CHAPTER 7
PRELIMINARY ENGINEERING DESIGN OF FACILITIES AND EQUIPMENT

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7.1 PREFACE

In this study, the JICA Study Team (JST) was to review the results of Feasibility Study (PETS-II) and modify the conceptual design carried out by RITES. However, the conceptual design drawings were not attached with PETS-II Report. The rough concept of design was available from the PETS-II report, but the design for structures and facilities was not presented. In parallel to JICA study, the RITES is presently conducting the final location survey and the conceptual design including the final route alignment. It was found that the outputs of above survey and design would be submitted after September 2007.

Considering the period of this study which ends in October this year, the JST could not wait for the submission of conceptual design by RITES. Accordingly JST decided to prepare the guideline design individually and the environmental social consideration survey, cost estimation and project implementation schedule will be prepared based on this guideline design. This guideline design will be presented to the Indian side and an agreement that the conceptual design by Indian side will be undertaken complying with JST guideline design will be obtained.

7.2 ALIGNMENT PLAN

7.2.1 Obtaining Available Information

In June 2007, the vertical alignment of RITES Study (PETS-I) was finally obtained. However, this information was insufficient to take a look at the whole alignment picture. The present situation on available information is shown below. The following table showing the shaded portion for which horizontal alignment, topographical map, and vertical alignment was obtained.

Table 7-1 Situation of Alignment Information Acquired from RITES

Section		Distance	Horizontal Alignment	Topographical Map	Vertical Alignment	Remarks
EFC	Sonnagar - MughalSarai	130km	No	No	Yes	
	MughalSarai - Fatehpur	270km	Yes	Yes but not all	No *	*It can not be used.
	Fatehpur - Dadri	490km	Yes	Yes but not all	Yes	
	Khurja - Ludhiana	390km	Yes	Partially	No	
WFC	JNPT - Valsad	240km	Yes	No	Yes	
	Valsad - Surat	70km	Yes	No	Yes	
	Surat - Ahmedabad	300km	Yes	No	No *	*It can not be used
	Ahmedabad - Palanpur	90km	Yes	Yes but not all	No *	*It can not be used.
	Palanpur - Madar	370km	Yes	Yes but not all	Yes *	*There is little information.
	Madar - Rewari	130km	Yes	Yes but not all	Yes	
	Rewari - TKD	210km	No	No	Yes	

Note: EFC: Eastern Freight Corridor, WFC: Western Freight Corridor

7.2.2 Previous Procedure

This JICA Study was proceeded to carry out reviewing of RITES PETS-II route alignment plan. However, although JST requested several times for obtaining a set of the route alignment planned on the topographical maps through MOR to RITES, it was not provided and the reason of national security/defense was cited. Therefore, JST considered other ways to review by using hand traced horizontal alignment records in RITES Office and layered it on 1/50,000 topographical maps borrowed from RITES.

However, since topographical maps of restricted area could not be obtained, the route alignment could not be reviewed between JNPT-Ahmedabad in Western Corridor and for the alignment close to Kanpur, Ambala and Saharanpur on Eastern Corridor. There are parts where topographical maps are missing in some areas for the same reason.

According to explanation of RITES, the DFC vertical alignment was not changed at all from the time of PETS-I Report completion, and since the latest vertical alignment is being worked out in their Final Location Survey (FLS), the vertical alignment on PETS-II alignment was not available. The written detail and compatibility of the vertical alignment of PETS-I seems to be differently drawn by the RITES sub-consultant who undertook the design, especially about 1/3rd length which could not be reviewed due serious errors in the levels.

In order to carry out of reviewing the RITES design with the above mentioned compelling shortage of information and to ensure the accuracy of the guideline design, JST decided to carry out its guideline design using an original technique.

7.2.3 The Original Technique of the Guideline Design

There is no change fundamentally, to perform the guideline design of the DFC route alignment by reviewing RITES design. However, since the original technique of the JST devised in order to compensate for shortage of data/information was carried out based on the information which JST obtained, apart from the existing data obtained from RITES, this in turn worked out to be a superior method of verifying RITES PETS-II from a completely independent viewpoint.

The basic concept for reviewing RITES route alignment plans, is by referring to the above mentioned horizontal alignment drawings which were hand traced and layered on 1/50,000 topographical maps, on the other hand, utilizing the hand traced alignment data to be modified to have its coordinates by plotting on GIS, and then carrying out coordinate conversion to plot these data on CAD software so that it becomes a visual alignment on the topographic feature map images.

The vertical and horizontal accurate location of existing lines which is considered indispensable basic information for alignment planning had been obtained by JST site survey over the whole existing railway track by taking video photography together with GPS data. JST made these data available for vertical alignment and further the earthwork quantities calculation using the same procedure as mentioned above. (It is separately referred to for the technique of earthwork quantity calculations)

The above mentioned video photography and GPS data is utilized for the check of different situations along the existing line, i.e. existence of ROB's and their structural arrangements, and existing bridges, etc., this assisted immensely and served as a reference data on the DFC route alignment planning.

