

4.3 Alignment Review

4.3.1 Reconnaissance of the Available Land for KCR and KUTC Alignment Option

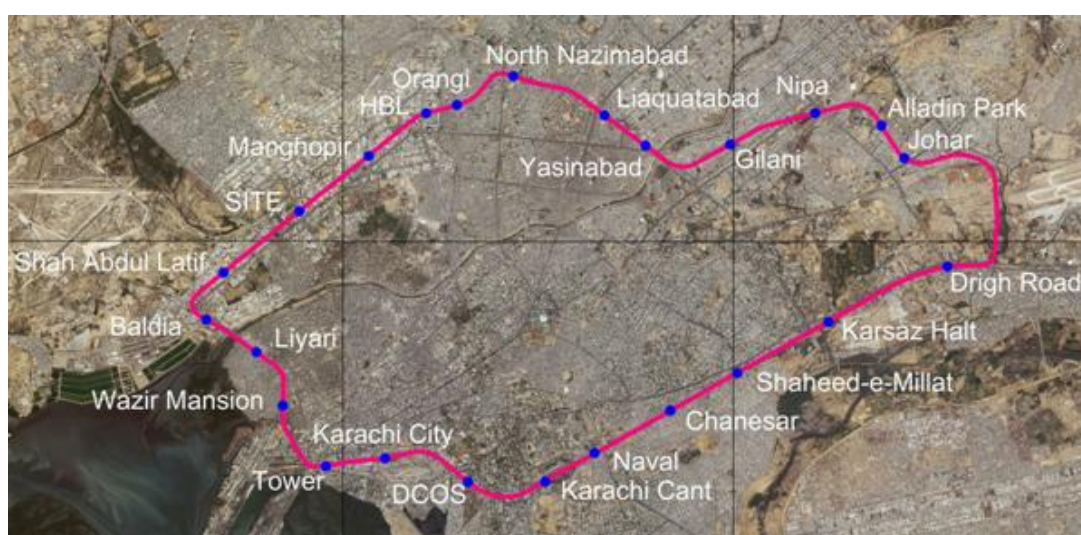
Before planning the alignment, JICA Study Team conducted reconnaissance of KUTC option of KCR alignment plan based on the available land through exchange of opinions with KUTC's technical staff. Appendix 4.2 gives detail observation at each section.

KUTC has planned 24 stations in RAP report shown in Table 4.3.1 and Figure 4.3.1.

Table 4.3.1 Station Name

No	Station Name	Type	No	Station Name	Type
1	Drigh Road	Elevated	13	Shah-Abdul-Latif	Elevated
2	Johar	Trench	14	Baldia	Elevated
3	Alladin Park	Trench	15	Liyari	Elevated
4	Nipa	On-ground	16	Wazir Mansion	On-ground
5	Giliani	Elevated	17	Tower	On-ground
6	Yasinabad	Elevated	18	Karachi City	Elevated
7	Liaquatabad	On-ground	19	DCOS	Elevated
8	North Nazimabad	On-ground	20	Karachi Cantt.	Elevated
9	Orangi	Elevated	21	Naval	On-ground
10	HBL	On-ground	22	Chanesar	On-ground
11	Manghopir	Elevated	23	Shaheed-e-Millat	On-ground
12	SITE	Elevated	24	Karsaz Halt	On-ground

Source; KUTC



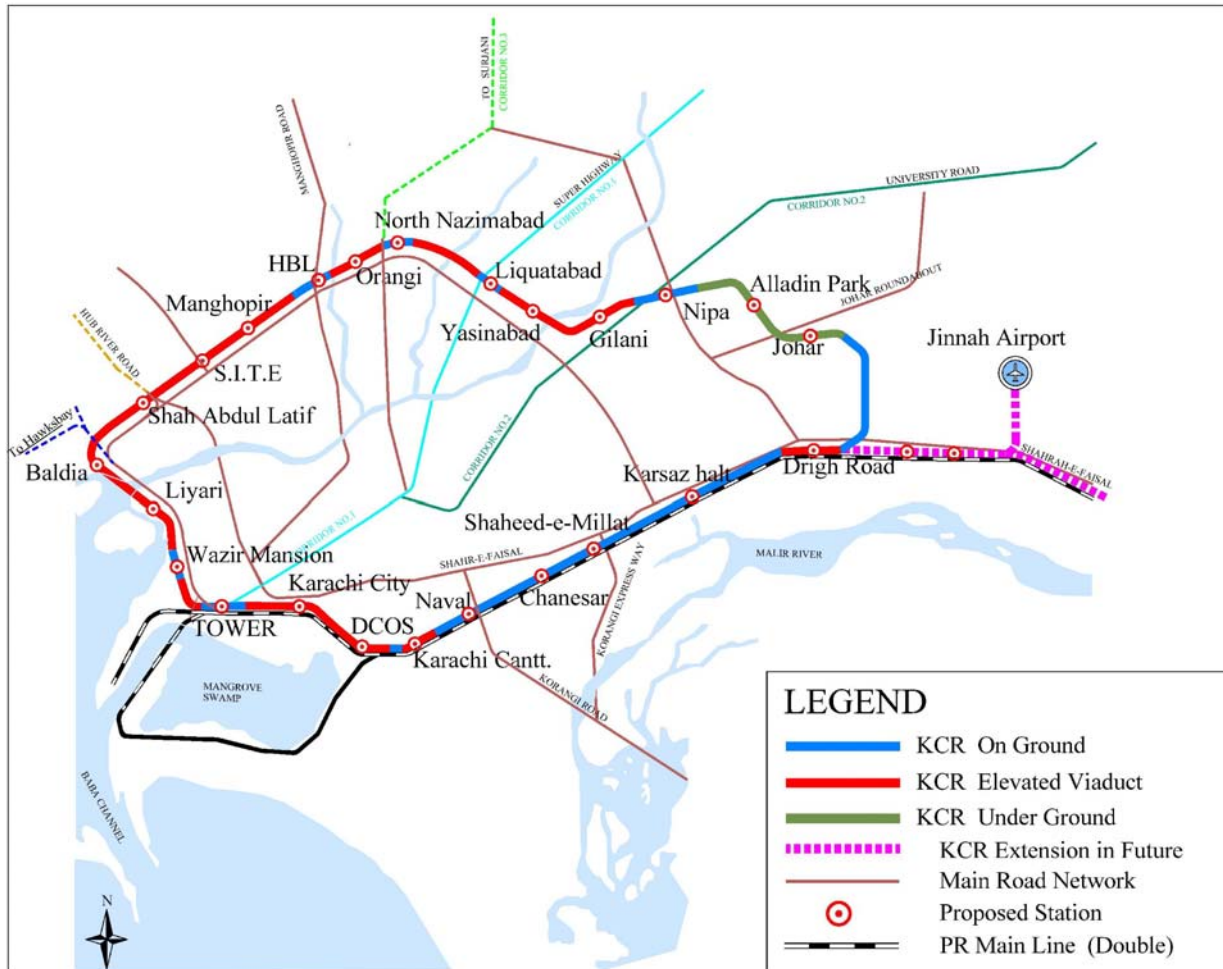
Source; JICA Study Team

Figure 4.3.1 Route Map and Station Name

4.3.2 Issues of Review

(1) Introduction of options

In SAPROF (II), JICA Study Team has studied two options: one is “Option A” which has entire circular route and the other is “Option B” where KCR operates between Drigh Road and Shah Abdul Latif via Karachi Cantt.



Source; JICA Study Team

Figure 4.3.2 Karachi Circular Railway Route Map

(2) Concept

JICA Study Team reviewed the KCR alignment based on the existing reports as data of topographic and boundary survey results have not been available yet at the time of the review.

The available reports and documents for this study are shown below:

- a) Topographic survey and boundary survey under the mentorship of KUTC
- b) Special Assistance for Project Formation for Karachi Circular Railway Project in the Islamic Republic of Pakistan (hereinafter referred to as “SAPROF (I)”)
- c) Resettlement Action Plan: Revival of KCR Final Report (hereinafter referred to as “RAP Plan”)
- d) Drawing documents composed by PR and KUTC

Furthermore, JICA Study Team modified KCR chainage from SAPROF (I), which starts from Drigh Road station in counter-clockwise direction in accordance with KUTC decision.

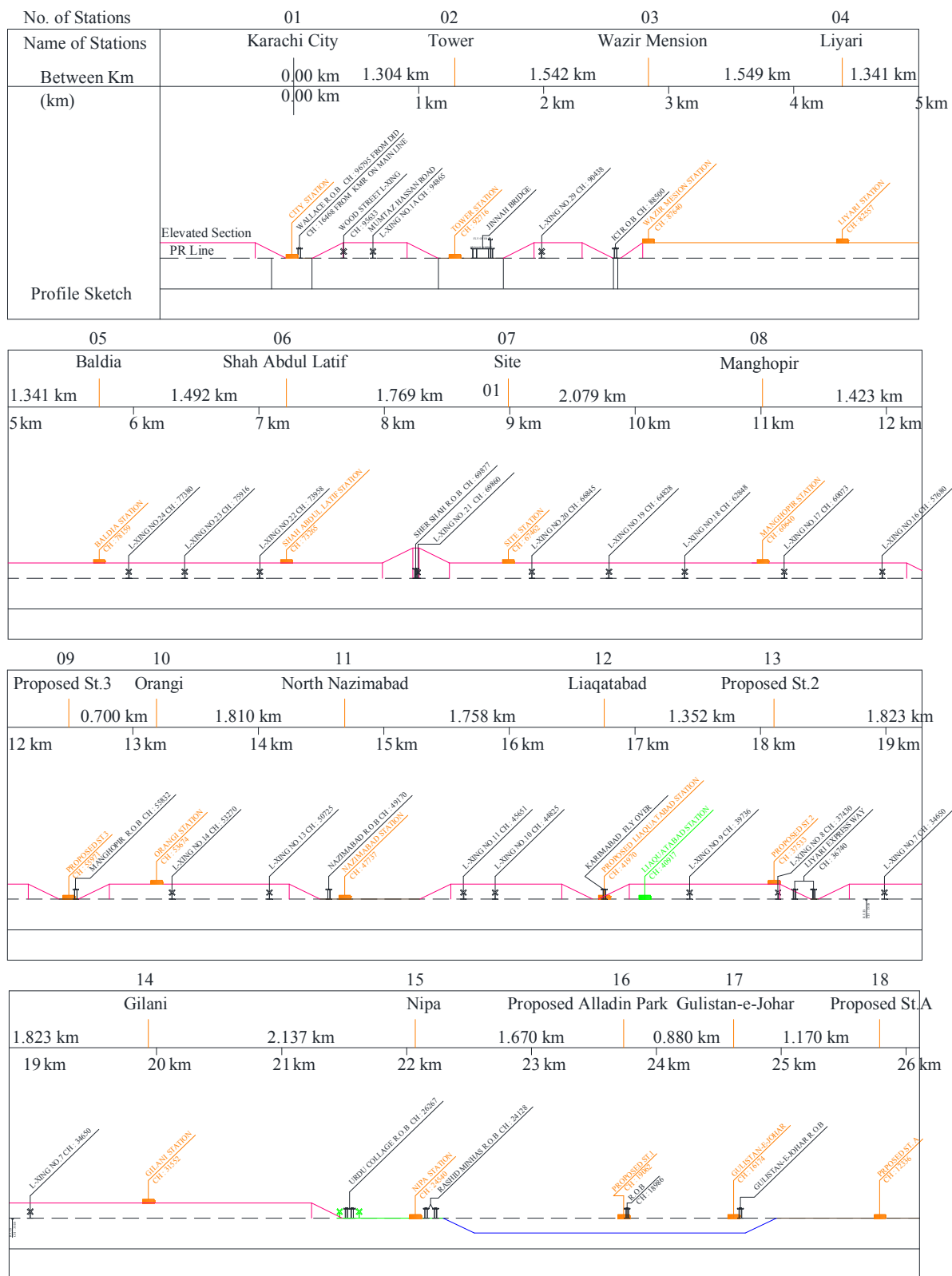
(3) Alignment and Railway Structure for Grade Separation with Roads/PR Lines

The railway structures for grade separation with roads or PR lines except on-ground track and bridge sections are planned in SAPROF (I) as shown in Table 4.3.2. And Figure 4.3.3 and Figure 4.3.4 provided by KUTC are the longitudinal profiles with crossing-roads in detail.

Table 4.3.2 Viaduct and Underpass Section Planned in SAPROF (I)

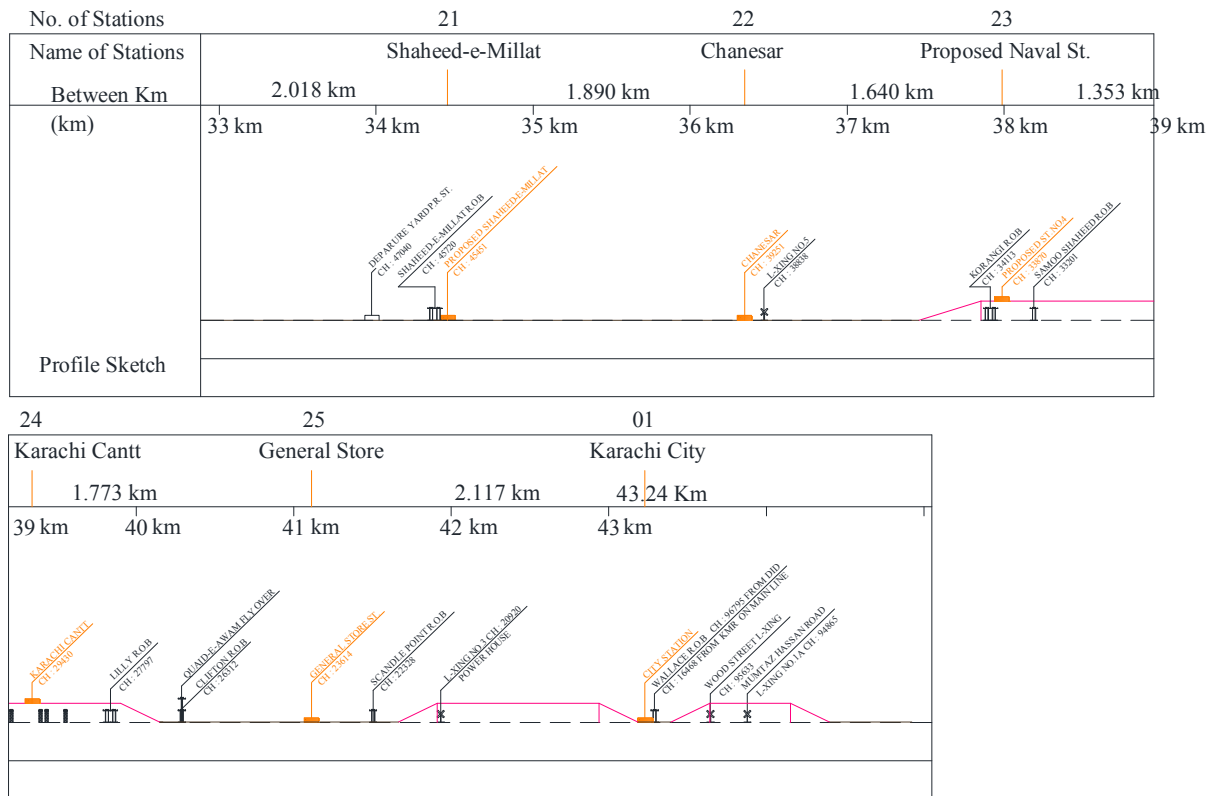
Line	Section	On-ground	Elevated	Culvert	Bridge	Total
KCR Main Line	Number of Stations	10	12	2	0	24
	Length (km)	15.68	23.68	2.28	1.42	43.24
Airport Line	Number of Stations	2	2	0		4
	Length (km)	2.69	3.31	0	0.11	6.11
Total	Number of Stations	13	13	2	0	28
	Length (km)	19.02	24.82	3.93	1.46	49.23

Source; JICA Study Team



Source; KUTC

Figure 4.3.3 Longitudinal Profile by KUTC (1/2)



Source; KUTC

Figure 4.3.4 Longitudinal Profile by KUTC (2/2)

JICA Study Team assessed the optimum KCR railway route alignment and structures with the following manners:

- 1) Route alignment and railway structure plan of KCR are made based on the results of topographic survey and boundary survey, and collected data.
- 2) Draft plan had been modified through exchange of opinions with KUTC.
- 3) Study Team conducts the examination on elevated track, railway underpass or on-ground section except the sections to be elevated due to railway-technical reasons along PR main lines.
- 4) Route alignment at parallel section to PR line is examined on the condition that any existing tracks which compete with KCR tracks are to be shifted to keep adequate clearance from KCR formation.

