency selection criteria:

The Implementing Agency should have registration with concern Authorities and experience in implementation of Resettlement Action Plan. The IA will be selected through quality and cost based selection method.

H. Implementation arrangements

The Implementing Agency has to keep office near the concerned locality (more than one in each zone) during the time of implementation of the RAP in order to ease contact with the APs, the cost of which will be specified in the budget.

The IA will make its own transport arrangements, which will be reflected in the budget.

The Project Director

Mass Rapid Transit (MRT) Line 5

Dhaka Mass Transit Company (DMTC)

Dhaka

ANNEXURE-5

TERMS OF REFERENCE (TOR) OF THE EXTERNAL MONITORING AGENCY (EMA)

Annex-5

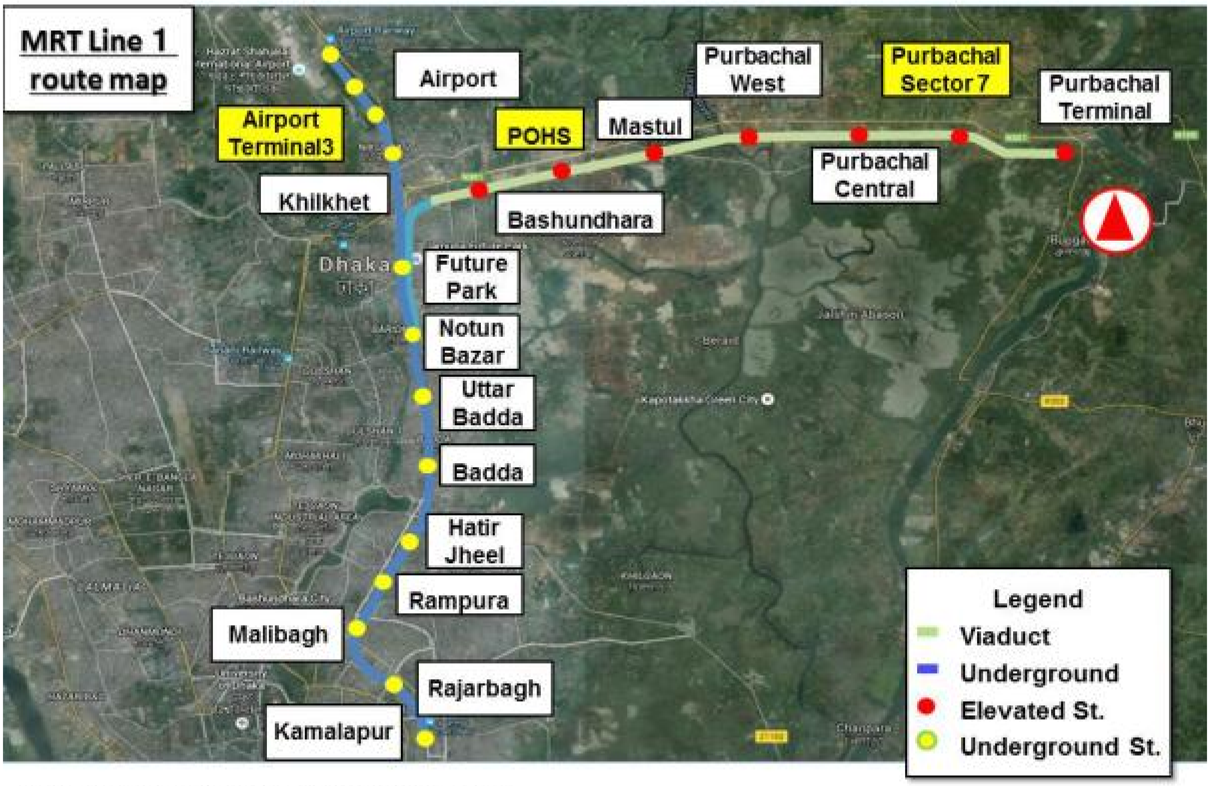
Terms of Reference of the External Monitoring Agency (EMA)

A. Project Background

The Government of Bangladesh with the financial loan from Japan International Cooperation Agency (JICA) has undertaken a project in order to alleviate traffic congestion and reduce air pollution in the Dhaka City by constructing environment friendly mass rapid transit system, thereby contributing to the economic and social development of Greater Dhaka Region and the MRT Line 1 was prioritized as the high priority project by Strategic Transport Plan (RSTP) for Dhaka.

The Resettlement Action Plan (RAP) for the project has been prepared in compliance with the Resettlement Framework (RF) prepared based on relevant national GoB Law with the policy of the JICA Guidelines for Environmental and Social Considerations and World Bank OP 4.12. A RAP Implementing NGO (INGO) or Social Consulting Firm i.e. IA will be engaged by Dhaka Mass Transit Company (DMTC) for implementation of the RAP.

The length of the MRT line 1 will be 27 km with 19 stations and one depot area. The stations are located both on the surface and underground and there will be one a depot area. The depot for this MRT line will be constructed in Purbachal. The average depth of metro tunnels will be 30 meter. In some areas, the tunnels will pass underneath existing homes and businesses and will restrict the vertical expansion for future construction, extension or utilization. In these cases DMTC will purchase or compensate the owners for this imposed restrictions. This can be termed as purchasing a subsurface easement from the property owner without affecting the existing infrastructures on the surface.



Yellow: 3 Additional Stations after Pre FS

Figure-1: Location of the Project

B. Key Objective of External Monitoring

Monitoring involves the collection and analysis of data on resettlement activities with the applying accruing information. Monitoring allows project participants to keep track of resettlement activities, to determine whether resettlement objectives are being achieved, and to make whatever changes are necessary to improve resettlement performance.

Evaluation is an assessment of resettlement performance and results in light of stated the objectives. Evaluation for purposes of the RAP is proposed to include a participatory component allowing the project participants to comment on their experience of the project. To be successful, monitoring and evaluation begins with clear resettlement design followed by identification and elaboration of appropriate criteria and indicators.

Indicators and Means for Verification

Indicators form the key elements of any monitoring and evaluation system. Indicators also make possible the comparison of inputs with the completion of outputs and achievement of objectives and goals, thus providing the basis for performance evaluation. Following indicators have been formulated to facilitate monitoring of Progress, Outputs, Effects, Impacts and Compliance in implementing the resettlement.

(1) Progress/Output Monitoring

Deliverables (outputs) have been clearly outlined in the Entitlement Matrix and the Assets Register which will form the basis for payment of compensation. Progress will be monitored on the basis of periodic outputs as per the Implementation Schedule, Annual Work Plan and Project Implementation Manual while outputs will be monitored on the basis of actual number of APs compensated.
Output monitoring will be reported through periodic reports produced by the PIU.

(2) Effect Monitoring

This will be used to measure the extent to which the immediate objectives have been achieved and give an idea of the results emanating from implementing the RAP e.g., percentage of APs now accessing better housing or improved livelihoods on account of being successfully resettled.

(3) Impact Monitoring

This is the process through which, assessment of the overall achievement of the resettlement goal will be made. Specifically, this is the system that will generate data to gauge success towards implementation of this RAP in terms of impact of the resettlement on the APs. The basis for impact monitoring is the baseline social-economic survey data against which the wellbeing of APs will be compared.

The EMA will review implementation process as per set policies in the RAP and assess the achievement of resettlement objectives, the changes in living standards and livelihoods, restoration of the economic and social base of the affected people, the effectiveness, impact and sustainability of entitlements, the need for further mitigation measures if any, and to learn strategic lessons for future policy formulation and planning.

Scope of Work

The scope of work of the Independent EMA will include the following tasks:

(1) To review and verify the progress in land acquisition/resettlement implementation of the Project and whether they have been followed as provided in the RAP.
(2) Provide a summary of whether involuntary resettlement was implemented (a) in accordance with the RAP, and (b) in accordance with the stated policy.
(3) Verify expenditure & adequacy of budget for resettlement activities.
(4) Describe any outstanding actions that are required to bring the resettlement activities in line with RAP. Describe further mitigation measures needed to meet the needs of any affected person or families judged and/or perceiving themselves to be worse off as a result of the Project. Provide a timetable and define budget requirements for these supplementary mitigation measures.
(5) Describe any lessons learned that might be useful in developing the new national resettlement policy and legal/institutional framework for involuntary resettlement.