The Google Earth satellite image data has unevenness in resolution, and the portion which is not distinguishable is intermingled. In such cases where an area needs to be checked in detail which was located in a low resolution portion, JST purchased the high resolution satellite image (Quick Bird), and this was made combined with Google Earth on CAD, and used for the checking of the subject area which should be avoided or re-aligned.

7.2.4 Concept of Route Alignment

For reviewing the route alignment, consideration for construction method, economical efficiency, etc. were kept in mind besides the following basic concepts. About any portion considered necessary for modification, it will only be proposed by stating clear reason.

1) The majority of alignment plan of RITES is kept mostly same as much as possible. (It will not be changed or modified without assigning a clear reason)
2) The plan should be made such that the social / natural environmental impact, such as relocation of inhabitants, to be as minimum as possible.
3) The plan is made based on the technical principle of the railway alignment parameters such as the minimum curve radius is about 700m, with the maximum gradient of 5‰, considered compensation due to the affect of vertical curve, etc.
4) Existing ROBs in parallel section are basically to be replaced. For considerably difficulty in ROBs replacement and a large scale/size of ROBs and/or for the ones located in congested area, detour of DFC will be considered.
5) The route is considered on the presumption that the level crossings in parallel section are to be grade separated, and all crossing roads along DFC detour section are to be RUBs.

   However, it is also considered based on the assumption that the construction of ROBs will be isolated from the DFC project, and their implementation will continue even after the completion of DFC. The level crossing can be converted to an automatic level crossing during the period until ROB is fully built and operational.

   In the case of sections that comprise of many level crossings which have to be grade separated such as for TVU $\geq$ 900,000, and the total number of level crossing are more than one in every 2km in between DFC stations, it will be an objective decision to consider elevating DFC. It will be decided whether or not to do so, by considering the surrounding topographical features, soil conditions and locations, etc.

6) When crossing a river, a highway, etc. (Important Bridges), it should cross at right-angle as far as possible. Even when it is unavoidable, in order to prevent designing a structure with an extreme angle of skew, the crossing angle shall be maintained at least 60 degrees or more, in principle.
7) Each Crossing Station of DFC is constructed on ground level in principle, however in case of detour section, it may have to be constructed on embankment or viaduct.

7.2.5 Guideline Design of Route Alignment Plan

As a result of review based on the concept stated in the preceding clause, some portions of modifications are proposed, as shown below. The modified portions of Phase I-a sections are described in the following paras.

Since the route alignment plan of RITES has repeated readjustment based on hand traced line as mentioned above, a high value of procedure error may get included.

Therefore, although it may look that RITES alignment has a portion which does not necessarily point out the correct reason for a major modification described here, since the alignment tracing error exists, JST proposal may not always be very different than the proposed RITES alignment.

The modified route proposals are shown in Figure 7-1 to Figure 7-9 with major reasons for their changes. Moreover, city areas, existing ROBs, etc. along the existing lines which are the cause of DFC detour are also shown in the figures.

In addition to above, it became clear by supplementary site survey that there was a portion for which rock excavation of about 10 m deep is needed near Sendra Station between Palanpur-Ajmer on the Western Corridor. Although it seems that consideration of detour for DFC route is required because of rock excavation close to existing railway which may be difficult to carry out, however at present, detour route planning cannot be done because of poor resolution of Google Earth satellite image. Therefore, JST will inform to MOR/DFCCIL/RITES that this area may require a detour route, and request to take necessary action in FLS by RITES.

1) Eastern Freight Corridor

a) Allahabad Detour (Figure 7-1)

Since it became clear that a Large Fortress, Local Community and Airport existed on the route where the detour route was proposed by RITES PETS-II Report, this was checked on the satellite imagery, and route which avoids these properties was proposed. Especially the distance between detour route and the Airport runway was kept as far as possible. Other modifications were to the alignment which crosses a river and some main roads, etc. which will be at a right angle as far as possible.

Detour line length is about 26.6 km, and the existing line length of this section is about 29.1 km, and the difference is shorter by about 2.5 km (For RITES proposed route, it is about 32.2 km, however this could be because of error of hand tracing).

b) Kanpur Detour (Figure 7-2)

Since Local Community exists on the detour route proposed by RITES, and also it crosses a river (may be a big canal) by an acute angle of skew, the route which can avoid this, is proposed. Detour line length is about 48.2 km, and the existing line length of this section is about 48.1 km, and the difference is only about 100 m in excess (it is about 45.1 km for RITES proposed route).

c) Etawah Detour (Figure 7-3)

The detour route that JST proposed for this section is not very much different from the detour route proposed by RITES, however, it was considered since the alignment which avoids a sewage-treatment plant and local communities, and it crosses main roads etc. at an angle nearly as close to a right-angle as possible.