(4) Station Location Plan

In SAPROF (I) Report, the number of stations is planned to be 24. Then RAP Plan by KUTC was made based on SAPROF (I) Report and had original station plans.

JICA Study Team made an optimal station plan with the following manners:

- 1) The station plans of SAPROF (I) and RAP Report are reviewed based on the results of site reconnaissance and site survey.
- 2) Layout of stations is planned based on the platform type (on-ground/elevated, island/ side), width and length which JICA Study Team proposed at inception meeting.
- 3) Station plan of KCR is made based on the following principals.
 - Examination based on the results of demand forecast.
 - To consider the appropriate connection with BRT under planning and existing bus route.
 - To consider the locations which contribute to the ridership enhancement of KCR.
 - To consider PR Karachi and KUTC's opinion about the locations as far as technically possible and proper.
 - To decide through exchange of opinions with KUTC.

4.3.3 Exchange of Opinions with KUTC

Regarding the draft alignment with railway structure plan and the draft station plan, exchange of opinions were conducted between KUTC and JICA Study Team, and the following main points are agreed on by them.

- PR existing tracks will be shifted to install KCR structures in the parallel section with PR line between Tower Station to Drigh Road Station.
- Therefore, stations in the parallel section should be examined in the premise of on-ground station.
- KUTC agreed with JICA Study Team on calculation of the height of structure at each station based on the dimension of structures and construction gauge of trains/cars/ passengers and so on.

4.3.4 Railway Alignment

(1) Route Planning Process

The alignment proposed by JICA Study Team was based on the RAP Plan, site reconnaissance, partial measurement, consultation with the persons concerned, and the finding shown below.

- 1) Available land for KCR and PR land are shown in RAP Plan drawing.
- 2) PR existing line has to be partially rearranged to install KCR structures, as PR tracks are too close to KCR proposed tracks at Tower, Karachi City, Karachi Cantt., and Drigh Road Stations.
- 3) Maintenance Depot and Rolling Stock Depot are located in the premise of Wazir Mansion and Depot Hill. Also, stabling yard will be prepared at Manghopir, Gilani and Drigh Road station.
- 4) All the existing level crossings will be eliminated by grade-separation.

(2) Control Point for planning KCR Route

Alignment Plan has to be conducted to avoid or fly over or go under control points which may not be on the proposed KCR route.

Control points include level crossings, crossing roads, highway and PR tracks as shown in Table 4.3.2 and Appendix 4-3 shows major control points in KCR line.

Table 4.3.3 Control Points on Planning Route

Control Point	Remark
Drigh Road Station	Viaduct station is installed directly above PR existing Drigh Road station
(1) Drigh Road R.O.B	Existing box culvert is already installed for KCR line
(2) Depot-Hill	To be strictly kept away from army land.
(3) Rashid Minhas R.O.B	Track layout depends on the site survey (location of road pier).
(4) Liyari Expressway Flyover	KCR line is required to be planned to fly over Liyari expressway
(5) Between Liyari and Wazir Mansion	KCR line shall be planned based on boundary survey.
(6) Jinnah Bridge	There are many piers of bridge on the way.
(7) Karachi City Station	Existing tracks will be competitive with new KCR tracks.
(8) Around DCOS Station	No space to put KCR tracks under two R.O.Bs.
(9) Karachi City and Cantt. Station	Existing facilities to be rebuilt due to installation of KCR line.
(10)~(12) Parallel Section with PR Line	Limited land between boundary and PR tracks.

Source: JICA Study Team

Table 4.3.4 Control Point for Crossing Road/Track in Vertical Alignment

CH (meter)	Structure	KUTC Plan	Vertical Clearance
0	Drigh Road		
590	Underpass		
890	Drigh Road R.O.B	under ROB	5.67
1,130	Culvert		
1,650	Level Crossing (crossed with not paved road)		
2,380	Culvert		
3,920	Level Crossing		
4,840	Gulistan-e-Johar R.O.B	under ROB	8.85
4,970	Johar		
5,730	ROB	under ROB	11
5,830	Alladin Park		
7,250	Level Crossing		
7,310	Rashid Minhas R.O.B	under ROB	6.53
7,450	Nipa		
7,970	Urdu Collage R.O.B	under ROB	6
8,260	Level Crossing NO.0-1		
8,510	Level Crossing NO.0-2		
8,920	Level Crossing		
9,210	Level Crossing NO.0-4		
9,400	Gilani		
9,430	Level Crossing NO.0-5		
9,460	Level Crossing		
9,700	Level Crossing		
10,360	Level Crossing		
10,490	Level Crossing NO.7		
10,640	Culvert		
11,060	LIYARI EXPRESS WAY(1)	flyover ROB	6.09
11,080	Gharibabad Nara (River)		
~			
11,160			
11,190	LIYARI EXPRESS WAY(2)	flyover ROB	6.79
11,360	Yasinabad		
11,370	Level Crossing No.8		
12,070	Level Crossing NO.9		
12,580	Liaquatabad		
12,720	Level Crossing		
12,750	Karimabad Fly Over	under ROB	5.95
12,800	Level Crossing		
13,620	Level Crossing NO.10		

CH (meter)	Structure	KUTC Plan	Vertical Clearance
13,690	Gujar Nallah Bed (River)		
~			
13,720			
13,870	Level Crossing NO.11		
14,730	North Nazimabad		
14,900	Level Crossing		
14,950	Nazimabad R.O.B	under ROB	5.75
15,420	Level Crossing No.13		
15,900	Level Crossing		
16,170	Orangi		
16,190	Level Crossing No.14		
16,460	Orangi Nara (River)		
~			
16,540			
16,850	HBL		
16,960	Manghopir R.O.B	under ROB	5.7
17,410	Culvert		
17,520	Level Crossing No.16		
18,040	Culvert		
18,250	Level Crossing No.17		
18,410	Manghopir		
19,120	Level Crossing No.18		
19,380	Culvert		
19,720	Level Crossing No.19		
20,300	SITE		
20,330	Level Crossing No.20		
21,120	Level Crossing		
21,240	Sher Shah R.O.B	flyover ROB	8
21,260	Level Crossing No.21		
22,120	Level Crossing/ Culvert		
22,500	Shah-Abdul-Latif		
22,500	Level Crossing No.22		
23,100	Level Crossing No.23		
23,550	Level Crossing No.24		
23,850	Baldia		
23,930	R.U.B (Railway Bridge)		
~24,090			
24,390	Lyari River		
~24,620			
25,130	Liyari		
25,750	Level Crossing		
26,480	Wazir Mansion		

CH (meter)	Structure	KUTC Plan	Vertical Clearance
26,840	Level Crossing (on Wazir Mansion)		
26,890	Culvert		
26,930	ICI R.O.B	under ROB	6.05
27,380	Level Crossing		
27,530	Level Crossing No.29		
27,950	Jinnah Flyover	under ROB	17.91
27,990	Jinnah Bridge	under ROB	6.54
~28,050		under ROB	6.54
28,090	Bridge	under ROB	6.85
~28,120		under ROB	6.85
28,360	Tower		
28,870	Level Crossing (Mumtaz Hassan Road)		
29,090	Level Crossing (Wood Street)		
29,460	Wallace R.O.B	under ROB	5.05
29,600	Karachi City	On-ground	
30,800	Level Crossing No.3		
31,170	Culvert		
31,250	Scandle R.O.B	under ROB	4.95
31,650	DCOS	On-ground	
31,930	Culvert		
32,460	Quaid-e-Awam Fly Over, Clifton R.O.B	under ROB	15.72
32,460		under ROB	5.05
32,920	Lilly R.O.B	under ROB	6.4
33,340	Karachi Cantt.		
34,560	Samoo Shaheed R.O.B	under ROB	5.7
34,700	Naval		
34,840	Korangi R.O.B	under ROB	5.6
35,910	R.U.B (Railway Bridge)		
36,280	Level Crossing No.5		
36,520	Chanesar		
36,590	Culvert		
37,370	Culvert		
38,160	Shaheed-e-Millat		
38,380	Shaheed-e-Millat R.O.B	under ROB	6.3
38,780	Departure Yard P.R. St.		
39,870	Culvert		
40,210	Culvert		
40,400	Karsaz Halt		
40,410	Culvert		
40,620	Culvert		
40,980	Culvert		
40,990	Culvert		

CH (meter)	Structure	KUTC Plan	Vertical Clearance
41,800	Level Crossing (non-paved road)		
42,260	Bridge	under ROB	6.5
42,340	Level Crossing		

Source: JICA Study Team

(3) Rail Level at Elevated Section

JICA Study Team calculated the rail level (hereinafter referred as “RL”) of KCR based on the construction gauge as shown in Table 4.3.5.

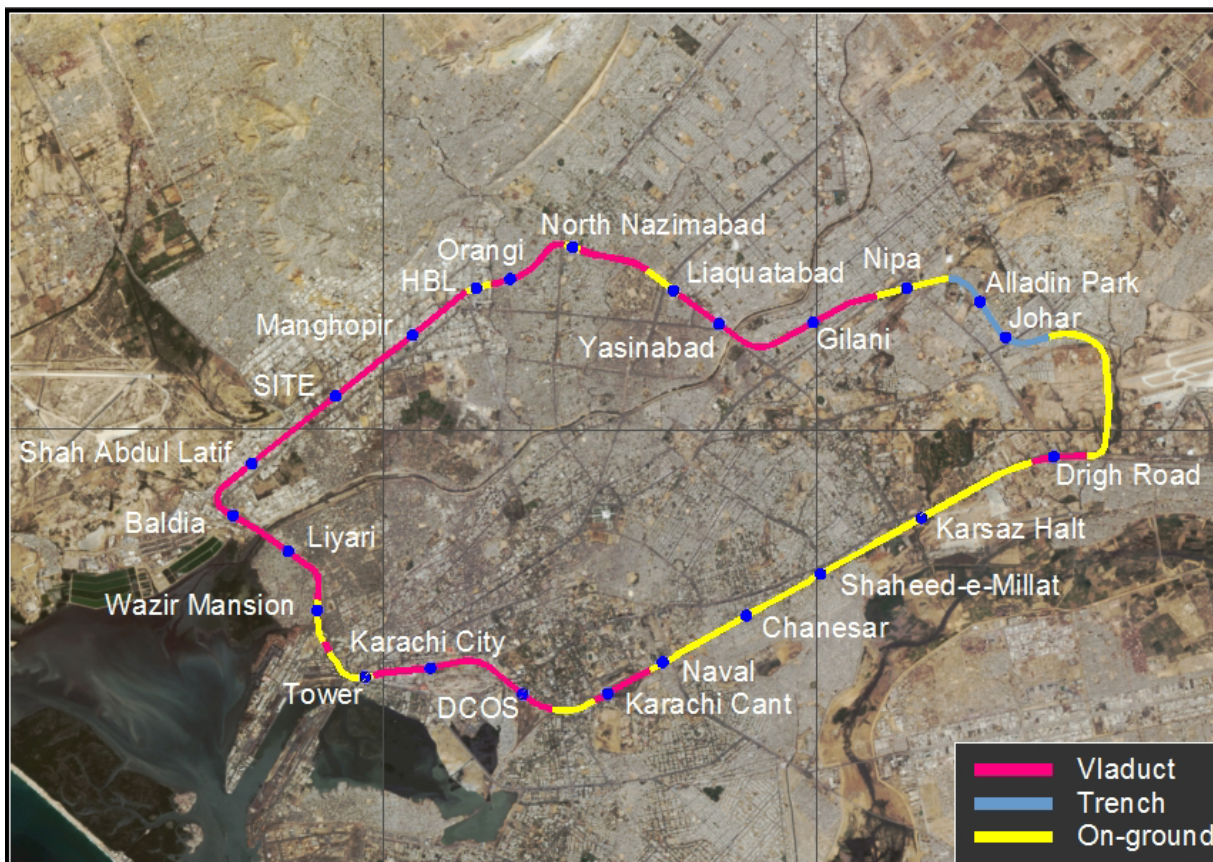
Table 4.3.5 Verification of Rail Level at Elevated Section

Section	Karachi Cantt.	Viaduct between stations Over-bridge
RL ~ Slab Level	0.7 m	0.7 m
Depth of main girder	2.0 m	2.0~3.5 m (depends on span)
Sign, light, etc	1.0 m	
Depth of concourse slab	2.5 m (including floor cover)	-
Construction gauge	6.35m (PR) 2.5 m (passenger)	6.0 m (vehicle)
RL ~ Ground Level	Min. 15.1 m	Min. 8.7 ~ 10.2 m

Source; JICA Study Team

(4) Proposed Alignment and Structures

The proposed alignment of KCR and arrangement of structures as the result of above review are shown in Figure 4.3.5 and Table 4.3.6.



Source; JICA Study Team

Figure 4.3.5 Draft Route and Alignment / Stations and Structures

Table 4.3.6 Elevated and Underpass Section Planned by SAPROF(I) and (II)

Source	On-ground (km)	Viaduct (km)	Culvert (km)	Bridge (km)	Total (km)
SAPROF(I) Circular Line	16.33	21.51	3.93	1.35	43.12
SAPROF(II) Option N-A	15.68	23.86	2.28	1.42	43.24
SAPROF(II) Option N-B	9.77	10.2	-	0.76	20.73

Source; SAPROF-I Report, JICA Study Team

4.3.5 Station Location and Type

(1) Review of RAP Plan and SAPROF (I)

JICA Study Team reviewed station plans in RAP Plan and SAPROF (I) Report considering results of site reconnaissance. Also, JICA Study Team proposed to change their station type, for example, from island platform to side platform. Such changes are mainly due to land availability, train operation plan and situations of crossroads.

Station plan is shown in Table 4.3.7 and the reviewed drawings are shown in Appendix 4-4.

Table 4.3.7 Station Plan (Chainage)

No.	Station Name	Station Type		Remark
		RAP Report	SAPROF(II)	
1	Drigh Road	-	Elevated, 2-Islands	Station for 4 tracks
2	Johar	Underground, Side	Underground, Side	
3	Alladin Park	Underground, Side	Underground, Side	
4	Nipa	On-ground, 2-Islands	On-ground, Island	Sidetrack unnecessary
5	Gilani	Elevated, 2-Islands	Elevated, 2-Islands	
6	Yasinabad	On-ground, Side	Elevated, Side	Clearance shortage
7	Liaquatabad	On-ground, Side	On-ground, Side	
8	North Nazimabad	On-ground, Side	On-ground, Side	Subject to change to elevated station due to road improvement
9	Orangi	Elevated, Side	Elevated, Island	Land shortage
10	HBL	On-ground, Side	On-ground, Side	
11	Manghopir	Elevated, Side	Elevated, 2-Islands	Loop-line required
12	SITE	Elevated, Side	Elevated, Side	
13	Shah-Abdul-Latif	Elevated	Elevated, Side	To fit to Land shape
14	Baldia	Elevated, Side	Elevated, Side	
15	Liyari	Elevated, 2-Islands	Elevated, 2-Islands	
16	Wazir Mansion	Elevated, Island	On-ground, Island	Economical issue
17	Tower	On-ground, Island	On-ground, Island	PR Shifting
18	Karachi City	On-ground, Island	Elevated, Island	Clearance shortage
19	DCOS	On-ground, Island	Elevated, Island	Clearance shortage
20	Karachi Cantt.	Elevated, Side	Elevated, Island	Location shifted
21	Naval	Elevated, Island	On-ground, Island	PR Shifting
22	Chanesar	On-ground, Island	On-ground, Island	
23	Shaheed-e-Millat	On-ground, Side	On-ground, Side	
24	Karsaz Halt	On-ground, Island	On-ground, Island	

Source: JICA Study Team

(2) Review of some stations from the point of Cross Section

Study Team found alignment issues regarding upper clearance in ROB section between Tower and DCOS. As a result of topographic survey, it is necessary to change the original plan in these stations.

The details are as follows. And at the basic design study stage, this issue should be fully checked.