(6) To Identify, quantify, and qualify the types of conflicts and grievances reported and resolved and assess whether the consultation and participation procedures followed in accordance with the RAP.
(7) To identify the strengths and weaknesses of the land acquisition/resettlement objectives and approaches, implementation strategies.
(8) Identification of the categories of impacts and evaluation of the quality and timeliness of delivering entitlements (compensation and rehabilitation measures) for each category and how the entitlements were used and their impact and adequacy to meet the specified objectives of the plans. The quality and timeliness of delivering entitlements, and the sufficiency of entitlements as per approved policy.
(9) To review the quality and suitability of the relocation sites from the perspective of the both affected and host communities.
(10) Review results of internal monitoring and verify claims through sampling check at the field level to assess whether land acquisition/resettlement objectives have been generally met. Involve the affected people and community groups in assessing the impact of land acquisition for monitoring and evaluation purposes.
(11) To monitor and assess the adequacy and effectiveness of the consultative process with affected APs, particularly those vulnerable, including the adequacy and effectiveness of grievance procedures and legal redress available to the affected parties, and dissemination of information about these.

C. Methodology and Approach

The general approach to be used is to monitor activities and evaluate impacts ensuring participation of all stakeholders especially women and vulnerable groups. Monitoring tools should include both quantitative and qualitative methods. The external monitor should reach out to cover:

(1) 100% APs who had property, assets, incomes and activities severely affected by Project works and had to relocate either to resettlement sites or who chose to self-relocate, or whose source of income was severely affected.
(2) 10% of persons who had property, assets, incomes and activities marginally affected by project works and did not have to relocate;
(3) 10% of those affected by off-site project activities by contractors and sub-contractors including employment, use of land for contractor's camps, pollution, public health etc.;

D. Other Stakeholders and their Responsibility

1. Dhaka Mass Transit Company(DMTC):

Dhaka Mass Transit Company (DMTC), for the Project, a Project Implementation Unit (PIU) headed by a Project Director (PD), at the project office will be established, that will be responsible for the overall execution of the Project. The PIU will consist of two units namely Engineering Service Unit (ESU) and Resettlement Unit (RU) for total implementation of the project. The PD will work on deputation from DMTC at the level of Superintending Engineer or Additional Chief Engineer. The project will be overseeing by the PD, DMTC. One implementation committee will be formed to provide overall guidelines and cooperation for project implementation and keep liaison with various stakeholders including Donor, different government organizations and other relevant agencies.

(1) Acquire, hold, manage and dispose of land and other property to private sector developers, to carry out the planning, engineering, design, construction, marketing, sales and other operations under the regulations of master plan
(2) Execute works in connection with the utilization of infrastructure such as supply and discharge of water, electricity, transportation and other services and amenities and generally to do anything necessary or expedient for purposes of such development and for purposes incidental thereto, provided that save as provided in this Act, nothing contained in this Act shall be construed as authorizing the disregard by the Authority of any law for the time being in force.
(3) Lead, monitor and evaluate the implementation of the project.

2. I-NGO/IA:

DMTC has selected an experienced I-NGO/IA for implementation of the RAP in the field level in coordination with the DC, DMTC and consultants. The I-NGO/IA has engaged in to assist the supervision consultant for updating of RAP during detailed design phase and implemented the RAP. The tasks of the I-NGO are to:

(1) Verify results of internal monitoring;
(2) Assess whether resettlement objectives have been met; specifically, whether
(3) Livelihoods and living standards have been restored or enhanced;
(4) Assess resettlement efficiency, effectiveness, impact and sustainability, drawing
(5) Lessons as a guide to future resettlement policy making and planning; and
(6) Ascertain whether the resettlement entitlements were appropriate to meeting the objectives, and whether the objectives were suited to AP conditions.
(7) Undertake any other assessment relevant to the resettlement process.

E. Team Composition of the EMA

Table-1 Team composition and qualifications

Position/expertise	Qualification and experience
1.TeamLeader/ Resettlement Expert	Masters in Social science/Environmental Sciences with 10 years working background in planning, implementation and monitoring of involuntary resettlement for infrastructure projects. Experience in institutional capacity analysis and implementation arrangement for preparation and implementation of resettlement plans, and knowledge in latest social safeguard policies of the international development financing institutions in Bangladesh
2. Social Impact Specialist/Anthropology	Masters in Social science /Environmental Sciences with 5 years working experience in social impact assessment including census and socio-economic surveys, stakeholders' consultation, and analysing social impacts to identify mitigation measures in compliance with social safeguard policies of the international development financing institutions and national legislations. Experience of preparing resettlement framework and action plans and implementation of plans for externally financed projects is essential.
3. Data Analyst	Graduate with working experience and knowledge of software, preferably relational, those are most commonly used in Bangladesh; demonstrated ability to design and implement automated management information system (MIS) for monitoring progress, comparing targets with achieved progress and the procedural steps

F. Time Frame and Reporting

External monitoring of the RAP will be undertaken alongside that of other project components. EMA will take place as follows:

(1) Time Frame

(4) **Baseline Monitoring**

The monitoring shall be applied within three months of contract date. For this, suitable baseline indicators related to income, assets, land ownership, expenditure pattern of key activities, housing conditions, access to basic amenities, demographic characteristics, indebtedness, etc. shall be applied.

(5) **Midterm Monitoring**

The project will undergo for four (4) years to accomplish the construction of underground tunnel, viaduct and stations. Midterm monitoring will be undertaken 6 months and 18 months to determine whether the Resettlement Process is both on track and on schedule, and Midterm monitoring shall be necessary to review project goals, objectives and even strategies towards enhancing delivery of resettlement assistance to APs. Midterm monitoring will also screen the project for emerging concerns/ impacts not anticipating in the design stage and hence allow for early resolution. Conditions and modalities for midterm monitoring are mirrored in the Post Project Monitoring briefly discussed below.

(6) **Post Project Monitoring:**

In order to determine final impacts of the resettlement activity, a final evaluation cum an impact assessment will be undertaken 40 months after conclusion of resettlement to evaluate whether the intended objectives were realised.

The monitoring reports should be submitted to DMTC and concerned parties with critical analysis of the achievement of the program and performance of DMTC and I-NGO/IA.

(2) Reporting

The reports shall provide monitoring and evaluation report covering the following aspects:

- Whether the resettlement activities have been completed as planned and budgeted;
- The extent to which the specific objectives and the expected outcomes/results have been achieved and the factors affecting their achievement or non-achievement;
- The extent to which the overall objective of the Resettlement Plan, pre project or improved social and economic status, livelihood status, have been achieved and the reasons for achievement / non achievement;
- Major areas of improvement and key risk factors;
- Major lessons learnt; and
- Recommendations.

Formats for collection and presentation of monitoring data will be designed in consultation with DMTC consultant's resettlement specialist.

G. Qualification of the Independent External Monitoring Agency

The I-EMA will have at least 5 years of experience in resettlement policy analysis and implementation of resettlement plans. Further, work experience and familiarity with all aspects of resettlement operations would be desirable. NGOs, Consulting Firms or University Departments (consultant organization) having requisite capacity and experience as follows can qualify for services of and external monitor for the project.

(1) NGOs, Consulting firms duly registered with GoB agencies or experienced private consultant firm is eligible.

(2) The applicant should have prior experience in social surveys in land based infrastructure projects and preparation of resettlement plans (RP, RAP/RAP, LARP) as per guidelines on involuntary resettlement of any of the JICA, ADB, World Bank and DAC-OECD.

(3) The applicant should have extensive experience in implementation and monitoring of resettlement plans, including the preparation of implementation tools.

(4) The applicant should be able to produce evidences of monitoring using tools such as computerized Management Information System with set criteria for measuring achievement.

(5) The applicant should have adequate manpower with capacity and expertise in the field of planning, implementation and monitoring of involuntary resettlement projects as per donor's guidelines.

ANNEXURE-6

GENDER

THE PREPARATORY STUDY

ON

THE DHAKA MASS RAPID TRANSIT

DEVELOPMENT PROJECT

(LINE 1)

Gender Action Plan

ALMEC Corporation

Oriental Consultants Global Co., Ltd.,

Nippon Koei Co., Ltd., and

Katahira & Engineers International

Abbreviations

ADB	Asian Development Bank
AIDS	Acquired immune deficiency syndrome
BRT	Bus Rapid Transit
BRTA	Bangladesh Road Transport Authority
BRTC	Bangladesh Road Transport Corporation
DMTC	Dhaka Mass Transit Company
FGD	Focus Group Discussion
GAP	Gender Action Plan
GEM	Gender Empowerment Measure
GRB	Gender Responsive Budgeting
HIV	Human Immunodeficiency Virus
ILO	International Labour Organization
MDGs	Millennium Development Goals
MRT	Mass Rapid Transit
LGED	Local Government Engineering Department
NSDS	National Sustainable Development Strategy
NWDP	National Women Development Policy
SDGs	Sustainable Development Goals
SHM	Stakeholder Meeting
WB	World Bank

Table of Contents

1 Gender related Legislative System and Policy in Bangladesh

1.1 Legislative System

1.1.1 Constitution

The Bangladesh Constitution was enacted in 1972, and highlights equality of all citizens, elimination of all discrimination including sex, equal opportunities and equal rights for men and women, equal work and equal social services for men and women, and so forth.

In particular, the Article 10 states that “Steps shall be taken to ensure participation of women in all spheres of national life”, the Article 19 (2) states that “The State shall adopt effective measures to remove social and economic inequality between man and women and to ensure the equitable distribution of wealth among citizens, and of opportunities in order to attain a uniform level of economic development throughout the Republic”, while the Article 28 (2) states that “Women shall have equal rights with men in all spheres of State and of public life”.

1.1.2 Law

A number of existing laws, including the Citizenship Act (2009), have been revised for the protection of abuse of women and girls. At the same time, the Dowry Prohibition Act, Child Marriage Restraint Act, Women and Children Repression Prevention Act (2000), Mobile Court Act (2009), Domestic Violence (Prevention and Protection) Act (2010), and etc., those new legal regulations were enacted for similar purposes[1].

In addition, the Bangladesh Road Transport Association (BRTA) has a plan to issue written circular on the punishment for any indecent behavior of the driver and the conductor with passengers[2].

1.2 Bangladesh Vision 2021

The "Vision 2021", which was formulated by the Center for Policy Dialogue in 2006, prescribes "Gender balance at all levels of education". This particular article states "Efforts will be in place to provide the right environment (effective law and order situation, security, freedom of mobility, etc.) and facilities (safe transport to schools and universities, adequate housing facilities, etc.) to female students in order for them to complete their education up to the tertiary level”. At the same time, the article of "Ensuring gender equality" states that in order to ensure unfettered opportunities for women to participate in public life, the increasing threats of violence to them will have to be effectively eliminated. This will require legislation to guarantee the protection of women backed by adequate investment of law enforcement targeted to the specific needs of women/girls and will also require policy, institutional and educational interventions to provide social as well as political protection to provide a sense of security to women across the country.

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[1] http://www.daily-sun.com/post/221285/New-womenfriendly-transport-law-creates-ray-of-hope-among-female-commuters, browsed in April, 2017

[2] ditto

1.3 Seventh (7th) Five Year Development Plan (FY2016-FY2020）

In the 6th Five Year Plan (FY 2011- FY2016), "Accelerating Growth and Reducing Poverty" was the main theme, while the current Plan, which is the 7th Plan, emphasizes "Accelerating Growth, Empowering Citizens". Regarding the 7th Plan, empowerment of the Nation is a goal, and also gender empowerment is one of the priority policies. Specifically it emphasizes to strengthen gender equality in education and employment, social inclusion and social protection.

The 7th Plan's basic approach is in line with the SDGs, which will be described later[3].

1.4 National Sustainable Development Strategy: NSDS 2010-21

With regard to the NSDS, it states about the improvement of women's employment opportunities and wages, particularly the measures to be taken to materialize the equal wage and equal work for man and women.

As for the transportation policy, please refer to 2-2-2.

1.5 National Women Development Policy: NWDP 2011

Women's development as a prerequisite for national development, human rights, girls' development, elimination of all abuses, education / training, guaranteeing women's equality as well as active role in economic activities, employment, and etc. , these kinds of wide range of policies are stipulated in the NWDP.

It also states regarding the efforts at national, regional and grassroots levels, also the partnerships of both in and outside country.

Main issues of the NWDP relating to this Project are as follows;

- To ensure active role of women and their equal rights in all the national economic activity.
- To ensure human rights and fundamental freedom of women.
- To establish gender equality in politics, administration, other areas of activity, socio-economic activity, education, culture, sports, and all areas in family life.
- To eliminate all forms of abuse of women and female children.
- To arrange safety of widows, aged, guardian less, husband abandoned, unmarried women and girl children.
- To ensure gender equal rate of wages, increase participation of women in the labor market, equal opportunity at the workplace, ensure security and removal of disparities in employment.
- To have the disabled women unified with the mainstream society and ensuring their active participation.

According to the Department of Women Affairs, they have no specific plan to review/revise the NWDP at this stage while several related laws and regulations have been done so.

1.6 Gender Equality Strategy of the Local Government Engineering Department:

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[3] "Development Planning in Bangladesh: 7th Five Year Plan and SDG Implementation", 2016, General Economic Division, Planning Commission

LGED

LGED was formed based on the "NWDP 2011" described above 1.4. Concerning all levels of LGED activities, it aims to develop women and to create gender friendly environment.

1.7 SDGs

United Nations 17 SDGs are expected to be achieved by 2030. The Goal 5 states "Achieve gender equality and empower all women and girls" In Bangladesh, it has made significant progress on gender, however, there is a long way to go to realize the goal in true sense. In this regard, integrated socio-economic development is expected to play a key role in achieving the Goal 5[4].

1.8 Female Employment Promotion Related Policy

In the above mentioned 1.2-1.5, equal opportunity for work, equal work and equal wages for men and women are targeted.

According to the "Decent Work Country Program 2012-2015" by ILO in Bangladesh, while women account for only 36% of the total workers, the increase rate of female workers is more than six times higher than the male counterparts. However, most of them (about 80%[5]) are engaged in the garment factory workers.

The participation of women in the labor market is gradually expanding, and there are improvement trends in gender equality in the employment opportunities, wages and working conditions. However, there remain some crucial issues which require further improvement such as expansion of education, ensuring equal wages for men and women, and etc.[6] In fact, with regard to the construction industry, there is a survey result which shows approximately 80% of men's wages are female ones[7].

1.9 Gender Responsive Budgeting: GRB[8]

The GRB was introduced in 2005, and there are 43 Ministries and Divisions which develop the respective GRB in FY 2017-FY 2018. Those Ministries and Divisions are categorized as follows;

Section 1: Empowering Women and Enhancing their Social Dignity

Section 2: Improving Women's Productivity and Participation in Labour Market

Section 3: Widening Women's Effective Access to General Public Sector Service and Income Generating Activities

Out of the total budget for the Road Transport and Highways Division in FY 2017-2018, 27.99% corresponds to the gender issues, showing slight growth from 27.3% in 2016 - 2017. The Ministry of Railways also shows similar figures. And both are categorized in Section 3.

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[4] The Bangladesh Accountant: Bangladesh Goes Through Sustainable Development Goals (Quarterly journal), 2016, The Institute of Chartered Accountants of Bangladesh,

[5] http://www.worldbank.org/en/news/feature/2017/02/07/in-bangladesh-empowering-and-employing-women-in-the-garments-sector, browsed in July, 2017

[6] "Decent Work Country Profile Bangladesh, 2013, ILO

[7] "JICA's Gender Equality and Empowerment of Women: Transportation (Project Information: Preparatory Survey for Dhaka-Chittagong National Highway No.1 Bridge Construction and Rehabilitation Project")

[8] "Gender Budgeting Report", 2017, Ministry of Finance

1.10 Measures against Infectious Diseases such as HIV/AIDS

Women in Bangladesh are vulnerable to HIV / AIDS in view of their socio-economic situation, Due to the low social and cultural status of women, access to education, employment, health care including HIV testing and counseling, etc. are limited. On the other hand, women are exposed to sexual abuse and violence from premature marriage, as well as their close relatives and husbands.

In the 7th Five-Year Plan, 22 items are set as standards and targets for health strategy, and the issues such as high risk group of HVI infection are also included[9]. It is targeted to maintain 0.7% level of 2011, and also to keep less than1.0% level until 2015 and 2021.

In the" 3rd National Strategic Plan for HIV and AIDS Response 2011-2015", the Goal is set as "by 2015, minimize the spread of HIV and minimize the impact of AIDS on the individual, family, community, and society". And the following objectives are highlighted:

- Implement services to prevent new HIV infections ensuring universal access;
- Provide universal access to treatment, care and support services for people infected and affected by HIV;
- Strengthen the coordination mechanisms and management capacity at different levels to ensure effective national multi-sector HIV/AIDS response;
- Strengthen the strategic information and research for evidence based response.

Although the prevalence remains low, Bangladesh is one of the only four countries in Asia and the Pacific where prevalence has increased more than 25 % over a decade till 2012[10].

Moreover, as of 2015, the number of HIV/AIDS infected people is estimated 9,600, and for women age 15 and over, it is estimated 3,200[11].

In addition, Bangladesh ratified the UN Convention on the Elimination of All Forms of Discrimination against Women in 1984.