1) Karachi Cantt. Station

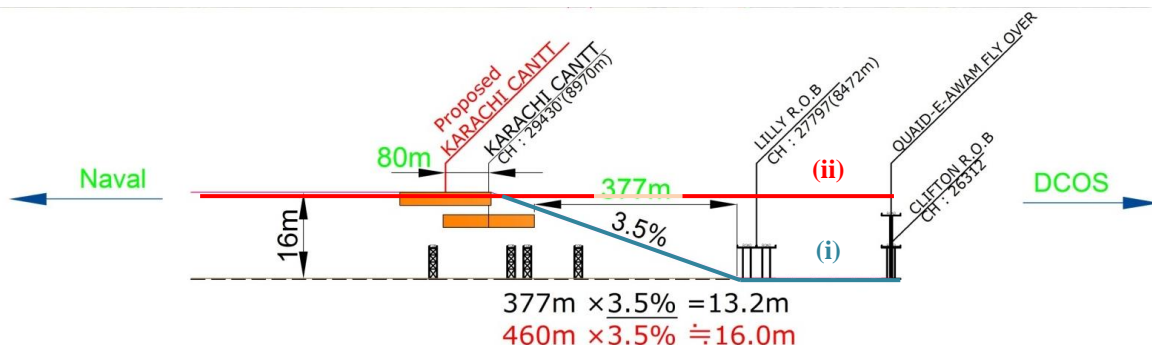
JICA Study Team also reviewed cross section drawings at Karachi Cantt Station which PR had prepared as shown in Figure 4.3.8. According to this drawing, rail level at the station is only 11 m high above the ground level despite 16 m required in standard design calculation by JICA Study Team as

shown in Figure 4.3.9.

JICA Study Team confirmed PR had considered less clearance for passengers and PR construction gauge than that in Table 4.3.5.

JICA Study Team proposes the following two options (See Figure 4.3.6) to keep the height of the station viaducts.

- i) To move the location of Karachi Cantt Station toward Naval.
- ii) To elevate KCR before Quaid-e-awam flyover without moving original location.



Source; JICA Study Team

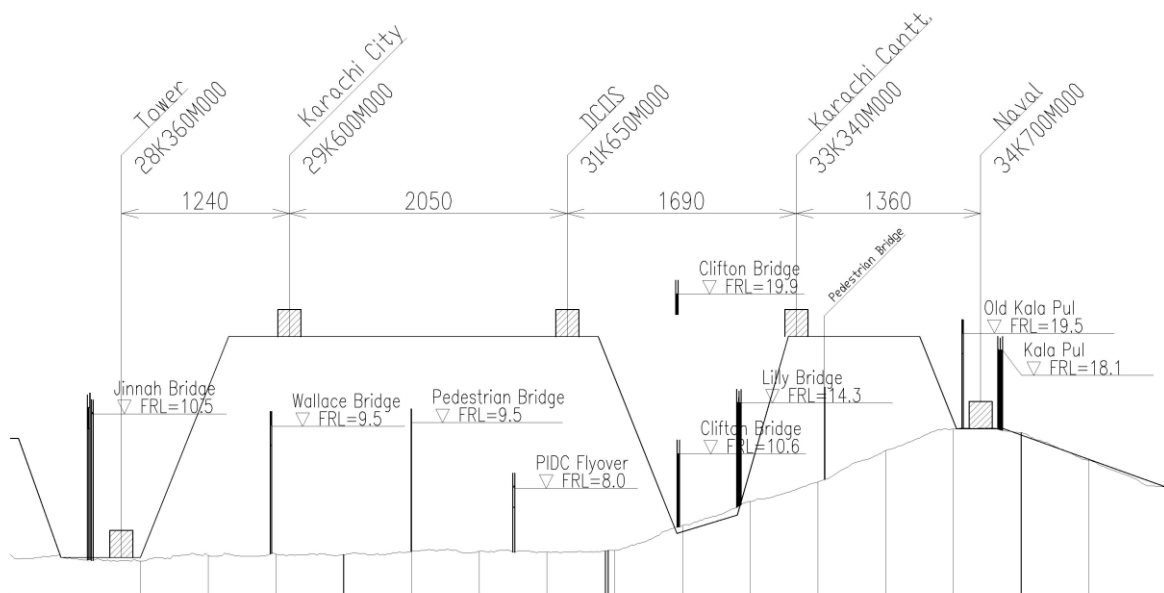
Figure 4.3.6 Comparison of Longitudinal Profiles near Karachi Cantt. Station

KUTC agreed to adopt Option (i) on the condition that JICA Study Team should make efforts to minimize the moving distance.

2) Karachi City Station and DCOS Station

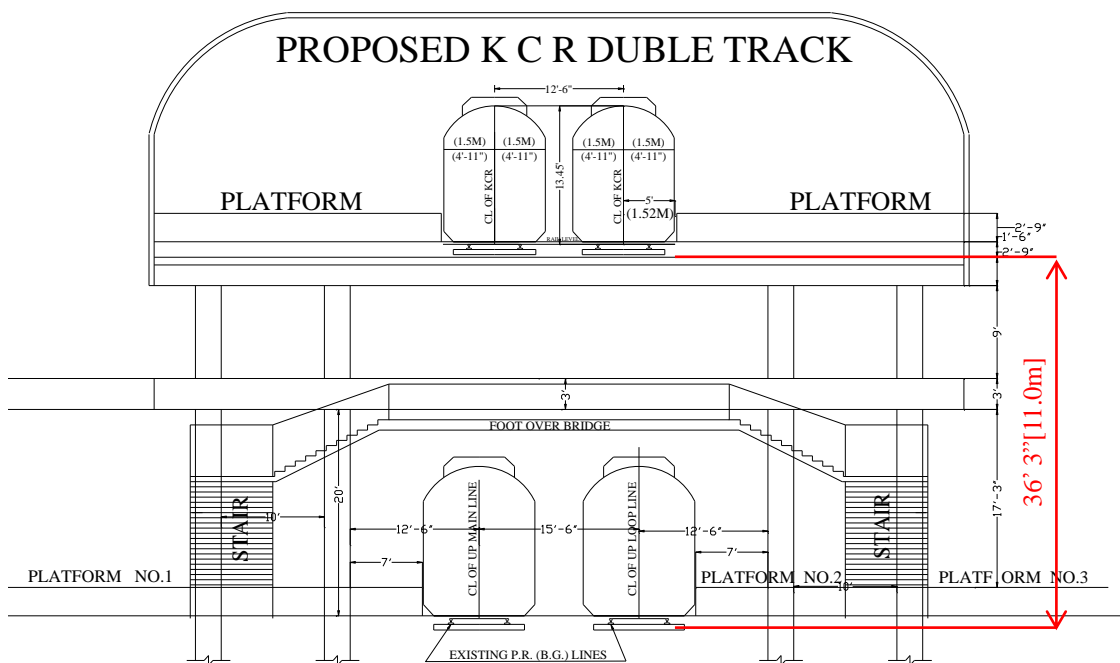
As shown in Table 4.3.7, there Karachi City Station and DCOS Station have an issue of clearance shortage to be solved. In spite of big efforts for examination to find the solution, there is no way but change from an on-ground station to an elevated type. Therefore, these both stations are changed to viaduct station.

In addition, this change can also provide advantage of smaller shifting of existing PR facilities in Karachi City Station to accommodate KCR facility.



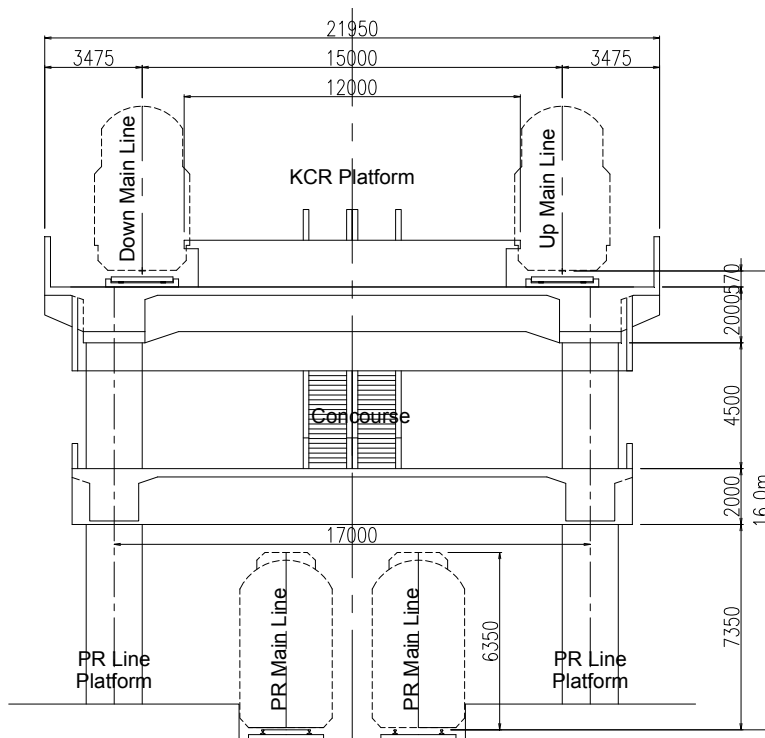
Source; JICA Study Team

Figure 4.3.7 Examination on the level of KCR around Karachi City Station



Source; KUTC

Figure 4.3.8 Cross Section at Karachi Cantt. Station Viaduct Prepared by PR



Source; JICA Study Team

Figure 4.3.9 Reviewed Cross Section at Karachi Cantt Station Viaduct

4.3.6 Track Layout

Final schematic track layouts for Option N-A and Option N-B are presented in Figure 4.3.10 and Figure 4.3.11 respectively.

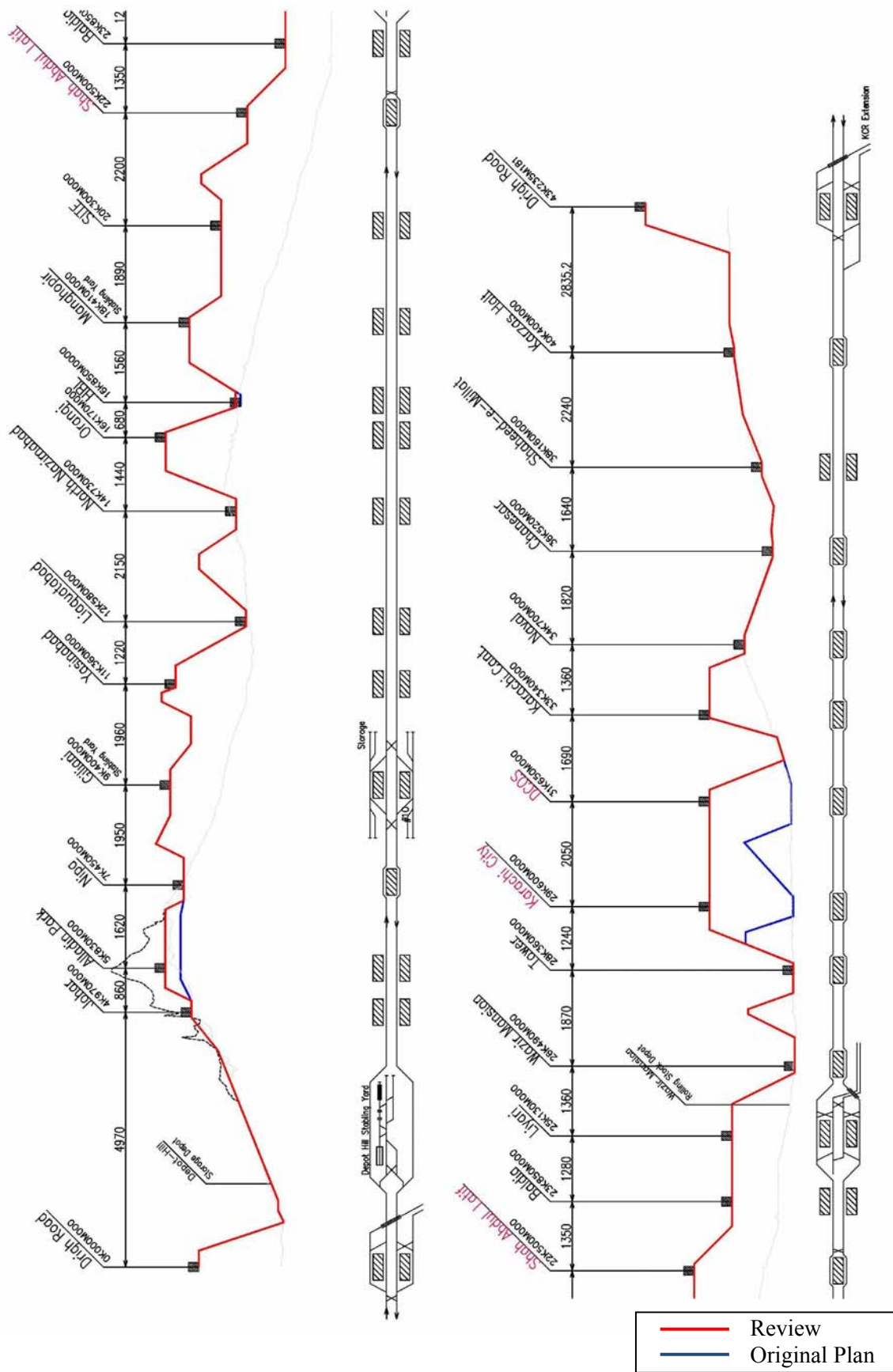
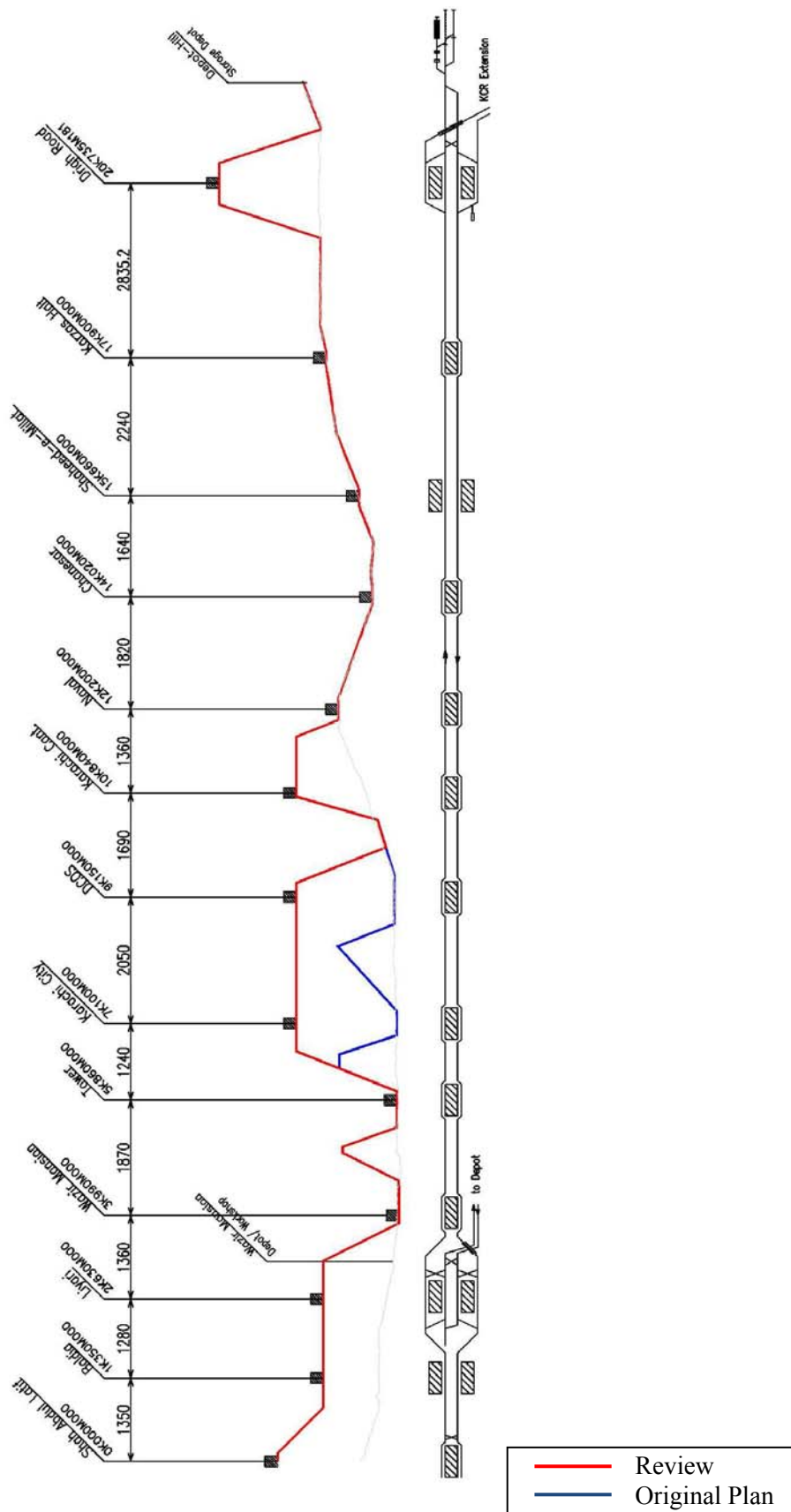


Figure 4.3.10 Schematic Track Layout for Option N-A



Source; JICA Study Team

Figure 4.3.11 Schematic Track Layout for Option N-B

4.3.7 Route Plan

JICA Study Team finalized KCR alignment through review and the site survey. Proposed alignment diagrams composed of plan drawings and longitudinal profile indicate KCR main tracks, sub tracks to depot/ workshop and proposed KCR ROW.

Especially in the section between Tower and Drigh Road, JICA Study Team indicates the formation width for KCR to clarify which PR tracks are competing with KCR structures.

Alignment diagrams and specification are shown in Appendix 4-5.

5. REVIEW OF PRELIMINARY DESIGN

5.1 Train Operation Plan

5.1.1 Purpose

The purposes of the train operation plans of SAPROF-II are as follows:

- A. To review the basic conditions of KCR train operation plans proposed at the beginning of this study in March 2012.
- B. To examine the optimum train formations and train operation headways from the opening 2022 to 2051 based on the reviewed demand forecast and the revised alignment plan using the new topographic map.
- C. To draw up the train diagrams of the opening year of KCR and that of KCR Extension Line, that is, 2022 and 2030 respectively based on two reviewed projected demand of the complete loop line plan (N-A1 and N-A2 options) and one partial operation plan (N-B1) and estimates the required number of train sets of each year from 2022 to 2050 for the three options.
- D. To provide the necessary data for examination of KCR track layout plans which make it possible to implement the frequent and stable train operations which satisfy transportation of the projected demands from 2022 to 2051.

5.1.2 Review of Basic Conditions for Train Operation Plan of KCR

(1) Proposed Rolling Stock for KCR

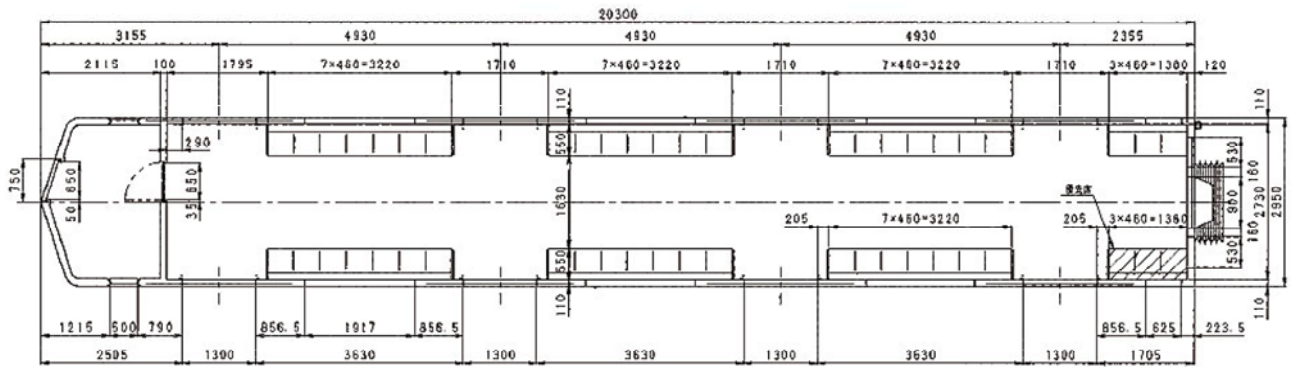
SAROF-I proposed that rolling stock to be used for KCR is a train set of multiple unit system based on the Japanese urban railway standards. Since alternative current 25kV x 2 (called AT system in Japan) is recommended for the KCR electric power system, multiple unit rolling stock with the same quality performance as TX-2000 series, which are used in Tsukuba Express (TX) Ltd, is planned as the proposed rolling stock of KCR.

The reasons why TX rolling stock was selected as the model rolling stock of KCR are as follows.

- A. To contribute to congestion reduction by transfer of trips from CBD radial road network to KCR, reduction of required time between KCR stations is very important by using rolling stock with high maximum speed performance because of the rather long average distance between stations (1.8 km). The TX-2000 series rolling stock has performance to satisfy such required conditions.
- B. TX has alternative current section between Moriya and Tsukuba and TX 2000 series have 25kVx2 traction system (cum direct current traction system).
- C. TX is a newly constructed railway completely separated from other railways and its situations are similar to KCR.

The reviews of train operation revealed that the average speed of KCR could be 43 km/h, which was expected to increase the projected demand of KCR by 10% or more. Therefore, JICA Study Team proposed the rolling stock having the same train operation curve performance as TX-2000 series.

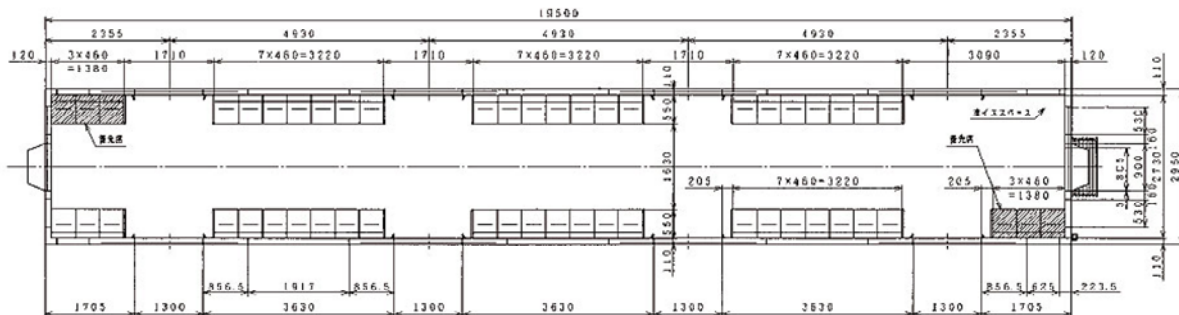
A TX train set of 6-car formation consists of 4 motor cars and 2 trailer cars (4M2T). The trailer type car (Tc) is used as head car and rear car. The head and rear type of TX-2000 series (called TX-2100) has no motor as shown in Figure 5.1.1.



Source: TX Technical Documents of Hitachi Ltd.

Figure 5.1.1 TX-2100

The TX 2000 series trains use two motor-car sets of TX-2200 (M1) and TX-3300 (M2). TX-2200 and TX-3300 are different in devices layout under car body and paired, but same in seat arrangement inside car body as shown in. A 6-car train set of TX 2000 series composes 2 TX-2100 cars and 2 motor-car sets of TX-2200 and TX-3300.



Source: TX Technical Documents of Hitachi Ltd.

Figure 5.1.2 TX-2200 or TX-2300 (Long Seats Type)

In the case of 4-car formation, a train set consists of 1 motor-car pair of TX-2200 & TX-2300 and 2 TX-2100 (2M2T). **However, in this case, improvement for increasing auxiliary power system from one set to two sets is required taking into account the air temperature of Karachi.**

The floor space for standing passengers inside cars is calculated as follows.

1) Floor Space of TX-2100

According to E7103 of Japan Industrial Standards (JIS) which provides a calculation method for the floor space of railway rolling stock, the floor space of TX-2100 is calculated referring to Figure 5.1.1 as follows:

a) Calculation of total inside floor space of a car

- Inside length of passenger space of a car: 17.965 m
- Inside width of passenger space of a car: 2.730 m
- Therefore, total inside floor space=17.965 x 2.730 = 49.044 m²

b) Calculation of total seats space of a car

- Depth of seat: 0.550 m
- Knee space: 0.250 m
- Total depth: 0.55+0.25 = 0.800 m

- Total length of seats for one side: 11.040 m
- Therefore, Total seat space of a car: $11.040 \times 0.800 \times 2 = 17.664 \text{ m}^2$

c) The available space for standing passengers

$$\mathbf{a - b = 49.044 - 17.664 = 31.38 \text{ m}^2}$$

2) Floor Space of TX-2200

As well, the floor space of TX-2200 is also calculated referring to Figure 5.1.2 as follows:

a) Inside Total Floor Space

- Inside length of a car: 19.260 m
- Inside width of a car: 2.730 m
- Therefore, Total inside floor space = $19.260 \times 2.730 \text{ m} = 52.5798 \text{ m}^2$

b) Total Seats Space

- Seats depth including knee space: $0.550 \text{ m} + 0.250 \text{ m} = 0.800 \text{ m}$
- Total seats length of left side: 12.420 m
- Total seats length of right side: 11.040 m
- Therefore, total seats space = $0.800 \times (12.420 + 11.040) = 18.768 \text{ m}^2$

c) The available space for standing passengers

$$\mathbf{a - b = 52.5798 - 18.768 = 33.81 \text{ m}^2}$$

(2) Passenger Capacity of Train Set

Generally, 4-car train formation has the following advantages than 6-car formation.

- Four-car train formation can provide more frequent service than 6-car formation.
- The total number of cars required with 4-car formations is less than that of 6-car formations.
- Electricity consumption of 4-car formations is less than that of 6-car, and the electricity fluctuations of 4-car formations are smaller than that of 6-car as well.
- Since 4-car operations can reduce platform length and effective length of tracks in stations and yards, the initial project cost can be reduced.

However, if headways of 4-car operations become short as 4 minutes due to the passenger demand, it would be difficult for a new railway company to perform punctual and stable train operations. Therefore, JICA Study Team determined headways of 4-car formations for the demand of KCR. The result showed that the headways would be 5 minutes or longer, so 4-car formations would have sufficient capacity for the passenger demand at the opening. Hence, 4-car train formation was proposed for KCR.

The passenger capacities of 4-car, 6-car and 8-car formation applied in the study are shown in Table 5.1.1, Table 5.1.2 and Table 5.1.3, respectively. They are based on the seats arrangement and passengers/m² of TX-2100 and pair of TX-2200 and TX-2300 collected from Metropolitan Intercity Railway Company known as TX in Japan.

Table 5.1.1 Passenger Capacities of a 4-car Formation

Car No. of a Train Set	1			2			3			4			Total			Total Space for Standing	Pass/m ²
	Se	St	T	Se	St	T	Se	St	T	Se	St	T	Se	St	GT		
100% of Normal Capacity	48	99	147	51	107	158	51	107	158	48	99	147	198	412	610	130.38	3.2
150% of Normal Capacity	48	148	196	51	160	211	51	160	211	48	148	196	198	616	814	130.38	4.7
180% of Normal Capacity	48	178	226	51	192	243	51	192	243	48	178	226	198	740	938	130.38	5.7
200% of Normal Capacity	48	198	246	51	214	265	51	214	265	48	198	246	198	824	1022	130.38	6.3
Remark	Se: No. of seated passengers, St: No. of standing passengers, T: Total, GT: Grand Total																

Source: Metropolitan Intercity Railway Company

Table 5.1.2 Passenger Capacity of 6-car Formation

Car No. of a Train Set	1			2			3			4			5			6			Total			Total Space for Standing	Pass/m ²
	Se	St	T	Se	St	T	Se	St	T	Se	St	T	Se	St	T	Se	St	GT					
100% of Normal Capacity	48	99	147	51	107	158	51	107	158	51	107	158	51	107	158	48	99	147	300	575	875	198.0	3.2
150% of Normal Capacity	48	148	196	51	160	211	51	160	211	51	160	211	51	160	211	48	148	196	300	936	1236	198.0	4.7
180% of Normal Capacity	48	178	226	51	192	243	51	192	243	51	192	243	51	192	243	48	178	226	300	1124	1424	198.0	5.7
200% of Normal Capacity	48	198	246	51	214	265	51	214	265	51	214	265	51	214	265	48	198	246	300	1252	1552	198.0	6.3
Remark	Se: No. of seated passengers, St: No. of standing passengers, T: Total, GT: Grand Total																						

Source: Metropolitan Intercity Railway Company

Table 5.1.3 Passenger Capacity of 8-car Formations

Car No. of a Train Set	1			2			3			4			5			6			7			8			Total			Total Space for Standing	Pass/m ²
	Se	St	T	Se	St	T	Se	St	T	Se	St	T	Se	St	T	Se	St	T	Se	St	T	Se	St	GT					
100% of Normal Capacity	48	99	147	51	107	158	51	107	158	48	99	147	48	99	147	51	107	158	51	107	158	48	99	147	396	824	1220	130.38	3.2
150% of Normal Capacity	48	148	196	51	160	211	51	160	211	48	148	196	48	148	196	51	160	211	51	160	211	48	148	196	396	1232	1628	130.38	4.7
180% of Normal Capacity	48	178	226	51	192	243	51	192	243	48	178	226	48	178	226	51	192	243	51	192	243	48	178	226	396	1480	1876	130.38	5.7
200% of Normal Capacity	48	198	246	51	214	265	51	214	265	48	198	246	48	198	246	51	214	265	51	214	265	48	198	246	396	1648	2044	130.38	6.3
Remark	Se: No. of seated passengers, St: No. of standing passengers, T: Total, GT: Grand Total																												

Source: Metropolitan Intercity Railway Company

(3) Transportation Capacity of TX Rolling Stock by Headways

The number of trains per hour at planning stage is planned in SAPROF-I on the premise that the congestion rate of trains is allowed up to 150% of normal accommodation capacity, which stands for 4.7 passengers/m² for standing passengers. SAPROF-I also recommends that train operation frequency should be increased at the stage when the congestion rate reaches to 180% or more of normal accommodation capacity which stands for 5.7 passengers/m², because allocation of pusher men on platforms are required to shut the doors for trains operations with more than 190% of normal accommodation capacity.

However, the European rolling stock companies use different basis of 6 passengers/m² for the floor space without seats to only show the accommodation capacity of a car. Due to this reason some staff of KUTC insisted to plan the train operation based on 200% of normal accommodation capacity at the opening stage. If the train operation is planned in such a manner, it would be very difficult for passengers to get off and ride on during peak hour even at the opening stage. There would be no room to meet the increasing future demand. In fact, in Europe they never use this basis for the actual train operation, and in Singapore the average car occupancy of SMRT is only 70.1% in 2010 according to their annual report. Therefore, JICA Study Team planned the KCR train operation based on the same method as that of SAPROF-I, and KUTC agreed to this approach.

Congestion Rate 150% (Estimated)**Congestion Rate 190% (Estimated)**

Source: JICA Study Team

Congestion Rate 200% (Estimated)

The doors do not slide smoothly due to too many passengers and pusher men are arranged on platforms of Tokyo Metro.



Source: JICA Study Team

As the results of interaction with KUTC, the transportation capacities of 4-car operation, 6-car operation and 8-car operation by headways in the case of TX rolling stock are calculated by the following formula as shown in Table 5.1.4.

- Formula for Planning: 150% accommodation capacity of a train x number of trains/h
- Formula for Timing of increase of number of trains/h:
180% accommodation capacity of a train x number of trains/h

Train operation plan shall be based on the projected maximum section passenger volume between stations.