Also Bangladesh has issued "Bangladesh Progress Report 2015" including the achievements of "MDGs 3: Promote Gender Equality and Empower Women".

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[9] "Background Paper on Health Strategy for preparation of 7th Five Year Plan", 2014, Planning Commission, Ministry of Planning

[10] "Global AIDS Response Progress Report (GARPR) Target 7: Eliminate Gender Inequalities and Gender-based Abuse and Violence and Increase the Capacity of Women and Girls to protect themselves from HIV Annual Progress Report Bangladesh 2015", UNAIDS

[11] http://www.unaids.org/en/regionscountries/countries/bangladesh, browsed in April, 2017

2 Gender and Urban Transport

Women need to play multitasking roles in their household and in their community, thus the needs on transport sector tend to differ between men and women[12]. Low-income women tend also to be dramatically less mobile than men in the same socio-economic groups. This fact is backed by the fact that the women often face sexual harassment in the street and on the public transportation[13][14].

According to the Department of Women Affairs, currently female drivers for public bus, taxi and also private vehicles have been trained in order to promote social mobility, job creation, and so on[15].

In order to tackle such situation, following policies and measures have been developed:

2.1 Transportation (Urban Transport) and Gender in the SDGs

The Goal 11.2 of the SDGs states “By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those vulnerable people, in particular, women, children, person physically challenged people and elder people.”

In order to achieve Goal 11.2 in Bangladesh, concrete action plan, including the introduction of MRT lines, has been incorporate. For this, “Proportion of population that has convenient access to public transport, by sex, age, and persons with disabilities” has been set as an indicator for performance measurement.[16].

2.2 Transport (Urban Transport) Policy and Gender in National Policy

2.2.1 7th Five Year Development Plan

The Government of Bangladesh recognizes a great deal of challenges in the transportation sector, and in particular, it is pointed out that the traffic congestion and the traffic management of the capital Dhaka is enormous.

Although there is no direct description, since the response to gender issues is emphasized in the 7th Plan, it is assumed that the gender consideration is also required for urban transport policy.

2.2.2 NSDS

In the NSDS, as stated above, improvement of women's employment opportunities and wages, as well as the measures to materialize the equal pay for equal work are listed.

In general, it is important to create an environment that realizes compliance with social matters related to work, such as safety of workplaces, transportation facilities and infrastructure among

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[12] “Mainstreaming Gender in Road Transport: Operational Guidance for World Bank”, 2010, World Bank

[13] Transport and Urban Poverty in Asia: 11. Gender, A Brief Introduction to the Key Issues, A. Rahman Paul Barter, 1998

[14] According to the senior social development specialist of the World Bank Bangladesh Office (met on the25th July, 2017), the situation unique to Bangladesh is the fact that sexual harassment and other harassments are happening to the women of any social classes (no discrimination on the socio-economic situation).

[15] It was explained by the Manager, Women Rights & Gender Equity of ActionAid (met on the 26th July, 2017), that some of the Embassies as well as NGOs such as ActionAid, CARE and BRAC, employ female drivers.

[16] “A Handbook Mapping of Ministries by Targets in the implementation of SDGs alighting with 7th Five Year Plan (2016-20)”, 2016, Support to Sustainable and Inclusive Planning (SSIP) Project, Planning Commission

others.

As for the specific matters of the NSDS including the transportation facilities, separate toilets, separate lunch rooms, different lunchtime for men and women, and day care centres at the workplace are suggested.

2.2.3 NWDP2011

In the NWDP 2011, it is clearly stipulated that "Ensuring Active Role of Women and Their Equal Rights in All the National Economic Activity". At the same time, it is aimed “To arrange for taking all other necessary and making special provision including transportation, housing accommodation, rest rooms and separate toilets and day care centers where women are employed in larger numbers (23.11).

2.2.4 Gender Equality Strategy of the LGED

In the subject matter, it highlights that “LGED, in accordance with this Gender Equality Strategy ensures that all of its infrastructures are made women-friendly, creates employment opportunities for the women in its different activities increasingly establishes a process of decision making in each and every work through participation of both men and women”. In this regards, concerning the Infrastructure Development under LGED, the followings are stated; “provisions for essential facilities exclusives for women are to be kept in the plans, designs and drawings for all infrastructures to be prepared and their proper implementation is to be ensured.”.

2.3 Gender Issues in the Transportation Sector (Urban Transport)

In Bangladesh, there are buses introducing female priority seats in Dhaka and Chittagong[17]. However, often the said seats are occupied by men, and sexual harassment is rampant in the buses. Moreover, not only the drivers and conductors are unhelpful, but harassment by the drivers have been happening[18].

According to the survey conducted by ActionAid in 2014, in order to avoid such sexual harassment, approximately 13 % of women do not use the public transportation[19].

According to a transport expert, it is said that the solution lay in an “organized mass transport system,” not in introducing more women-only buses or in reserving more seats for women[20].

As women do the majority of unpaid work; caring for children, the elderly and the sick and often combine these unpaid caring responsibilities with paid work, their travel patterns are often more frequent and complex than those of men. On the other hand, women often escort vulnerable people around the public transportation network, such as taking children to school or the elderly to medical services. Or/and, the women often carry goods, etc.[21]

In Dhaka, 80% of low-income female factory workers cannot afford public transport and have to

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[17] http://www.thedailystar.net/star-weekend/everyday-battle-women-commuters-1316401,browsed in April 2017

[18] http://www.observerbd.com/2015/06/01/91872.php, http://www.thedailystar.net/frontpage/woes-women-commuters-184099, browsed in April, 2017

[19] http://www.thedailystar.net/frontpage/woes-women-commuters-184099, browsed in April, 2017

[20] ditto

[21] “Freedom to Move”, 2016, ActionAid

walk to work[22].

Furthermore, there are no washrooms/toilets nearby bus stops, etc., the current situation of the public transport is not women-friendly[23].

2.4 Gender Issues and Countermeasures in Urban Transport Policy

2.4.1 Dhaka Structure Plan 2016-2035

In line with the aforementioned matter, public transport is not comfortable and easy in Dhaka, particularly for women, children or elderly people due to poor accessibility and non-integrated transport network.

Given the above fact, the Plan sets a goal as "safe, affordable, sustainable and connected communities". For this end, the followings are addressed to achieve the goal; "providing a greater choice of travel modes (Bus/BRT/MRT/Rail/Taxi), distributing goods and services more efficiently, etc. and so forth.

2.5 Approaches to Gender Mainstreaming in Urban Transport

2.5.1 Bus

As mentioned in the above "2-2", Bangladesh Road Transport Corporation (BRTC) now operates 17 buses in the city exclusively for women. It announced adding more buses in its fleet from next year[24].

Bangladesh Road Transport Authority (BRTA), on the other hand, has so far given training to 1.5 lakh drivers in which the issue of decent behaviour with female passengers was included.[25].

A monitoring team (15 members) headed by BRTA chairperson is working to curb the harassment of women in the public transport[26].

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[22] ditto

[23] ditto

[24] http://www.daily-sun.com/post/221285/New-womenfriendly-transport-law-creates-ray-of-hope-among-female-commuters, browsed in April, 2017

[25] ditto

[26] ditto

3 Current Status of Gender Mainstreaming in Urban Transport Sector by the Other Donors

3.1 ADB

3.1.1 ADB Projects and Gender[27]

ADB introduced the Guidelines on Women and Development in 1998.

Gender equality and empowerment of women are indispensable for realizing the ambition for inclusive and sustainable development in Asia. Within the ADB's "Strategy 2020", gender equity is positioned as an important element in promoting comprehensive and sustainable growth, poverty reduction, improving standard of living, and achievement of those.

ADB considers gender mainstreaming as a main strategy and approach, it is an ADB's policy that promote gender equality and empowerment of women in all sectors.

On the other hand, "Gender Equality and Women's Empowerment Operational Plan 2013-2020 (Gender Plan)" was approved in 2013. As a road map for ADB's operation, the said Plan highlights the necessity of elimination of gender gap and disparity in Asian region. At the same time, it enhances the realization of better outcomes as well as strengthening of monitoring on gender equality.

Moreover, in order to ensure materialization of gender equality, "Gender Action Plan" has been introduced as a "Gender Mainstreaming Tool" for the detailed strategy and activity in each project. Also sector-wised "Gender Tool Kits" have been developed.