Table 5.1.4 Transportation Capacity/hour of 4-car, 6-car and 8-car and 4-car & 8-car Mixed Train Operations

Headways	4-car Operation			6-car Operation			8-car Operation		
	100% accommodation	150% accommodation	180% accommodation	100% accommodation	150% accommodation	180% accommodation	100% accommodation	150% accommodation	180% accommodation
Basic Capacity/train	610	814	938	926	1,236	1,424	1,242	1,658	1,910
16m (3.75 trains/h)	2,288	3,053	3,518	3,473	4,635	5,340	4,658	6,218	7,163
15m (4 trains/h)	2,440	3,256	3,752	3,704	4,944	5,696	4,968	6,632	7,640
13m20s (4.5 trains/h)	2,745	3,663	4,221	4,167	5,562	6,408	5,589	7,461	8,595
12m (5 trains/h)	3,050	4,070	4,690	4,630	6,180	7,120	6,210	8,290	9,550
10m (6 trains/h)	3,660	4,884	5,628	5,556	7,416	8,544	7,452	9,948	11,460
8m (7.5 trains/h)	4,575	6,105	7,035	6,945	9,270	10,680	9,315	12,435	14,325
7.5m (8 trains/h)	4,880	6,512	7,504	7,408	9,888	11,392	9,936	13,264	15,280
6m40s (9 trains/h)	5,490	7,326	8,442	8,334	11,124	12,816	11,178	14,922	17,190
6m (10 trains/h)	6,100	8,140	9,380	9,260	12,360	14,240	12,420	16,580	19,100
5m (12 trains/h)	7,320	9,768	11,256	11,112	14,832	17,088	14,904	19,896	22,920
4m (15 trains/h)	9,150	12,210	14,070	13,890	18,540	21,360	18,630	24,870	28,650
3m20s (18 trains/h)	10,980	14,652	16,884	16,668	22,248	25,632	22,356	29,844	34,380
3m (20 trains/h)	12,200	16,280	18,760	18,520	24,720	28,480	24,840	33,160	38,200
2.5m (24 trains/h)	14,640	19,536	22,512	22,224	29,664	34,176	29,808	39,792	45,840
2m (30 trains/h)	18,300	24,420	28,140	27,780	37,080	42,720	37,260	49,740	57,300

Table 5.1.5 Transportation Capacity/hour of 4-car, 6-car and 8-car and 4-car & 8-car Mixed Train Operations

Car Formation	4-car			8-car			4-car & 8car Mixed Train Operation	
	150%	180%	180%	150%	180%	180%	150%	180%
Congestion Rate	6,105	7,035	7,504	6,632	7,640	7,640	12,737	14,875
8m/4car+16m/8car	6,512	7,504	8,442	7,461	8,595	8,595	13,144	15,144
7.5m/4car+15m/8car	7,326	8,442	9,380	8,290	9,550	9,550	14,787	17,037
6m40s/4car+13m20/8	8,140	9,380	11,256	9,948	11,460	11,460	16,430	18,930
6m/4-car+12m/8-car	9,768	11,256	14,070	12,435	14,325	14,325	19,716	22,716
5m/4-car+10m/8-car	12,210	14,070					24,645	28,395
4m/8-car + 8m/8-car								

Source: JICA Study Team

(4) Stopping Time at Stations

The stopping time at stations proposed in SAPROF-1 was reviewed referring to BTS in Bangkok, Delhi Metro and SMRT in Singapore, and the revised stopping time at stations is as shown in Table 5.1.6.

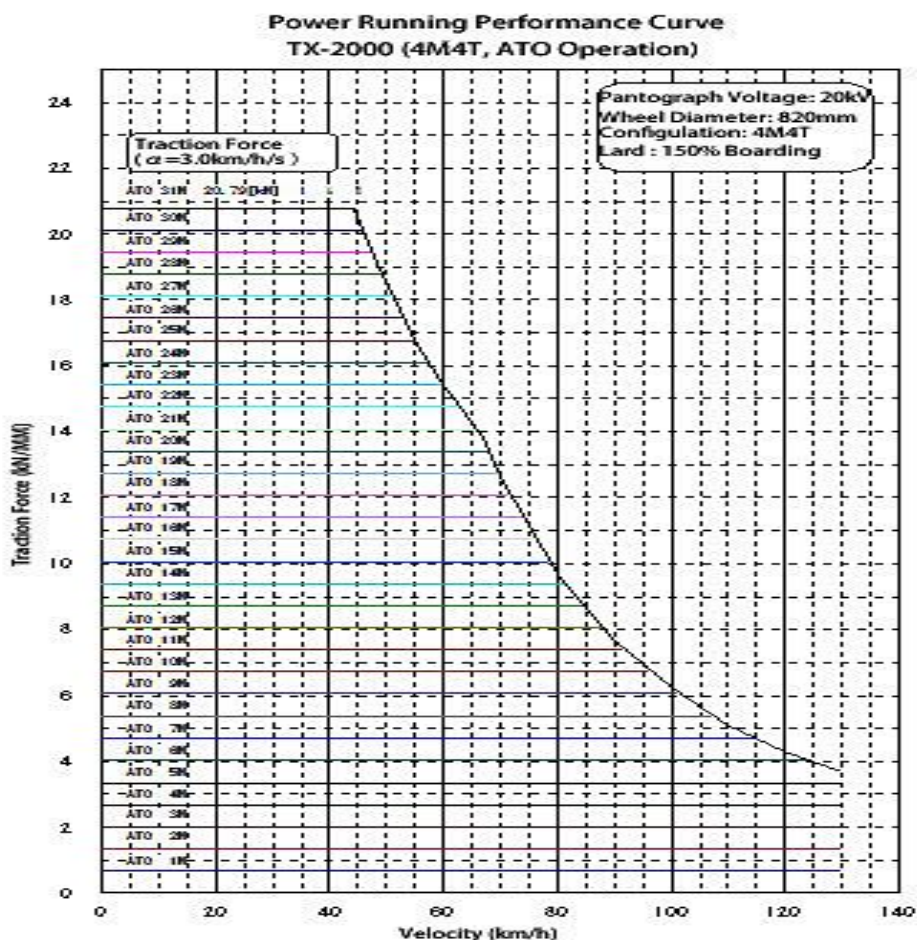
Table 5.1.6 Stopping Time at KCR Stations

Station Name	Drigh Road	Johar	Alladin Park	Nipa	Gilani	Yashinabad
Stopping Time (Second)	60	30	30	30	30	30
Station Name	Liaquatbad	North Nazimabad	Orangi	HBL	Manghopir	SITE
Stopping Time (Second)	30	30	30	30	30	30
Station Name	Shah Abdul Ratif	Baldia	Liari	Wazir Mansion	Tower	Karachi City
Stopping Time (Second)	30	30	60	30	30	30
Station Name	DCOS	Karachi Cantt	Naval	Chanesar	Shaheed-e-Millat	Karzas Halt
Stopping Time (Second)	30	60	30	30	30	30

Source; JICA Study Team

(5) Power Running Traction Force-Speed Performance Curve of TX 2000

To assess running time between stations, the train operation curve shall be drawn based on the power running pull-speed performance curve of TX 2000 shown in Figure 5.1.3, curve data, gradient data, and so on.



Source; Materials provided by Hitachi Ltd.

Figure 5.1.3 Traction Force-Speed Performance Curve of TX2000

(6) Time Zone of A Day (Peak Hour, Semi-peak Hour and Off-peak Hour)

Time zones of Karachi proposed by SAPROF-I based on the examinations of JICA 2005 Bus Survey data in Karachi were slightly revised by request of KUTC as shown in Table 5.1.7.

The train operation planning is conducted based on the revised time zones.

Table 5.1.7 Time Zone (Peak Hour, Semi-peak Hour and Off-peak Hour)

Time Zone	Morning	Daytime	Evening	Percentage by Daily Passengers (%)
Peak Hour	7:00-11:00	-	16:00-21:00	7.3
Semi-Peak Hour	11:00-13:00	15:00-16:00	21:00-22:00	6.0
Off-Peak Hour	6:00-7:00	13:00-15:00	22:00-23:30	4.8

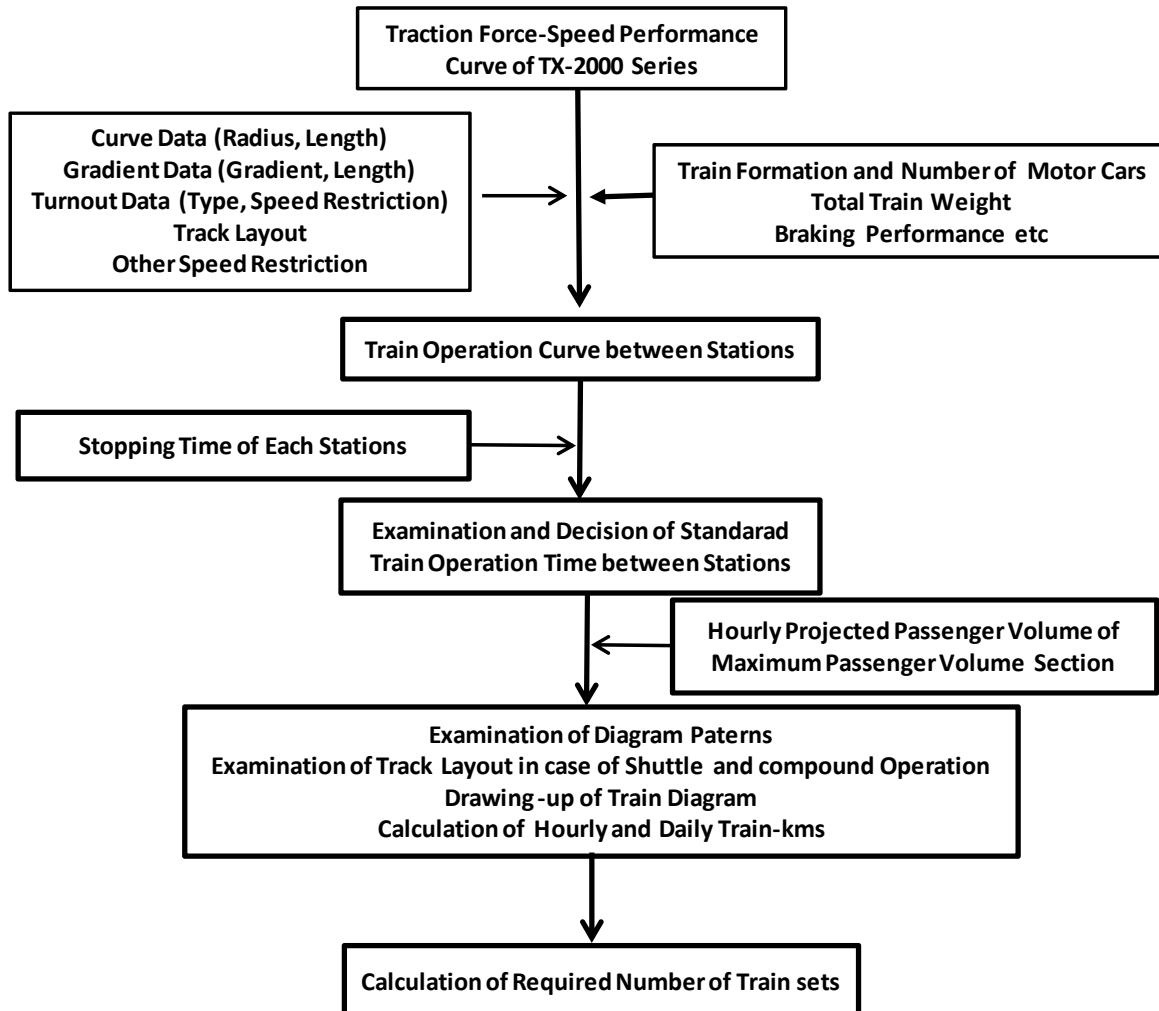
Source: JICA Study Team

5.1.3 Train Operation Planning

(1) Work Flow of Train Operation Planning

The work flow of train operation planning is as shown in Source: JICA Study Team

Figure 5.1.4.



Source: JICA Study Team

Figure 5.1.4 Work Flow of Train Operation Planning

(2) Standard Train Operation Time between Stations

According to Figure 5.1.4, the train operation curve between stations were drawn based on traction force-speed performance curve data of the proposed rolling stock, alignment and track conditions such as curve radius, gradient and turnout conditions and train formation data for each section between stations.

The required time between stations is calculated based on the obtained train operation curve for each station-station section. The standard train operation time is decided in such a way that 10% of allowance running time is added to the required time.

As a next step, a standard train operation time table is made taking into account the above standard train operation time and the stopping time of each KCR station as shown in Table 5.1.8 for N-A1 and N-A2 and Table 5.1.9 for N-B1 respectively.

Table 5.1.8 Standard Train Operation Time Table for N-A1 and N-A2

Counterclockwise (Up)					Station	Kilometerage	Clockwise (Down)							
Direction of Traffic	4-car Train Operation						Direction of Traffic	4-car Train Operation						
	Standard Operation Time	Stopping Time	Scheduled Operation Time	Summed Operation Time				Standard Operation Time	Stopping Time	Scheduled Operation Time	Summed Operation Time			
					Drigh Road	0								
↓	0:03:50						↑	0:03:50	0:01:00	0:04:50	1:00:00			
		0:00:30	0:04:20	0:04:20	Johar	4k970			0:00:30	0:01:50	0:55:10			
↓	0:01:20						↑	0:01:20						
		0:00:30	0:01:50	0:06:10	Alladin Park	5k830			0:00:30	0:02:10	0:53:20			
↓	0:01:50						↑	0:01:40						
		0:00:30	0:02:20	0:08:30	Nipa	7k450			0:00:30	0:02:40	0:51:10			
↓	0:02:00						↑	0:02:10						
		0:00:30	0:02:30	0:11:00	Gilani	9k400			0:00:30	0:02:30	0:48:30			
↓	0:02:10						↑	0:02:00						
		0:00:30	0:02:40	0:13:40	Yasinabad	11k360			0:00:30	0:02:00	0:46:00			
↓	0:01:30						↑	0:01:30						
		0:00:30	0:02:00	0:15:40	Liaquatbad	12k580			0:00:30	0:02:30	0:44:00			
↓	0:02:10						↑	0:02:00						
		0:00:30	0:02:40	0:18:20	North Namizabad	14k730			0:00:30	0:02:20	0:41:30			
↓	0:01:40						↑	0:01:50						
		0:00:30	0:02:10	0:20:30	Orangi	16k170			0:00:30	0:01:40	0:39:10			
↓	0:01:10						↑	0:01:10						
		0:00:30	0:01:40	0:22:10	HBL	16k850			0:00:30	0:02:20	0:37:30			
↓	0:01:50						↑	0:01:50						
		0:00:30	0:02:20	0:24:30	Manghopir	18k410			0:00:30	0:02:20	0:35:10			
↓	0:01:50						↑	0:01:50						
		0:00:30	0:02:20	0:26:50	Site	20k300			0:00:30	0:02:40	0:32:50			
↓	0:02:10						↑	0:02:10						
		0:00:30	0:02:40	0:29:30	Shah Absdul Latif	22k500			0:00:30	0:02:20	0:30:10			
↓	0:01:40						↑	0:01:50						
		0:00:30	0:02:10	0:31:40	Baldia	23k850			0:00:30	0:02:10	0:27:50			
↓	0:01:30						↑	0:01:40						
		0:01:00	0:02:30	0:34:10	Lyari	25k130			0:01:00	0:02:30	0:25:40			
↓	0:01:40						↑	0:01:30						
		0:00:30	0:02:10	0:36:20	Wazir Mansion	26k490			0:00:30	0:02:50	0:23:10			
↓	0:02:30						↑	0:02:20						
		0:00:30	0:03:00	0:39:20	Tower	28k360			0:00:30	0:02:10	0:20:20			
↓	0:01:30						↑	0:01:40						
		0:00:30	0:02:00	0:41:20	Karachi City	29k600			0:00:30	0:02:30	0:18:10			
↓	0:02:10						↑	0:02:00						
		0:00:30	0:02:40	0:44:00	DCOS	31k650			0:00:30	0:02:30	0:15:40			
↓	0:01:50						↑	0:02:00						
		0:01:00	0:02:50	0:46:50	Karachi Cantt	33k340			0:01:00	0:02:40	0:13:10			
↓	0:01:40						↑	0:01:40						
		0:00:30	0:02:10	0:49:00	Naval	34k700			0:00:30	0:02:20	0:10:30			
↓	0:02:00						↑	0:01:50						
		0:00:30	0:02:30	0:51:30	Chanesar	36k520			0:00:30	0:02:20	0:08:10			
↓	0:01:50						↑	0:01:50						
		0:00:30	0:02:20	0:53:50	Shaheed-e-Millat	38k160			0:00:30	0:02:40	0:05:50			
↓	0:02:10						↑	0:02:10						
		0:00:30	0:02:40	0:56:30	Karzas Halt	40k400			0:00:30	0:03:10	0:03:10			
↓	0:02:30						↑	0:02:40						
		0:01:00	0:03:30	1:00:00	Drigh Road	43k235								
	0:46:30	0:13:30	1:00:00					0:46:30	0:13:30	1:00:00				

Source: JICA Study Team

Table 5.1.9 Standard Train Operation Time Table for N-B1

Counterclockwise (Up)					Station	Kilometerage	Clockwise (Down)				
Direction of Traffic	4,8-car Train Operation						Direction of Traffic	4,8-car Train Operation			
	Standard Operation Time	Stopping Time	Scheduled Operation Time	Summed Operation Time				Standard Operation Time	Stopping Time	Scheduled Operation Time	Summed Operation Time
↓	0:01:40				Shah Abdul Latif	22k500	↑	0:01:50		0:01:50	0:29:40
		0:00:30	0:02:10	0:02:10	Baldia	23k850	↑	0:01:40	0:00:30	0:02:10	0:27:50
↓	0:01:30				Lyari	25k130	↑	0:01:30	0:01:00	0:02:30	0:25:40
		0:01:00	0:02:30	0:04:40	Wazir Mansion	26k490	↑	0:02:20	0:00:30	0:02:50	0:23:10
↓	0:01:40				Tower	28k360	↑	0:01:40	0:00:30	0:02:30	0:18:10
		0:00:30	0:02:10	0:06:50	Karachi City	29k600	↑	0:02:00	0:00:30	0:02:30	0:15:40
↓	0:02:30				DCOS	31k650	↑	0:02:00	0:00:30	0:02:30	0:13:10
		0:00:30	0:03:00	0:09:50	Karachi Cantt	33k340	↑	0:01:40	0:01:00	0:02:40	0:10:30
↓	0:01:30				Naval	34k700	↑	0:01:50	0:00:30	0:02:20	0:08:10
		0:00:30	0:02:10	0:11:50	Chanesar	36k520	↑	0:01:50	0:00:30	0:02:20	0:05:50
↓	0:02:00				Shaheed-e-Millat	38k160	↑	0:02:10	0:00:30	0:03:10	0:03:10
		0:00:30	0:02:30	0:22:00	Karzas Halt	40k400	↑	0:02:40			
↓	0:01:50				Drigh Road	43k235					
		0:00:30	0:02:20	0:24:20							
↓	0:02:10										
		0:00:30	0:02:40	0:27:00							
↓	0:02:30										
		0:01:00	0:03:30	0:30:30							
	0:23:00	0:07:30	0:30:30					0:23:10	0:06:30	0:29:40	

Source: JICA Study Team

(3) Train Operation Plan of N-A1 Option

1) Outline of Demand Forecast of N-A1 Option

There are two demand forecast options for complete circular railway plan. The demand forecast of N-A1 Option was conducted presuming that existing bus routes concerned will be rearranged by connecting with KCR stations in such a way that KCR passengers can use KCR with maximum two times transfers between buses and KCR. As the results of demand forecast of N-A1, the maximum sectional passenger volume/hour by time zone is estimated as shown in Table 5.1.10.

2) Train Operation Planning for N-A1 Option

In case of N-A1, during the time from 2022 to the end of 2029, KCR conducts simple circular train operations and in this case, trains/hour can be decided based on maximum sectional passengers volume/hour for up direction and down direction separately. Judging from Table 5.1.4 and Table 5.1.10, the projected demand from 2022 to the end of 2029 can be transported by 5 minutes headways with 4-car train formation for the direction of the most sectional passengers.

However, when KCR extension opens in 2030, huge passenger volume from the extension line pours into the KCR line. Since these passengers of the KCR extension cannot be dealt by 4-car or 6-car train formation, the train operation with 8-car formation will be required. Consequently, the mixed train operation, 4-car operation for the circular line passengers and 8-car operation for the KCR extension passengers, are planned.

Table 5.1.10 Projected Maximum Sectional Passenger Volume/hour between Stations by Time Zone of N-A1

(a) PR Parallel section

Year	PR Parallel						Remarks	
	Anti-clockwise (Up)			Clockwise (Down)				
	Karachi Cantt-Naval			Karachi Cantt-Naval				
2022	Daily Passengers	111,312			Daily Passengers	125,687		Opening of KCR
	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)		
	8,126	6,679	5,343	9,175	7,541	6,033		
2023	8,274	6,801	5,441	9,343	7,679	6,143	Increase Rate; 1.827 %	
2024	8,425	6,925	5,540	9,513	7,819	6,255		
2025	8,579	7,052	5,641	9,687	7,962	6,370		
2026	8,736	7,180	5,744	9,864	8,108	6,486		
2027	8,896	7,312	5,849	10,044	8,256	6,605		
2028	9,058	7,445	5,956	10,228	8,407	6,725		
2029	9,224	7,581	6,065	10,415	8,560	6,848		
2030	Daily Passengers	221,106			Daily Passengers	227,370		Opening of KCR Extension and Fare Rate Raising
	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)		
	16,141	13,266	10,613	16,598	13,642	10,914		
2031	16,436	13,509	10,807	16,901	13,891	11,113	Increase Rate; 1.827%	
2032	16,736	13,756	11,004	17,210	14,145	11,316		
2033	17,042	14,007	11,205	17,524	14,404	11,523		
2034	17,353	14,263	11,410	17,845	14,667	11,733		
2035	17,670	14,523	11,619	18,171	14,935	11,948		
2036	17,993	14,789	11,831	18,503	15,208	12,166		
2037	18,322	15,059	12,047	18,841	15,485	12,388		
2038	18,656	15,334	12,267	19,185	15,768	12,615		
2039	18,997	15,614	12,491	19,535	16,057	12,845		
2040	18,957	15,581	12,465	19,494	16,023	12,818	As the results of BRT Improvement Completion, 2% decrease	
2041	19,304	15,866	12,693	19,851	16,316	13,052	Increase Rate; 1.827 %	
2042	19,656	16,156	12,925	20,213	16,614	13,291		
2043	20,016	16,451	13,161	20,583	16,917	13,534		
2044	20,381	16,752	13,401	20,959	17,226	13,781		
2045	20,754	17,058	13,646	21,342	17,541	14,033		
2046	21,133	17,369	13,896	21,731	17,861	14,289		
2047	21,519	17,687	14,149	22,129	18,188	14,550		
2048	21,912	18,010	14,408	22,533	18,520	14,816		
2049	22,312	18,339	14,671	22,944	18,858	15,087		
2050	22,720	18,674	14,939	23,364	19,203	15,362		
2051	23,135	19,015	15,212	23,791	19,554	15,643		

Source: JICA Study Team

(b) Loop Section

Year	Loop						Remarks
	Anti-clockwise (Up)			Clockwise (Down)			
	Orangi-HBL			Orangi-HBL (2030 Downward: North Nazimabad-Orangi)			
2022	Daily Passengers	96,231		Daily Passengers	82,131		Opening of KCR
	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	
	7,025	5,774	4,619	7,025	5,774	4,619	
2023	7,153	5,879	4,703	7,153	5,879	4,703	Increase Rate; 1.827 %
2024	7,284	5,987	4,789	7,284	5,987	4,789	
2025	7,417	6,096	4,877	7,417	6,096	4,877	
2026	7,552	6,208	4,966	7,552	6,208	4,966	
2027	7,690	6,321	5,057	7,690	6,321	5,057	
2028	7,831	6,436	5,149	7,831	6,436	5,149	
2029	7,974	6,554	5,243	7,974	6,554	5,243	
2030	Daily Passengers	108,982		Daily Passengers	87,772		Opening of KCR Extension and Fare Rate Raising
	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	
	7,956	6,539	5,231	7,956	6,539	5,231	
2031	8,101	6,658	5,327	8,101	6,658	5,327	Increase Rate; 1.827%
2032	8,249	6,780	5,424	8,249	6,780	5,424	
2033	8,400	6,904	5,523	8,400	6,904	5,523	
2034	8,553	7,030	5,624	8,553	7,030	5,624	
2035	8,709	7,158	5,727	8,709	7,158	5,727	
2036	8,869	7,289	5,831	8,869	7,289	5,831	
2037	9,031	7,422	5,938	9,031	7,422	5,938	
2038	9,196	7,558	6,046	9,196	7,558	6,046	
2039	9,364	7,696	6,157	9,364	7,696	6,157	
2040	9,344	7,680	6,144	9,344	7,680	6,144	As the results of BRT Improvement Completion, 2% decrease
2041	9,515	7,820	6,256	9,515	7,820	6,256	Increase Rate; 1.827 %
2042	9,689	7,963	6,371	9,689	7,963	6,371	
2043	9,866	8,109	6,487	9,866	8,109	6,487	
2044	10,046	8,257	6,605	10,046	8,257	6,605	
2045	10,229	8,408	6,726	10,229	8,408	6,726	
2046	10,416	8,561	6,849	10,416	8,561	6,849	
2047	10,607	8,718	6,974	10,607	8,718	6,974	
2048	10,800	8,877	7,102	10,800	8,877	7,102	
2049	10,998	9,039	7,231	10,998	9,039	7,231	
2050	11,199	9,204	7,363	11,199	9,204	7,363	
2051	11,403	9,372	7,498	11,403	9,372	7,498	

Source: JICA Study Team

(c) KCR Extension

Year	Loop						Remarks
	Up			Down			
	DrighColony-Star gate			DrighColony-Star gate			
2022	Daily Passengers	222,705		Daily Passengers	-		Opening of KCR
	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	
	16,257	13,362	10,690	-	-	-	
2023	-			-	-	-	Increase Rate; 1.827 %
2024	-			-	-	-	
2025	-			-	-	-	
2026	-			-	-	-	
2027	-			-	-	-	
2028	-			-	-	-	
2029	-			-	-	-	
2030	Daily Passengers	222,705		Daily Passengers	204,759		Opening of KCR Extension and Fare Rate Raising
	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	
	16,257	13,362	10,690	14,947	12,286	9,828	
2031	16,554	13,606	10,885	15,220	12,510	10,008	Increase Rate; 1.827%
2032	16,857	13,855	11,084	15,499	12,739	10,191	
2033	17,165	14,108	11,287	15,782	12,971	10,377	
2034	17,479	14,366	11,493	16,070	13,208	10,567	
2035	17,798	14,628	11,703	16,364	13,450	10,760	
2036	18,123	14,896	11,917	16,663	13,695	10,956	
2037	18,454	15,168	12,134	16,967	13,946	11,156	
2038	18,791	15,445	12,356	17,277	14,200	11,360	
2039	19,135	15,727	12,582	17,593	14,460	11,568	
2040	19,095	15,694	12,555	17,556	14,430	11,544	As the results of BRT Improvement Completion, 2% decrease
2041	19,443	15,981	12,785	17,877	14,693	11,755	Increase Rate; 1.827 %
2042	19,799	16,273	13,018	18,203	14,962	11,969	
2043	20,160	16,570	13,256	18,536	15,235	12,188	
2044	20,529	16,873	13,498	18,875	15,513	12,411	
2045	20,904	17,181	13,745	19,219	15,797	12,637	
2046	21,286	17,495	13,996	19,571	16,085	12,868	
2047	21,674	17,815	14,252	19,928	16,379	13,103	
2048	22,070	18,140	14,512	20,292	16,679	13,343	
2049	22,474	18,472	14,777	20,663	16,983	13,587	
2050	22,884	18,809	15,047	21,040	17,294	13,835	
2051	23,302	19,153	15,322	21,425	17,609	14,088	

Source: JICA Study Team

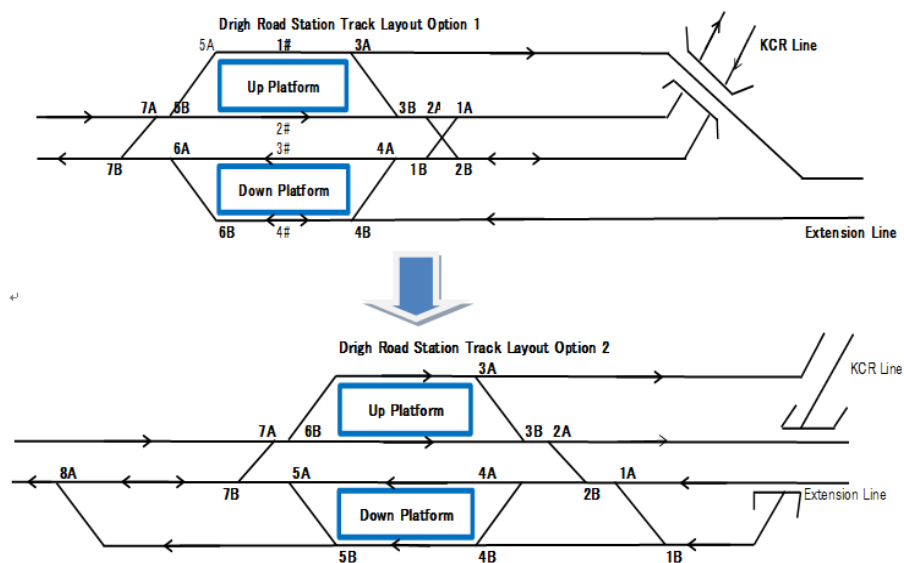
The transportation capacity per hour for the mixed train operation is shown in lower part of Table 5.1.4. To reduce the number of required train sets, half number of trains from the KCR extension are planned to be operated by shuttling at Drigh Road. The rest half trains from the KCR extension are planned to continue to run and to be operated by shuttling at Lyari.

In the case of through-train operation between the KCR extension and the KCR line, the following conditions are required in train operation planning.

- A. The headways of the KCR line should be multiple number of that of the KCR extension.
- B. The headways of trains to up-direction of the KCR extension should be same as that to down-direction. Headways are, therefore, determined based on larger passenger demand between up-direction and down-direction.

The train operation plan of N-A1 was shown in Table 5.1.11.

In addition the track layout at Drigh Road was proposed to suit shuttling operation of the KCR extension trains at Drigh Road as shown in Figure 5.1.5. If this change is not permitted due to the restriction of upper space of the existing PR main line, the shuttling operation of the KCR extension trains at Drigh Road becomes difficult and as the result it is proposed that the half trains from the extension line are operated to Lyari, the rest trains continue to run to Gilani, and shuttling are made at Lyari or Gilani. In this case, the number of train sets for the KCR extension will increase. Confirming the availability of upper space of the PR line for the new track layout at Drigh Road by KUTC is necessary. The entire track layout of N-A1 Option is as shown in Figure 5.1.6.



Source: JICA Study Team

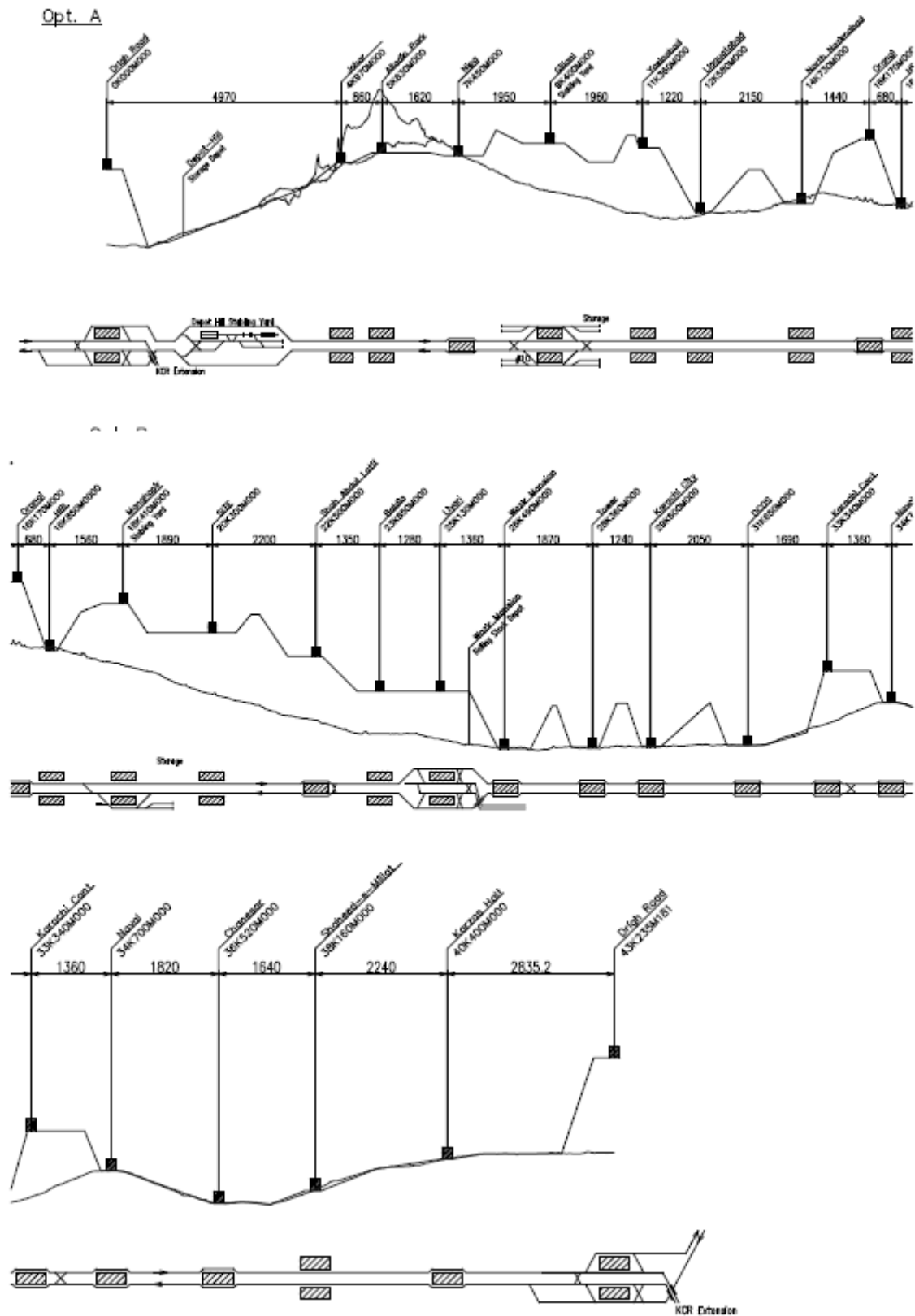
Figure 5.1.5 Track Layout Change of Drigh Road for Shuttling Operation of Extension Train

The train operation time table and train operation chart of N-A1 are presented in Appendix 5.1.