3.1.2 Gender Issues in the Transport Sector

In many of the Transport Sector projects, the design and services are not considering women's needs, concerns, priorities and preferences. Also, there is only a limited number of women involved in this particular sector, thus the women's voices are not reflected in the policies as well as decision-making process. In this regard, as mentioned above, ADB has developed "Gender Tool Kit: Transport", and it provides guidance by drawing attention to the gender dimensions of transport, and how to mainstream gender equality issues into transport project design, implementation and policy engagement. In particular, mobility is experienced differently by women and men, as they use different modes of transport for different purposes and in different ways depending on their socially determined reproductive, productive, and community related gender roles. Women's and men's relative economic and social status and livelihoods also influence their different transport needs and utilization of transport services. These differences need to be well understood in order to inform the design of gender-inclusive transport projects[28].

According to a gender expert at the ADB Bangladesh Office, the Gender Empowerment Measure (GEM) itself in the country has been improving over the past several years. In particular, as of 2015 when the survey on MRT Line 6 was conducted, there was no ADB project which categorized[29] as "EGM" or "GEN" (as described in "3.1.3") in the country[30] However, at

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[27] https://www.adb.org/themes/gender/overview, browsed in April, 2017

[28] "Gender Tool Kit: Transport Maximizing the Benefits of Improved Mobility for All", 2013, ADB

[29] "Guidelines for Gender Mainstreaming Categories of ADB Project", 2012, ADB

[30] It was explained that in 2015 (when the JICA Study Team for Line 6 visited ADB Bangladesh Office) there were no projects at the level of "EGM" or above categorized under ADB Bangladesh Office.

this stage, a certain progress has been recognized in the transport sector. Furthermore, it is worth noting of the “Gender Responsive Budgeting” in Bangladesh.

Yet, some challenges remain, such as lack of understanding on gender issues at the executing agency, the shun of female employment due to differences in physical power of men and women[31], tendency to consider the Gender Action Plan as an "option" not compulsory (it is compulsory).

3.1.3 Transport Sector Projects and Response to Gender Issues in Bangladesh

The above mentioned gender categorization system to materialize gender mainstreaming is set as follows;

Category I: Gender Equity as a theme (GEN)

Category II: Effective Gender Mainstreaming (EGM)

Category III: Some Gender Elements (SGE) and

Category IV: No Gender Elements (NGE)

1) Greater Dhaka Sustainable Urban Transport Project (GDSUTP)[32]

The project, which is categorized "EGM" in the gender categorization system, is scheduled to be implemented from 2015 to 2019.

As a feature related to the design of the project, it is planned to construct BRT which is safe for the poor, women, children, the elderly and the physically challenged people, and are friendly to women and children.

As a result, access to women's public transportation is expected to improve. And the Project will also provide employment opportunities for women, and bus pass will be subsidized for garment factory workers who include many poor women.

The Gender Action Plan of the project includes setting facilities at bus stops and kiosks considering safety of women, such as lighting, security, separate toilets for men and women, 20% of reserved seats for young children, pregnant women, children, elderly and physically challenged people. Not only to secure those seats, but to actually let them use the seats, line up men and women separately at the station, priority boarding for pregnant women, elderly, children and physically challenged people are the essential points. At the same time, regarding the operation of the BRT, at least 10% of female staff should be hired, and organize awareness raising training which includes gender issues, and etc.

2) Dhaka Metro Project[33][34]

The said project, which is planned to be implemented, is categorized “SGE” in the gender categorization system, the project is to pursue the needs of women in the transport sector, possibility of employing women in construction and the safety.

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[31] For instance, women may take more time than male counterparts to lift and carry heavy items at the construction site, which may affect the construction cost, etc.

[32] https://www.adb.org/projects/42169-013/maiin, browsed in July, 2017

[33] https://www.adb.org/projects/49258-003/main, browsed in July, 2017

[34] Gender specialist, whom the author met on 20th July, 2017, explained that the said project has not been commenced yet,

In addition, the capability of the executing agency will be assessed whether they have the ability to incorporate gender-friendly designs into metro infrastructure and services. The project aims to realize a design that is friendly to women, the elderly, physically challenged people and children so that it becomes a sound option of means of transportation in the process of enabling women's economic empowerment.

3) Others

Although not in the urban transport sector, for the future plans in the transport sector of ADB, there are several railway projects such as South Asia Sub-regional Economic Cooperation (SASEC) related projects, Rural Infrastructure Maintenance Program, Railway Sector Investment Program, and so forth.

3.1.4 Shared Views on Gender Consideration for the Project

The followings are the Gender Specialist’s viewpoints through her experiences[35];

- Secure lighting to give the passengers a sense of security;
- Separate ques for men and women at the ticket booth;
- Establishment of automatic ticket inspection machine exclusively for women, children, elderly, physically challenged people (or priority lane for them);
- Separate cars for men and women at peak hours;
- Securing female-only retail space such as snack sales, etc.;
- Regular patrol by male and female security officers during off hours;
- Placement of male and female staff at the security control room;
- Establishment of saree guard[36].

3.2 The World Bank (WB)

3.2.1 Gender Issues in the WB Projects[37]

Based on the past experiences, lessons learned and findings, the WB has developed the "Gender Strategy (FY 2016-2023 FY)".In order for the WB to achieve eradication of extreme poverty and promotion of coexistence for sustainable development, gender equity plays a core role.

The WB Gender Strategy focuses on four objectives: 1. Improving human endowments; 2. Removing constraints for more and better jobs; 3. Removing barriers to women’s ownership of, and control over assets; and 4.Enhancing women’s voice and agency, and engaging men and

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[35] At the time of preparing gender action plans for the GDSUTP, the Gender Specialist whom the author met during the course of study for the Project in Dhaka has not been assigned yet. One of the items of the Gender Action Plan which is "priority boarding for pregnant women, elderly, children and physically challenged people" is rather unrealistic, she said.
Regarding the caste, there seems to be various opinions but the above mentioned Gender Specialist has provided following supplementary information; the majority of people in Bangladesh are Muslim, thus while the social classes exist, the caste does not.

[36] Saree guard has been introduced in Delhi Metro Project, however, the proportion of those wearing in Saree in Delhi has been decreased while those of Bangladesh (Dhaka) should be higher than in Delhi at this stage. Though the cost may increase, the Saree guard should be set in Metro Lines in Dhaka.

[37] https://openknowledge.worldbank.org/handle/10986/23425, browsed in April, 2017

boys[38].

On the other hand, in line with the "Environmental and Social Framework" approved in August 2016, the said framework will be applied to all projects which to be commenced from 2018.

The framework will be used to protect people and the environment related to the project[39]. In order to clarify the environmental and social risks and impacts related to the projects. as the condition of the loan, 10 standards are set out including the followings; assessment and management of environmental and social risks as well as impacts, labor and working conditions, involvement of stakeholders and disclosure of information[40].

3.2.2 Gender Issues in the Transport Sector[41]

A transport related study results showed that women are more willing to use the public transportation than men if such transportation facilities are clean and comfortable.

If the time required for movement is to be shortened, it will be easier for women to balance the housework and the work outside.

Whether women use the public transportation or not is highly depending on the safety. Furthermore, by taking the following countermeasures, positive impacts, such as women's safety concern to be reduced, etc., will be enhanced.

- Policy interventions focusing on infrastructure : lighting in stations, design to allow for strollers, alarm systems, and so on;
- Pricing measures : based on analysis of travel patterns with measures such as ticketing and route design;
- Management and institutional measure: organizational arrangements, policies, contracts and terms of engagement for operators;
- Information measures to foster behavior change: by focusing education campaigns on operators increasing the use of law enforcement, and relying on public sector organizations

3.2.3 Transport Sector Projects and Response to Gender Issues in Bangladesh

1) Bangladesh Second Rural Roads and Markets Improvement and Maintenance Project

Although not in the urban transport sector, the said project was implemented from December 1996 till March 2003. Under this project, 78,000 workers were engaged in construction work and others as part of employment and income generation, out of those 25% of workers were women. Also, 13,000 poor women were employed for maintenance work by LGED even after the project[42].

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[38] "World Bank Group Gender Equality, Poverty Reduction and Inclusive Growth: 2016-2023 Gender Strategy", 2016, World Bank Group

[39] http://www.worldbank.org/en/programs/environmental-and-social-policies-for-projects/brief/the-environmental-and-social-framework-esf, browsed in July, 2017

[40] "Environmental and Social Framework", 2017, The World Bank

[41] Gender Equality, Poverty Reduction and Inclusive Growth: Part IV The Strategic Objectives: Economic Opportunities, Removing Constraints for More and Better Jobs, Transport, 2017, The World Bank

[42] http://documents.worldbank.org/curated/en/842201474895983875/pdf/000020051-20140607174045.pdf, browsed in July, 2017

2) Clean Air and Sustainable Environment Project[43]

The said project aims to "improve air quality and safe mobility in Dhaka through the implementation of demonstration initiatives in urban transport and brick making. Under this project, based on the sample surveys of women who use existing facilities and services, gender action plan was developed. The plan is to incorporate women's needs and priorities as much as possible.