Table 5.1.11 Train Operation Plan of N-A1 (Headways and Trains/hour by Time Zone)

Year	Circular Train Operation: 4-car formation						Extension Train Operation in PR Parallel Section : 8-car formation					
	Counter-clockwise (Up)			Clockwise (Down)			Counter-clockwise (Up)			Clockwise (Down)		
	Peak Hour	Semi-peak Hour	Off-pek Hour	Peak Hour	Semi-peak Hour	Off-pek Hour	Peak Hour	Semi-peak Hour	Off-pek Hour	Peak Hour	Semi-peak Hour	Off-pek Hour
2022	6m (10trains/h)				6m (10trains/h)							
2023												
2024												
2025												
2026												
2027												
2028												
2029	5m (12 trains/h)	6m40s (9trains/h)	8m (7.5trains/h)	5m (12trains/h)	6m40s (9trains/h)		10m (6trains/h)	13m20s (4.5trains/h)	16m (3.75trains/h)	10m (6trains/h)	13m20s (4.5trains/h)	16m (3.75trains/h)
2030												
2031												
2032												
2033												
2034												
2035												
2036												
2037												
2038												
2039	5m (12trains/h)	7m30s (8trains/h)	7m30s (8trains/h)	5m (12trains/h)	7m30s (8trains/h)		10m (6trains/h)	15m (4trains/h)	15m (4trains/h)	10m (6trains/h)	15m (4trains/h)	
2040												
2041												
2042												
2043												
2044												
2045												
2046	5m (12trains/h)	7m30s (8trains/h)	7m30s (8trains/h)	5m (12trains/h)	7m30s (8trains/h)		10m (6trains/h)	15m (4trains/h)	15m (4trains/h)	10m (6trains/h)	15m (4trains/h)	
2047												
2048												
2049												
2050												
2051												

Source: JICA Study Team



Source: JICA Study Team

Figure 5.1.6 KCR Track Layout of N-A1,A2 Option

(4) Train Operation Plan of N-A2 Option

1) Outline of Demand Forecast of N-A2 Option

The demand forecast of N-A2 Option was conducted presuming that existing bus routes concerned are not rearranged according to installation of the KCR stations.

As the results of demand forecast of N-A2, the maximum sectional passenger volume per hour by time zone is estimated as shown in Table 5.1.11.

2) Train Operation Planning for N-A2 Option

The train operation for N-A2 option is planned with the same concept as N-A1 option. Simple circular 4-car train operations are conducted during the time from 2022 to the end of 2029 and mixed train formation operations are made after the KCR extension line opens in 2030 because the huge passenger volume pours into the KCR line.

The circular train operation will be conducted by 4-car formation based on the maximum sectional passenger volume between stations from Lyari to Drigh Road through Gilani. The trains from the extension line will be operated with 8-car formation, half of which return back to the extension line by shuttling at Drigh Road and the rest half of which continue to go through the KCR line and return back to the extension line by shuttling at Lyari.

The transportation capacity of the mixed operation shown in Table 5.1.4 is applied to the train operation plan between Drigh Road and Lyari through Karachi Cantt.

The train operation plan of N-A2 is made in the same manners as that of N-A1 as shown in Table 5.1.12. As the result, the trains per hour during the peak hour between Drigh Road and Lyari through Nipa from 2030 to 2040 decrease from 12 trains/hour to 10 trains/hour. JICA Study Team judged such decrease is allowable to suppress the increase of required train sets.

In addition, the proposed track layout at Drigh Road is shown in Figure 5.1.5 as N-A2 also requires shuttling of half trains from the extension line at Drigh Road. Therefore, if the track layout change is not allowed due to no availability of above-space of the existing PR line, all the trains should continue to be operated to Lyari or Gilani, and the number of required train sets will increase.

The time table and train operation chart of N-A2 are presented in Appendix 5.1.

Table 5.1.12 Projected Maximum Sectional Passenger Volume/hour between Stations by Time Zone of N-A2

(a) PR Parallel section

Year	PR Parallel						Remarks	
	Anti-clockwise (Up)			Clockwise (Down)				
	Karachi Cantt-Naval			Karachi Cantt-Naval				
2022	Daily Passengers	102,925			Daily Passengers	116,623		Opening of KCR
	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)		
	7,514	6,176	4,940	7,514	6,176	4,940		
2023	7,653	6,290	5,032	7,653	6,290	5,032	Increase Rate; 1.852%	
2024	7,794	6,406	5,125	7,794	6,406	5,125		
2025	7,939	6,525	5,220	7,939	6,525	5,220		
2026	8,086	6,646	5,317	8,086	6,646	5,317		
2027	8,236	6,769	5,415	8,236	6,769	5,415		
2028	8,388	6,894	5,515	8,388	6,894	5,515		
2029	8,543	7,022	5,618	8,543	7,022	5,618		
2030	Daily Passengers	210,076			Daily Passengers	216,794		Opening of KCR Extension and Fare Rate Raising
	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)		
	15,336	12,605	10,084	15,826	13,008	10,406		
2031	15,620	12,838	10,270	16,119	13,249	10,599	Increase Rate; 1.852%	
2032	15,909	13,076	10,461	16,418	13,494	10,795		
2033	16,203	13,318	10,654	16,722	13,744	10,995		
2034	16,504	13,565	10,852	17,031	13,998	11,199		
2035	16,809	13,816	11,053	17,347	14,258	11,406		
2036	17,121	14,072	11,257	17,668	14,522	11,617		
2037	17,438	14,332	11,466	17,995	14,791	11,832		
2038	17,761	14,598	11,678	18,328	15,065	12,052		
2039	18,089	14,868	11,894	18,668	15,344	12,275		
2040	18,056	14,841	11,872	18,633	15,315	12,252	As the results of BRT Improvement Completion, 2% decrease	
2041	18,390	15,115	12,092	18,978	15,599	12,479	Increase Rate; 1.852%	
2042	18,731	15,395	12,316	19,330	15,888	12,710		
2043	19,078	15,680	12,544	19,688	16,182	12,946		
2044	19,431	15,971	12,777	20,053	16,482	13,185		
2045	19,791	16,267	13,013	20,424	16,787	13,429		
2046	20,158	16,568	13,254	20,802	17,098	13,678		
2047	20,531	16,875	13,500	21,187	17,414	13,931		
2048	20,911	17,187	13,750	21,580	17,737	14,189		
2049	21,298	17,506	14,004	21,980	18,065	14,452		
2050	21,693	17,830	14,264	22,387	18,400	14,720		
2051	22,095	18,160	14,528	22,801	18,741	14,993		

Source: JICA Study Team

(b) Loop Section

Year	Loop						Remarks
	Anti-clockwise (Up)			Clockwise (Down)			
	Orangi-HBL			Orangi-HBL (2030 Downward: North Nazimabad-Orangi)			
2022	Daily Passengers	85,131		Daily Passengers	71,583		Opening of KCR
	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	
	6,215	5,108	4,086	5,226	4,295	3,436	
2023	6,330	5,202	4,162	5,322	4,375	3,500	Increase Rate; 1.852 %
2024	6,447	5,299	4,239	5,421	4,456	3,564	
2025	6,566	5,397	4,318	5,521	4,538	3,630	
2026	6,688	5,497	4,398	5,624	4,622	3,698	
2027	6,812	5,599	4,479	5,728	4,708	3,766	
2028	6,938	5,702	4,562	5,834	4,795	3,836	
2029	7,066	5,808	4,646	5,942	4,884	3,907	
2030	Daily Passengers	98,930		Daily Passengers	82,328		Opening of KCR Extension and Fare Rate Raising
	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	
	6,010	4,940	3,952	6,010	4,940	3,952	
2031	6,121	5,031	4,025	6,121	5,031	4,025	Increase Rate; 1.852%
2032	6,235	5,124	4,099	6,235	5,124	4,099	
2033	6,350	5,219	4,175	6,350	5,219	4,175	
2034	6,468	5,316	4,253	6,468	5,316	4,253	
2035	6,587	5,414	4,331	6,587	5,414	4,331	
2036	6,709	5,515	4,412	6,709	5,515	4,412	
2037	6,834	5,617	4,493	6,834	5,617	4,493	
2038	6,960	5,721	4,577	6,960	5,721	4,577	
2039	7,089	5,827	4,661	7,089	5,827	4,661	
2040	7,076	5,816	4,653	7,076	5,816	4,653	As the results of BRT Improvement Completion, 2% decrease
2041	7,207	5,924	4,739	7,207	5,924	4,739	Increase Rate; 1.852 %
2042	7,341	6,033	4,827	7,341	6,033	4,827	
2043	7,477	6,145	4,916	7,477	6,145	4,916	
2044	7,615	6,259	5,007	7,615	6,259	5,007	
2045	7,756	6,375	5,100	7,756	6,375	5,100	
2046	7,900	6,493	5,194	7,900	6,493	5,194	
2047	8,046	6,613	5,291	8,046	6,613	5,291	
2048	8,195	6,736	5,388	8,195	6,736	5,388	
2049	8,347	6,860	5,488	8,347	6,860	5,488	
2050	8,501	6,987	5,590	8,501	6,987	5,590	
2051	8,659	7,117	5,693	8,659	7,117	5,693	

Source: JICA Study Team

(c) KCR Extension

Year	Loop						Remarks
	Up			Down			
	DrighColony-Star gate			DrighColony-Star gate			
2022	Daily Passengers	222,705		Daily Passengers	-		Opening of KCR
	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	
	16,257	13,362	10,690	-	-	-	
2023	-	-	-	-	-	-	Increase Rate; 1.852 %
2024	-	-	-	-	-	-	
2025	-	-	-	-	-	-	
2026	-	-	-	-	-	-	
2027	-	-	-	-	-	-	
2028	-	-	-	-	-	-	
2029	-	-	-	-	-	-	
2030	Daily Passengers	218,720		Daily Passengers	199,976		Opening of KCR Extension and Fare Rate Raising
	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	
	15,967	13,123	10,499	14,598	11,999	9,599	
2031	16,262	13,366	10,693	14,869	12,221	9,777	Increase Rate; 1.852%
2032	16,563	13,614	10,891	15,144	12,447	9,958	
2033	16,870	13,866	11,093	15,424	12,678	10,142	
2034	17,183	14,123	11,298	15,710	12,912	10,330	
2035	17,501	14,384	11,507	16,001	13,152	10,521	
2036	17,825	14,651	11,721	16,297	13,395	10,716	
2037	18,155	14,922	11,938	16,599	13,643	10,915	
2038	18,491	15,198	12,159	16,907	13,896	11,117	
2039	18,834	15,480	12,384	17,220	14,153	11,323	
2040	18,799	15,451	12,361	17,188	14,127	11,302	As the results of BRT Improvement Completion, 2% decrease
2041	19,147	15,737	12,590	17,506	14,389	11,511	Increase Rate; 1.852 %
2042	19,502	16,029	12,823	17,830	14,655	11,724	
2043	19,863	16,326	13,061	18,161	14,927	11,941	
2044	20,231	16,628	13,302	18,497	15,203	12,162	
2045	20,605	16,936	13,549	18,840	15,485	12,388	
2046	20,987	17,250	13,800	19,188	15,771	12,617	
2047	21,376	17,569	14,055	19,544	16,063	12,851	
2048	21,772	17,894	14,316	19,906	16,361	13,089	
2049	22,175	18,226	14,581	20,274	16,664	13,331	
2050	22,585	18,563	14,851	20,650	16,973	13,578	
2051	23,004	18,907	15,126	21,032	17,287	13,829	

Source: JICA Study Team

Table 5.1.13 Train Operation Plan of N-A2 (Headways and Number of tTrains/hour by Time Zone)

Year	Circular Train Operation: 4-car formation						Extension Train Operation in PR Parallel Section : 8-car formation						
	Counter-clockwise (Up)			Clockwise (Down)			Counter-clockwise (Up)			Clockwise (Down)			
	Peak Hour	Semi-peak Hour	Off-pek Hour	Peak Hour	Semi-peak Hour	Off-pek Hour	Peak Hour	Semi-peak Hour	Off-pek Hour	Peak Hour	Semi-peak Hour	Off-pek Hour	
2022	6m (10trains/h)	7m30s (8trains/h)		5m (12trains/h)	6m40s (9trains/h)								
2023													
2024													
2025													
2026													
2027													
2028													
2029													
2030													
2031													
2032													
2033													
2034			8m (7.5trains/h)	6m (10trains/h)	7m30s (8trains/h)	8m (7.5trains/h)	12m (5trains/h)	15m (4trains/h)	12m (5trains/h)	15m (4trains/h)			
2035													
2036													
2037													
2038													
2039								16m (3.75trains/h)			16m (3.75trains/h)		
2040													
2041	5m (12 trains/h)	6m (10trains/h)		5m (12 trains/h)	6m (10trains/h)					10m (6trains/h)	12m (5trains/h)	10m (6trains/h)	12m (5trains/h)
2042													
2043													
2044													
2045													
2046													
2047													
2048													
2049													
2050													
2051	4m (15trains/h)		6m40s (9trains/h)	4m (15trains/h)		6m40s (9trains/h)	8m (7.5trains/h)		13m20s (4.5trains/h)	8m (7.5trains/h)		13m20s (4.5trains/h)	

Source: JICA Study Team

(5) Train Operation Plan of N-B1 Option

1) Outline of Demand Forecast of N-B1 Option

The demand forecast of N-B1 Option was conducted presuming that existing bus routes concerned will be rearranged according to the installation of the KCR stations. As the results of demand forecast of N-B1, the projected maximum sectional passenger volume per hour by time zone is obtained as shown in Table 5.1.13.

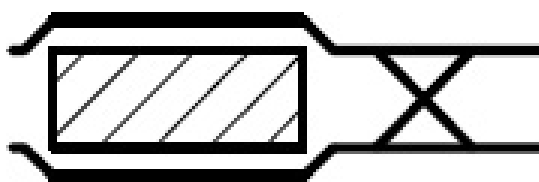
2) Train Operation Planning for N-B1 Option

In the case of N-B1, train operations are conducted by shuttling at the both end stations, Drigh Road and Shah Abdul Ratif, from the opening year of 2022 to 2030 and shuttling at the terminal station of the extension line instead of Drigh Road and Shah Abdul Ratif from 2030 afterward. Therefore, the following points are considered in the train operation planning.

- A. The numbers of trains per hour for up-direction and down-direction should be same. Consequently, the number of trains per hour required for larger passenger volume is selected for both directions.
- B. Taking into account no circular train operation and the larger volume of projected demand of the extension line, two kinds of trains operation plan between Drigh Road and Shah Abdul Ratif and trains between the terminal station and Shah Abdul Ratif are meaningless. From the opening year of 2030 of the extension line, the single pattern train operations between the terminal station of the extension line and Shah Abdul Ratif is planned.

As the results of examination of Table 5.1.4 and Table 5.1.13, the 4-car train formation and 8-car train formation are judged to be adequate. The train operation plan of N-B1 is proposed as shown in Table 5.1.14.