As a social dimension of lesson learned from the Phase 1 of the said project, the importance of consideration, especially for physically challenged people, can be pointed out. The WB Bangladesh Office refers to the Singapore practices when it comes to setting disability-friendly transport related facilities, in accordance with those, the following issues were cited as advice for the Project (MRT Line 1 and Line 5);

- To secure accessibility to wheelchair users, visually and hearing impaired people, etc.
- To design and provide information considering physically challenged people at the station premises, platforms and otehrs.

3) Others

Currently, the WB Bangladesh mainly deals with rural transport projects in the transport sector.

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[43] http://projects.worldbank.org/P098151/clean-air-sustainable-environment-project?lang=en&tab=overview, browsed in July, 2017

4 Gender Action Plan for Dhaka MRT Development Project

4.1 Potential Female Users' Needs

At the project sites, 19 stakeholder meetings (SHM) and 4 Focus Group Discussions (FGD) were held for both Line 1 and Line 5. Particularly, regarding the SHM, there were relatively limited female participants, and it was difficult for them to express their opinions in front of male counterparts. Thus, the FGDs which targeted only women were separately organized.

FGD :

Venue	Date	No of Participants
Purbachal (Depo) (Bhaktabari, Rupganj)	March 19, 2017	14
Purbachal (Depo) (Bjaltabaro. Pitalganj)	May 2, 2017	8

The needs of the potential female users are listed below.

4.1.1 Design of Station

- Separate ticket booths for male and female passengers
- Separate washrooms for male and female passengers
- Separate prayer rooms (space) for male and female passengers
- Adequate lighting facilities
- Clean waiting room (space) and platform
- Installation of escalator/lift
- Installation of drinking water facility
- Allocation of vendor (small business) area (space) for women

4.1.2 Design of Rolling Stock

- Separate compartments for male and female passengers
- Reserved/priority seats for pregnant women, women with young children, children, elderly people and physically challenged passengers
- Adequate lighting

4.1.3 Construction

- Employment of women for construction work
- Equal pay/work/opportunities for male/female workers
- Employment of women for construction project related work (e.g.: supporting staff, cooking, cleaning, laundry, catering, etc.)
- Separate prayer rooms (space), washroom, changing rooms, dining space (different timing between male/female for lunch break) for male/female workers/staff
- Provision of training to raise awareness on gender

- Provision of training on prevention of HIV/AIDS

4.1.4 Operation

- Deployment of female staff for both ground operation and on board
- Setting affordable fares
- Setting time schedule to meet women's needs
- Keep clean (station, platform, train, etc.)
- Responding to gender issues, measures on sexual harassment and implementation of those

4.1.5 Others

- Concerning the resettlement plan, consideration should be given to the women so that they will also be able to obtain financial compensation
- In relation with the above, not only the financial compensation but provision of employment opportunities should be also considered
- During the planning stage, women’s opinions should be heard as well as women’s participation of decision making should be secured

Workers, service holders, students, businessmen etc., will be the potential user of the MRT.

Using MRT, the followings are expected: better opportunities for business, easy access to the market for buying and selling commodities, time saving, strengthen communication with relatives, better educational opportunities for girls, and so on.

However due consideration should be provided for the design and operation of the MRT since it is relatively new to the country, particularly women.

In addition to the opinions of participants of the FGDs mentioned above, suggestions and advice from the other donors and Department of Women, informal views of the said people/official concerned as well as the local staff of the Project are listed below.

- Many educational institutions such as universities, including girls' universities, have been established around the project sites. Specifically, along the MRT Line 1, there are approximately 30 educational institutions (high school level or above), for example, Viqarunnisa Noon School & College (girls), Motijieel Girls School, and Habibullah Bahar University College (co-education)[44]. It is expected that the students going to these educational institutions would utilize the MRT. Moreover, in consideration of the present situation in Bangladesh, when the daughters passed the university entrance examination, there are cases that the parents decide to relocate their houses/apartments to the nearby area of their daughters’ university[45]. It is due to the safety reason of the daughters. Given this situation, it is also expected that the women’s educational opportunities will be expanded as well as easy access to educational institutions will be secured.
- There is a necessity to take measures to prevent intrusion of homeless, etc. inside the

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[44] Refer to the Appendix 1.

[45] Those who do not have private cars, such as lower middle classes, they cannot send/pick up their daughters to/ from their schools. Thus there are cases that the family may relocate their homes to nearby their daughter’s school.

station premises after closure of the business hour of the MRT operation. Particularly, as a security point of view, it is required to take thorough precautions to prevent women from not using the MRT because of the security reason.

- It is ideal to secure stroller and wheelchair spaces in the compartments of MRT.
- Followings are to enhance utilization of the MRT for children and women: cartoon images and soft music in the station and the compartments[46].
- Give due consideration to not only women but also physically challenged people.
- As for the tickets, weekly and monthly passes to be issued.
- Clean separate “public type of “washrooms for men and women (open to non-MRT users)

4.2 Potential Female Employment (wage level)

In consideration of the desire of women resided in the project sites with realistic views, the job category and wage level of potential female employees are described as follows.

Regarding the wage level, it is stated based on the "total" part of monthly average wage by job category and gender in urban area of Bangladesh (FY2015-FY2016).

(Unit:Tk)

Job Category	Wage Level [47,48](monthly)	Remarks
Construction worker	9,535	
Project staff (supporting staff such as administrative, etc.)	17,397	Clerical Support Workers
Project staff (cleaning/laundry)	9.535	(entire project office)
Project staff (cooking)	9,535	Lunch, etc.
Catering (individual)	9,535	Indirect support work related to the project (cooking such as meals/snacks and delivery to offices, etc.)

4.3 Perspectives of Disability and Development

During field study in Dhaka, consideration towards physically challenged people was emphasized by FGD, the Department of Women's Affairs, and other donors.
JICA has set a vision as "Dynamic development that all people benefit from" and under this, “Disability and Development” has been implemented[49].
On the other hand, regarding the issue-specific guidelines on "Disability and Development"[50], it describes current situation on “Gender and Disability” as follows;
“Women with disabilities in developing countries are facing triple discrimination”

- as female;
- as disabled, and;
- as poor

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[46] With regard to this matter, advertisements can be an alternative plan.
[47] Quarterly Labour Force Survey Bangladesh 2015-2016, 2017, Bangladesh Bureau of Statistics
[48] International Standard Classification of Occupations, 2012, International Labour Organization
[49] JICA’s activities on Disability and Development, 2015, JICA
[50] Issue specific guidelines: “Disability and Development”, 2015, JICA

In view of this matter, it is required to implement JICA's projects based on the Article 6"Women with Disabilities[51]" of "Convention on the Rights of Persons with Disabilities", which Bangladesh ratified in November 2007[52].
Furthermore, in the guidelines of "Transportation and large-scale public facilities and Disabilities" part, the followings have been pointed out as current situation.

- Public transportation and others in developing countries are often unfriendly/ unavailable to the physically challenged people.
- Because of inadequacies in transportation, physically challenged people face difficulties in commuting, going to school and social participation.

It is also required to implement JICA's projects in line with the Article 9 "Accessibility" and Article 20 "Personal mobility" of "Convention on the Rights of Persons with Disabilities"[53]

Under the "Delhi Mass Rapid Transport System Project (Phase1-3)" implemented in Indi, a certain number of seats not only for women but also for the physically challenged people are secured.[54] Besides, at each station, elevators which can accommodate wheelchairs, induction blocks for the visually impaired, priority seats for physically challenged people, discount tickets for physically challenged people, etc. have been introduced[55], Likewise, under the "Mass Transit System Project in Bangkok", the executing agency formulated barrier-free guidelines and took proper actions considering the physically challenged people to be able to use the MRT[56].

It is indispensable for the Project to consider not excluding such physically challenged people, including women.

4.4 Gender Action Plan (Draft)

In accordance with the current situation in Bangladesh, specifically in urban area, opinions of local residents (women) at the project sites, results of survey on MRT Line 6, experiences of the other major donors in the country, views of gender experts in other donors, etc., the following Gender Action Plan (Draft) has been developed.

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[51] ditto (Article 6,Convention on the Rights of Persons with Disabilities:"1. States Parties recognize that women and girls with disabilities are subject to multiple discrimination, and in this regard shall take measures to ensure the full and equal enjoyment by them of all human rights and fundamental freedoms."" "2. States Parties shall take all appropriate measures to ensure the full development, advancement and empowerment of women, for the purpose of guaranteeing them the exercise and enjoyment of the human rights and fundamental freedoms set out in the present Convention." By using the MRT, physically challenged women would be able to expand their range of social activities, including work, etc.,,and be able to develop capacity and improve self-sustainability.)