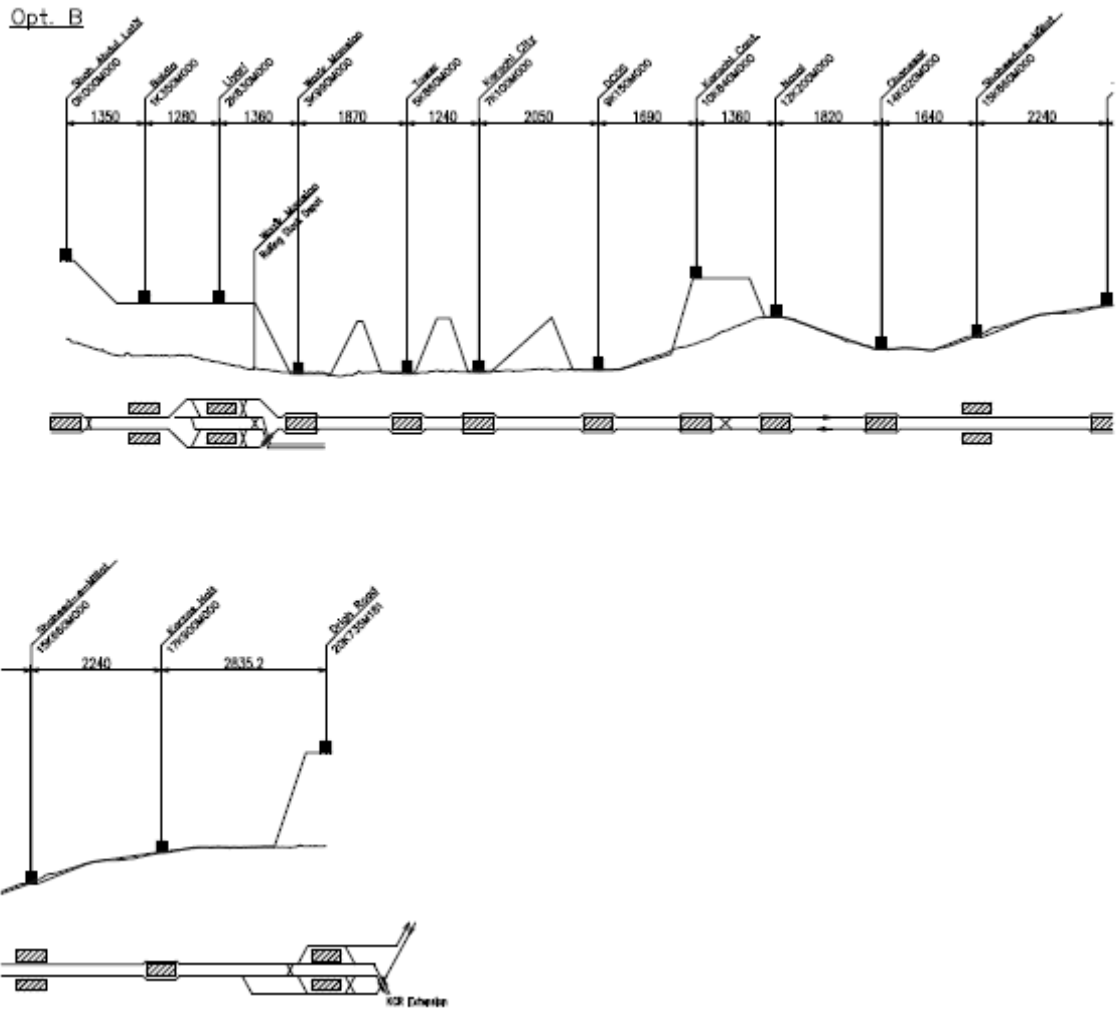
In addition a scissors crossover is installed before platform in Shah Abdul Ratif to conduct shuttling there as shown in Figure 5.1.7.



Source: JICA Study Team

Figure 5.1.7 Track Layout of Shah Abdul Ratif

The entire KCR track layout of N-B1 is shown in Figure 5.1.8.



Source: JICA Study Team

Figure 5.1.8 KCR Track Layout of N-B1 Option

Table 5.1.14 Projected Maximum Sectional Passenger Volume of N-B1

(a) Main Line							Remarks
Year	KCR Train (Drigh Road—Shah Abdul Ratif)						
	Anti-clockwise (Up)			Clockwise (Down)			
	Karachi Cantt • Naval			Karachi Cantt • Naval			
2022	Daily Passengers	106,980		Daily Passengers	118,121		Opening of KCR
	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	
	7,810	6,419	5,135	8,623	7,087	5,670	
2023	7,957	6,540	5,232	8,785	7,221	5,777	Increase Rate; 1.886%
2024	8,107	6,663	5,331	8,951	7,357	5,886	
2025	8,260	6,789	5,431	9,120	7,496	5,997	
2026	8,416	6,917	5,534	9,292	7,637	6,110	
2027	8,574	7,047	5,638	9,467	7,781	6,225	
2028	8,736	7,180	5,744	9,646	7,928	6,342	
2029	8,901	7,316	5,853	9,828	8,078	6,462	
2030	KCR ALL	218,875		KCR ALL	230,983		Opening of KCR Extension and Fare Rate Raising
	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	
	15,978	13,133	10,506	16,862	13,859	11,087	
2031	16,279	13,380	10,704	17,180	14,120	11,296	Increase Rate; 1.886%
2032	16,586	13,633	10,906	17,504	14,387	11,509	
2033	16,899	13,890	11,112	17,834	14,658	11,726	
2034	17,218	14,152	11,321	18,170	14,934	11,948	
2035	17,543	14,418	11,535	18,513	15,216	12,173	
2036	17,873	14,690	11,752	18,862	15,503	12,402	
2037	18,210	14,967	11,974	19,218	15,795	12,636	
2038	18,554	15,250	12,200	19,580	16,093	12,875	
2039	18,904	15,537	12,430	19,950	16,397	13,118	
2040	19,260	15,830	12,664	20,326	16,706	13,365	
2041	19,624	16,129	12,903	20,709	17,021	13,617	
2042	19,994	16,433	13,147	21,100	17,342	13,874	
2043	20,371	16,743	13,394	21,498	17,669	14,135	
2044	20,755	17,059	13,647	21,903	18,003	14,402	
2045	21,146	17,381	13,904	22,316	18,342	14,674	
2046	21,545	17,708	14,167	22,737	18,688	14,950	
2047	21,952	18,042	14,434	23,166	19,040	15,232	
2048	22,366	18,383	14,706	23,603	19,400	15,520	
2049	22,787	18,729	14,983	24,048	19,765	15,812	
2050	23,217	19,083	15,266	24,502	20,138	16,111	
2051	23,655	19,443	15,554	24,964	20,518	16,414	

Source: JICA Study Team

(b) KCR Extension

Year	KCR Extension Section (Drigh Road – Madina Masjid Zafar)						Remarks
	Up			Down			
	DrighColony-Star gate			DrighColony-Star gate			
2022	Daily Passengers	-		Daily Passengers	-		Opening of KCR
	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	
	-	-	-	-	-	-	
2023	-	-	-	-	-	-	Increase Rate; 1.886%
2024	-	-	-	-	-	-	
2025	-	-	-	-	-	-	
2026	-	-	-	-	-	-	
2027	-	-	-	-	-	-	
2028	-	-	-	-	-	-	
2029	-	-	-	-	-	-	
2030	Daily Passengers	184,258		Daily Passengers	162,195		Opening of KCR Extension and Fare Rate Raising
	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	Peak Hour (7.3%)	Semi-peak Hour (6%)	Off-peak Hour (4.8%)	
	13451	11,055	8,844	11,840	9,732	7,785	
2031	13,705	11,264	9,011	12,064	9,915	7,932	Increase Rate; 1.886%
2032	13,963	11,476	9,181	12,291	10,102	8,082	
2033	14,226	11,693	9,354	12,523	10,293	8,234	
2034	14,495	11,913	9,531	12,759	10,487	8,390	
2035	14,768	12,138	9,710	13,000	10,685	8,548	
2036	15,047	12,367	9,894	13,245	10,886	8,709	
2037	15,330	12,600	10,080	13,495	11,092	8,873	
2038	15,619	12,838	10,270	13,749	11,301	9,041	
2039	15,914	13,080	10,464	14,008	11,514	9,211	
2040	16,214	13,327	10,661	14,273	11,731	9,385	
2041	16,520	13,578	10,862	14,542	11,952	9,562	
2042	16,832	13,834	11,067	14,816	12,178	9,742	
2043	17,149	14,095	11,276	15,096	12,407	9,926	
2044	17,472	14,361	11,489	15,380	12,641	10,113	
2045	17,802	14,632	11,705	15,670	12,880	10,304	
2046	18,138	14,908	11,926	15,966	13,123	10,498	
2047	18,480	15,189	12,151	16,267	13,370	10,696	
2048	18,828	15,475	12,380	16,574	13,622	10,898	
2049	19,183	15,767	12,614	16,886	13,879	11,103	
2050	19,545	16,065	12,852	17,205	14,141	11,313	
2051	19,914	16,368	13,094	17,529	14,408	11,526	

Source: JICA Study Team

Table 5.1.15 Train Operation Plan of N-B1 (Headways and Number of Trains/ hour by Time

Year	Circular Train Operation						KCR Extension Train Operation					
	Counter-clockwise (Up)			Clockwise (Down)			Counter-clockwise (Up)			Clockwise (Down)		
	Peak Hour	Semi-peak Hour	Off-pek Hour	Peak Hour	Semi-peak Hour	Off-pek Hour	Peak Hour	Semi-peak Hour	Off-pek Hour	Peak Hour	Semi-peak Hour	Off-pek Hour
2022	4-car Operation			4-car Operation			-			-		
2023	5m (12trains/h)	6m40s (9trains/h)	8m (7.5trains/h)	5m (12trains/h)	6m40s (9trains/h)	8m (7.5trains/h)						
2024												
2025												
2026												
2027												
2028												
2029												
2030	8-car Through-Operation (Shah Abdul Rafiq-Drigh Road-Madina Masjid Zafar)											
2031	5m (12trains/h)	6m40s (9trains/h)	8m (7.5trains/h)	5m (12trains/h)	6m40s (9trains/h)	8m (7.5trains/h)	5m (12trains/h)	6m40s (9trains/h)	8m (7.5trains/h)	5m (12trains/h)	6m40s (9trains/h)	8m (7.5trains/h)
2032												
2033												
2034												
2035												
2036												
2037												
2038												
2039												
2040												
2041												
2042												
2043												
2044												
2045	5m (12trains/h)	5m (12trains/h)	5m (12trains/h)	5m (12trains/h)	5m (12trains/h)	5m (12trains/h)	5m (12trains/h)	5m (12trains/h)	5m (12trains/h)	5m (12trains/h)	5m (12trains/h)	5m (12trains/h)
2046												
2047	4m (15trains/h)	6m40s (9trains/h)	4m (15trains/h)	6m40s (9trains/h)	4m (15trains/h)	6m40s (9trains/h)	4m (15trains/h)	6m40s (9trains/h)	4m (15trains/h)	6m40s (9trains/h)	4m (15trains/h)	6m40s (9trains/h)
2048												
2049												
2050												
2051												

Source: JICA Study Team

(6) Required Number of Train sets and Cars

The required number of train sets is estimated with the following method.

- A. Maximum daily train-km is restricted to 600 train-km/day.
- B. Required train sets are calculated based on the train operation chart in such a way that each train operates within 600 km/day.
- C. Required stand-by train sets is round-up value of 10% of required number of train sets.
- D. Train-km/day in 2022 and 2030 are estimated based on the train operation chart and that of other years are estimated by comparing the train operation plan in the year concerned and that in 2030.
- E. Required train sets are estimated based on the train-km/day of 2022 and 2030.

The required number of train sets and cars for N-A1, N-A2 and N-B1 options is estimated as shown in Table 5.1.16, Table 5.1.17 and Table 5.1.18.

Table 5.1.16 Required Number of Train Sets and Cars of N-A1 Option

Year	KCR (4-car Formation)			Extension (8-car Formation)			Number of cars
	Train Sets	Standby	Total	Train Sets	Standby	Total	
2022	22	3	25				100
2023	22	3	25				100
2024	22	3	25				100
2025	22	3	25				100
2026	22	3	25				100
2027	22	3	25				100
2028	22	3	25				100
2029	22	3	25				100
2030	24	3	27	6	1	7	164
2031	24	3	27	6	1	7	164
2032	24	3	27	6	1	7	164
2033	24	3	27	6	1	7	164
2034	24	3	27	6	1	7	164
2035	24	3	27	6	1	7	164
2036	24	3	27	6	1	7	164
2037	24	3	27	6	1	7	164
2038	24	3	27	6	1	7	164
2039	24	3	27	6	1	7	164
2040	24	3	27	6	1	7	164
2041	24	3	27	6	1	7	164
2042	24	3	27	6	1	7	164
2043	24	3	27	6	1	7	164
2044	24	3	27	6	1	7	164
2045	24	3	27	6	1	7	164
2046	24	3	27	6	1	7	164
2047	24	3	27	6	1	7	164
2048	24	3	27	6	1	7	164
2049	30	3	33	8	1	9	204
2050	30	3	33	8	1	9	204
2051	30	3	33	8	1	9	204

Source: JICA Study Team

Table 5.1.17 Required Number of Train Sets and Cars of N-A2 Option

Year	KCR (4-car Formation)			Extension (8-car Formation)			Number of cars
	Train Sets	Standby	Total	Train Sets	Standby	Total	
2022	22	3	25	25	4	100	100
2023	22	3	25	25	4	100	100
2024	22	3	25	25	4	100	100
2025	22	3	25	25	4	100	100
2026	22	3	25	25	4	100	100
2027	22	3	25	25	4	100	100
2028	22	3	25	25	4	100	100
2029	22	3	25	25	4	100	100
2030	20	3	23	5	1	6	140
2031	20	3	23	5	1	6	140
2032	20	3	23	5	1	6	140
2033	20	3	23	5	1	6	140
2034	20	3	23	5	1	6	140
2035	20	3	23	5	1	6	140
2036	20	3	23	5	1	6	140
2037	20	3	23	5	1	6	140
2038	20	3	23	5	1	6	140
2039	20	3	23	5	1	6	140
2040	20	3	23	5	1	6	140
2041	24	3	27	6	1	7	164
2042	24	3	27	6	1	7	164
2043	24	3	27	6	1	7	164
2044	24	3	27	6	1	7	164
2045	24	3	27	6	1	7	164
2046	24	3	27	6	1	7	164
2047	24	3	27	6	1	7	164
2048	24	3	27	6	1	7	164
2049	24	3	27	6	1	7	164
2050	24	3	27	6	1	7	164
2051	30	3	33	8	1	9	204

Source: JICA Study Team

Table 5.1.18 Required Number of Train Sets and Cars of N-B1 Option

Year	KCR (4-car Formation)			Extension (8-car Formation)			Number of cars
	Train Sets	Standby	Total	Train Sets	Standby	Total	
2022	3	25	25	4	100	100	22
2023	3	25	25	4	100	100	22
2024	3	25	25	4	100	100	22
2025	3	25	25	4	100	100	22
2026	3	25	25	4	100	100	22
2027	3	25	25	4	100	100	22
2028	3	25	25	4	100	100	22
2029	3	25	25	4	100	100	22
Year	KCR (8-car Formation)			Extension (8-car Formation)			Number of cars
	Train Sets	Standby	Total	Train Sets	Standby	Total	
2030	3	23	5	1	6	140	20
2031	3	23	5	1	6	140	20
2032	3	23	5	1	6	140	20
2033	3	23	5	1	6	140	20
2034	3	23	5	1	6	140	20
2035	3	23	5	1	6	140	20
2036	3	23	5	1	6	140	20
2037	3	23	5	1	6	140	20
2038	3	23	5	1	6	140	20
2039	3	23	5	1	6	140	20
2040	3	23	5	1	6	140	20
2041	3	27	6	1	7	164	24
2042	3	27	6	1	7	164	24
2043	3	27	6	1	7	164	24
2044	3	27	6	1	7	164	24
2045	3	27	6	1	7	164	24
2046	3	27	6	1	7	164	24
2047	3	27	6	1	7	164	24
2048	3	27	6	1	7	164	24
2049	3	27	6	1	7	164	24
2050	3	27	6	1	7	164	24
2051	3	33	8	1	9	204	30

Source: JICA Study Team