[52] Convention on the Rights of Persons with Disabilities

[53] ditto

[54] https://www.jica.go.jp/oda/project/ID-P159/field.html, browsed in July, 2017

[55] https://www2.jica.go.jp/ja/evaluation/pdf/2010_ID-P139_4_f.pdf, browsed in July, 2017

[56] https://www2.jica.go.jp/ja/evaluation/pdf/2007_TXXV-3_4_f.pdf, browsed in July, 2017

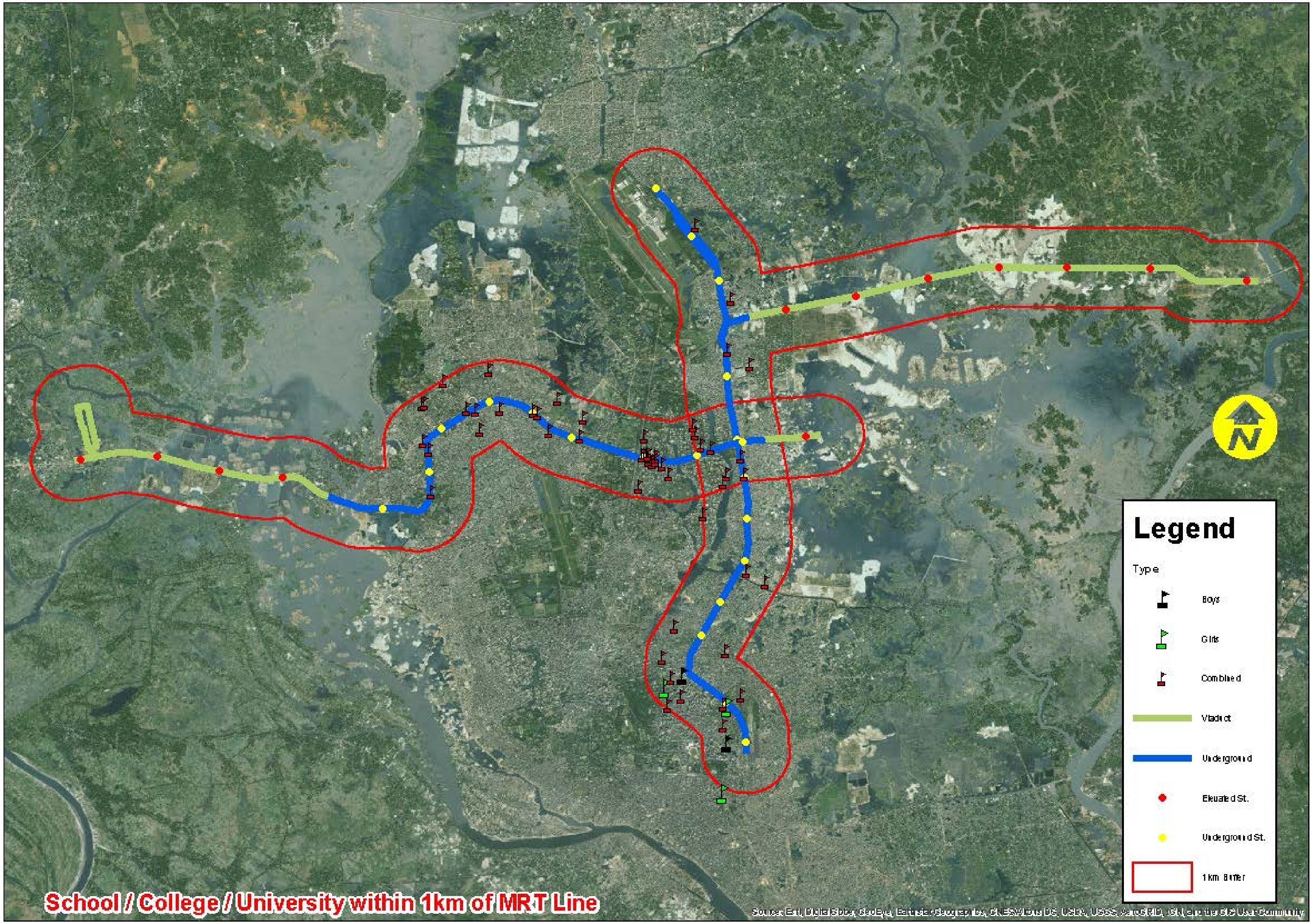
Gender Action Plan

Stage		Gender Responsive Action: GAP for Line 1 and Line 5	Responsibility	Actual
Detailed design	Design of Station	Separate ticket booths or separate queuing system for male and female passengers		
		Establishment of priority ticket gates for women, children, elderly, and physically challenged people		
		Separate washrooms for male and female passengers (at the main stations, it is ideal to establish washrooms where non-passengers can also use)		
		Separate prayer rooms (space) for male and female passengers		
		Space for baby care (breastfeeding, change diapers/clothes, etc.)		
		Setting up information counters at the main stations (or provide information at the ticket booth, etc.)		
		Adequate lighting		
		Installation of passenger emergency alarms		
		Installation of security cameras		
		Installation of shutter to prevent intrusion from outside during closure of the operation (night time, etc.)		
		Installation of escalator/lift		
		Installation of braille block for visually impaired		
		Installation of audio announcement equipment (including support for the visually impaired)		
		Installation of display guidance		
		Allocation of vendor (small business) area (space) for women		
	Design of Rolling Stock	Women and children-only compartments at peak hours		
		Reserved/priority seats for pregnant women, women with young children, children, elderly people and physically challenged passengers		
		Space for strollers and wheelchairs		
		Adequate heights and size of the steps into the trains for any passengers		
		Installation of audio announcement equipment (including support for the visually impaired)		
		Adequate heights of the straps for female passengers		
		Easy access to grab rails/bars		
		Adequate lighting		
		Installation of passenger emergency alarms		

Stage		Gender Responsive Action: GAP for Line 1 and Line 5	Responsibility	Actual
Construction		Employment of women for construction work		
		Employment of women for construction project related work (e.g.: supporting staff, cooking, cleaning, laundry, catering, etc.)		
		Equal pay/work/opportunities for male/female workers		
		Separate prayer rooms (space), washrooms, changing rooms, and dining space for male/female workers/staff		
		Different timing for lunch break between male/female workers/staff		
		Provision of training to raise awareness on gender		
		Provision of training on prevention of HIV/AIDS		
		The above to be included in the tender documents		
		Gender-responsive resettlement plan (refer to the Resettlement Action Plan)		
Operation	Service	Deployment of female staff for both ground operation and on board		
		Deployment of male and female security guards (collaboration with the police)		
		Setting affordable fares		
		Introduction of discount fares for the students, elderly, etc.		
		Introduction of weekly, monthly, etc. passes (discount tickets)		
		Introduction of IC card		
		Setting time schedule to meet women's needs		
		Keep clean (station, platform, train, etc.)		
		Gender responsive measurements (including sexual harassment, etc.) and implementation of those		
	Gender Aware-ness	Gender awareness training for the staff (gender-responsive planning/implementation, prevention of sexual harassment, etc.) in collaboration with Department of Women Affairs/NGO		
		Gender awareness activities (PR) for passengers		
	Employ-ment of female staff	Securing female staff at all stations/at least main Metro sections (ticket booths, information desks, train staff, etc.)		
		Separate prayer rooms (space), washrooms, changing rooms, and dining space for male/female staff		
		Different timing for lunch break between male/female staff		
		Establishment of child care centre (space)		
		Securing gender-responsive working conditions (e.g. provision of maternity leave/childcare leave, flexible working hours to take care of baby/small children/elderly parents or in-laws, etc., establishment of dormitory, etc.)		
		Provision of equal training/promotion opportunities for male/female staff		
		Equal pay/work/opportunities for male/female staff		

Appendix 1: List of Educational Institutions around Line 1 (high school and above)

Name of Educational Institution	Type
Viqarunnisa School & College	Girls
Lions Model School	Co-ed
Kormitola High school	Co-ed
Civil Aviation model High school	Co-ed
Notordome College	Boys
Shiddeswari Boys School	Boys
Gulshan Model School & College	Co-ed
Regents College	Co-ed
Australian School	Co-ed
Green Dale International School	Co-ed
BIMS College	Co-ed
Habibullah Bahar University	Co-ed
Presidency University	Co-ed
Technology & Sciences University	Co-ed
Manarat College	Co-ed
North South University	Co-ed
Queen Mary College	Co-ed
East West University	Co-ed
Imperial College	Co-ed
Stamford University	Co-ed
National Bank School & College	Co-ed
Gov Khilgong High School	Co-ed
Motijheel Boys school & College	Co-ed
Shahjahanpur Railway School	Co-ed
Motijieel Girls School	Girls
Little Flower School & College	Co-ed
Mothijheel School & College	Co-ed



Educational Institution Map around 1 and 5 (high school or higher)

Appendix 2: References

国家政策･計画 / National Policy/National Plan

タイトル / Title	発行元 / Publisher	発行年 / Year of Publication
Bamgladesh Vision 2021	Centre for Policy Dialogue	2007
National Women Development Policy 2011	Ministry of Women and Child Affairs	2011
National Sustainable Development Strategy 2010-21	General Economics Division, Planning Commission	2013
Gender Equality Strategy of the Local Government Engineering Department (LGED)	LGED	2014
Millennium Development Goals: Bangladesh Progress Report 2015	General Economics Division, Planning Commission	2015
Seventh Five Year Plan 2016-2020 (Gender Equality and Women's Empowerment): Gender Empowerment, Social Inclusion and Social Protection	General Economics Division, Planning Commission	2015
Gender Budgeting Report 2017-2018	Ministry of Finance	2017

都市交通政策、都市交通に係るジェンダー課題 / Urban Transport Policy, Gender Issue in Urban Transport

Transport and Urban Poverty in Asia: 11. Gender, A Brief Introduction to the Key Issues	A. Rahman Paul Barter	1998
Dhaka Structure Plan 2016-2035	Regional Development Planning, Ministry of Housing and Public Works	-
Strategic Transport Plan for Dhaka: Urban Transport Policy (Final Report)	Dhaka Transport Coordination Board (The Louis Berger Group, Inc.)	-
Baseline Survey of Safe City Program	Bangladesh Institute of Development Studies	2014
A Handbook Mapping of Ministries by Targets in the implementation of SDGs alighting with 7th Five Year Plan (2016-20)	Planning Commission	2016
Open Transport Development and Integration of ICT and Transport	WB	2015
Freedom to Move: Safe Cities for Women	ActionAid	2016

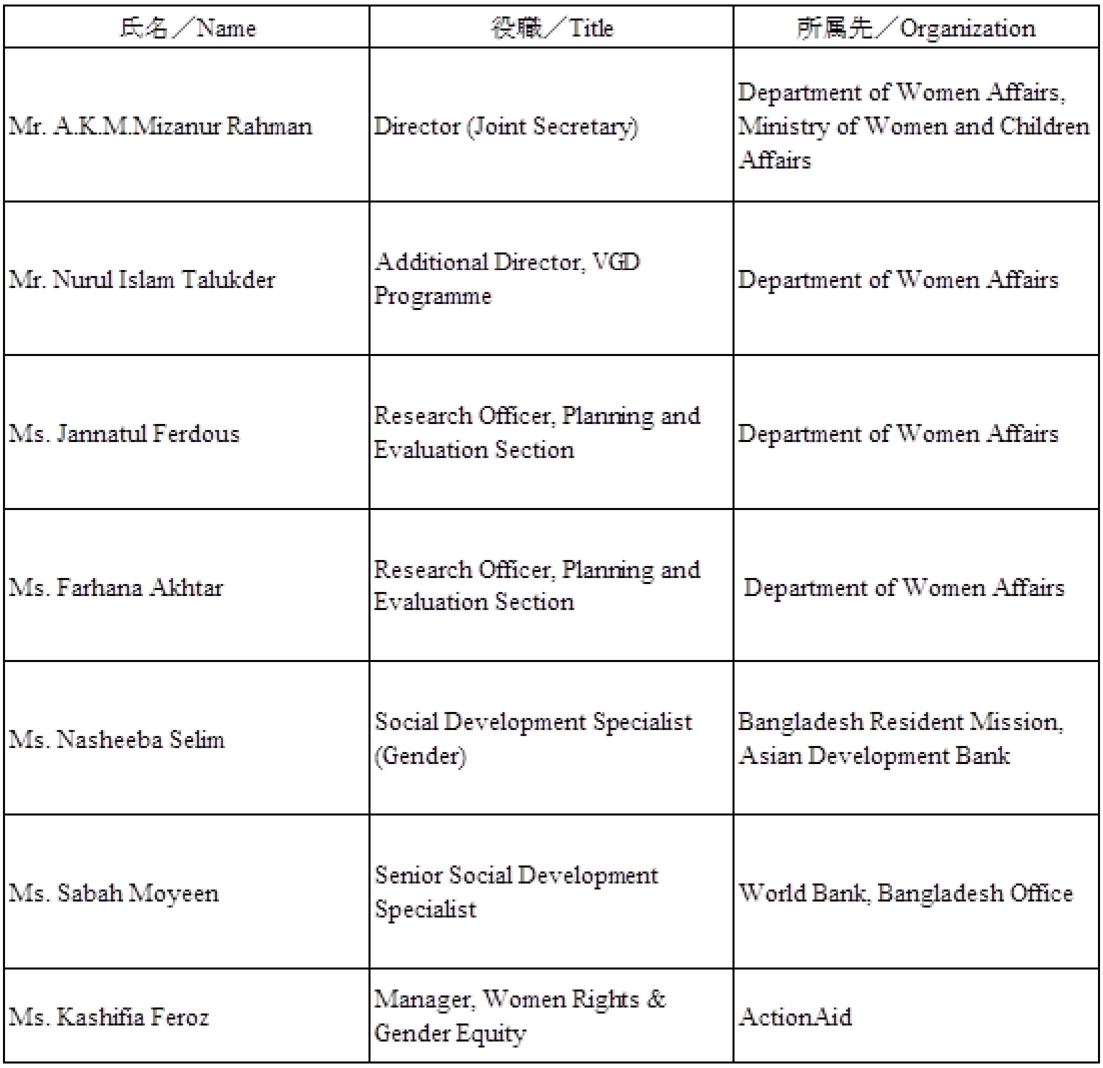
HIV/AIDS 関連

3rd National Strategic Plan for HIV and AIDS Response 2011-2015	National AIDS/STD Programme, Directorate General of Health Services, Ministry of Health & Family Welfare	2010
Background Paper on Health Strategy for preparation of 7th Five Year Plan	Ministry of Planning	2014
Millennium Development Goals: Bangladesh Progress Report 2015	General Economics Division, Planning Commission	2015
Gender and HIV/AIDS in Bangladesh: A review (Journal of Health and Social Sciences 2016)	Department of Sociology, University of Chittagong	2016
Gender Assessment of the National HIV Response in Bangladesh: A Country Report 2014	National AIDS/STD Programme, UNAIDS Bangladesh	-
Global AIDS Response Progress Report Target 7: Eliminate Gender Inequalities and Gender-based Abuse and Violence and Increase the Capacity of Women and Girls to protect themselves form HIV (Annual Progress Report Bangladesh 2015)	UNAIDS	2015

その他/Others

Quarterly Labour Force Survey Bangladesh 2015-2016	Bangladesh Bureau of Statistics	2017
Mainstreaming Gender in Road Transport: Operation Guidance for World Bank Staff	WB	2010
World Bank Group Gender Equality, Poverty Reduction and Inclusive Growth: 2016-2023 Gender Strategy	WB	2016
Guidelines for Gender Mainstreaming Categories of ADB Project	ADB	2012
Gender Tool Kit: Transport Maximizing the Benefits of Improved Mobility for All	ADB	2013
International Standard Classification of Occupations	ILO	2012
Decent Work Country Programme 2012-2015	ILO	2012
Decent Work Country Profile Bangladesh	ILO	2013

Appendix 3: List of Concerned Organizations



氏名／Name	役職／Title	所属先／Organization
Mr. A.K.M.Mizanur Rahman	Director (Joint Secretary)	Department of Women Affairs, Ministry of Women and Children Affairs
Mr. Nurul Islam Talukder	Additional Director, VGD Programme	Department of Women Affairs
Ms. Jannatul Ferdous	Research Officer, Planning and Evaluation Section	Department of Women Affairs
Ms. Farhana Akhtar	Research Officer, Planning and Evaluation Section	Department of Women Affairs
Ms. Nasheeba Selim	Social Development Specialist (Gender)	Bangladesh Resident Mission, Asian Development Bank
Ms. Sabah Moyeen	Senior Social Development Specialist	World Bank, Bangladesh Office
Ms. Kashifia Feroz	Manager, Women Rights & Gender Equity	ActionAid