Detour line length is 16.2 km and it is almost the same in length as RITES route, while the existing line length of this section is about 13.3 km. The difference is in excess by about 2.9 km.

d) Aligarh Detour (Figure 7-4)

Since resolution of Google Earth satellite image in this section was very low and check in detail was not possible, JST purchased the high resolution satellite image (Quick Bird) and amalgamated it with Google Earth image on CAD for DFC alignment planning. As a result, the detour route proposed by RITES runs through the city built-up area, therefore JST proposed the modified alignment which avoids the city area. Detour line length is about 33.9 km, and the existing line length of this section is about 32.0 km, and the difference is about 1.9 km in excess (it is about 26.3 km for RITES proposed route).

2) Western Freight Corridor

a) Vadodara - Ahmedabad Detour (Figure 7-5 (1),Figure 7-5 (2))

This section is a lengthy detour, because the city areas are fully developed, with many built-up areas and also there are 20 existing ROBs along the existing line. The detour route which RITES had proposed bypasses the city area of Vadodara, and then it runs along for about 10 km with the existing line near Vasad, and further takes a large detour route which avoids the city areas of Anand, Nadiad, Ahmedabad, Kalol, and Mahesana.

There is an existing ROB in this parallel section near Vasad, and it is also noticed on the to and for RITES route plan, local communities exists, and the line also crosses the Mahi River by an acute angle of skew, etc. JST proposes the route which avoids these factors and connects both detour routes. Although JST detour is almost similar to that of RITES proposal except in Vasad area, some modification was required in order to avoid local communities and a wildlife sanctuary. Proposed detour line length is about 211.4 km, and the existing line length of this section is about 189.5 km, and the difference is about 21.9 km in excess (the RITES proposed detour route is about 216.6 km).

b) Palanpur Detour (Figure 7-6)

Although the detour route proposed by RITES was about 18.1 km which avoids the existing city area and reverts back to the parallel section with existing line, since a wildlife sanctuary exists between Chitrasani-Jethi of the existing line, JST proposes the route which avoids this. As shown in the figure, although the existing line is running through the wildlife sanctuary for about 2.5 km only, there is no way except a detour route through the northern side of the Ghats because the other possible route is blocked by the Ghats and Dry Valleys. Therefore the length of the detour route became34.6 km, and the existing line length of this section is about 34.6 km, and the difference is about 5.5 km in excess.

c) Kishangarh Detour (Figure 7-7)

Since resolution of Google Earth satellite image in this section is very bad and detailed checking is not possible, JST purchased the high resolution satellite image (Quick Bird) as mentioned earlier, and used it along with the Google Earth image on CAD for DFC alignment planning. As a result, it became clear that the detour route proposed by RITES runs through a marble processing facility and the line requires a deep excavation of a mountain located towards the existing line, therefore JST proposes modified alignment which avoids these area. Detour line length is about 16.6 km, and the existing line length of this section is about 13.4 km, and the difference is about 3.2 km in excess (it is about 13.3 km for RITES proposed route).

d) Phulera Detour (Figure 7-8)

On the detour route which RITES proposed, there are a few built-up areas on the route, a route which avoids this, is proposed by JST. Detour line length is about 19.4 km, and the existing line length of this section is about 16.3 km, and the length of RITES route is about 23.6 km.

e) Ringas Detour (Figure 7-9)

The detour route which RITES proposed crosses ‘Wadi’(Dry Valley) which turns into a river during the rainy season at three places, therefore the required total bridge length becomes more than 3 km. If these construction costs are included, besides replacement of the existing ROB which will be very difficult, evidently the route parallel to the existing line is better suited. However, since the parallel route has to cross an existing branch line by rail-flyover and also needs to pass over the existing ROB close to the branch line for which height of embankment becomes 20m or more, shorter detour is proposed by JST. It seems that the RITES route is so much different due to an error of hand tracing by JST, however it is assumed that it has a certain reason to be different from an original proposal. Detour line length is about 11.4 km, and the existing line length of this section is about 10.4 km, and the length of RITES route is about 36.7 km.

f) Rewari Alignment (Figure 7-10)

Although a new line from Rewari to Dadri is planned which connects Western with Eastern Corridor at Dadri, since detailed investigations are required because of technical issue like a long tunnel and viaduct, this line is removed from Phase I-a to be included in Phase I-b.

On the other hand, the container traffic to Delhi Metropolitan Area is an important component of the DFC project, it is necessary to provide transportation route from Rewari towards Gurgaon, in the direction of Delhi. For the above reason, it is prepared the connecting line avoiding the city's Master Plan area linking to the existing tracks through a northwest direction from Rewari Junction Station of DFC. Rewari Junction Station is built as a terminal station of Phase I-a, this connecting line is also included in Phase I-a. One connecting line elevates over three existing lines and further connects the existing track towards Gurgaon, while the other connecting line alongside the previous line elevates only over two existing lines and further connects the existing track towards Hisar.

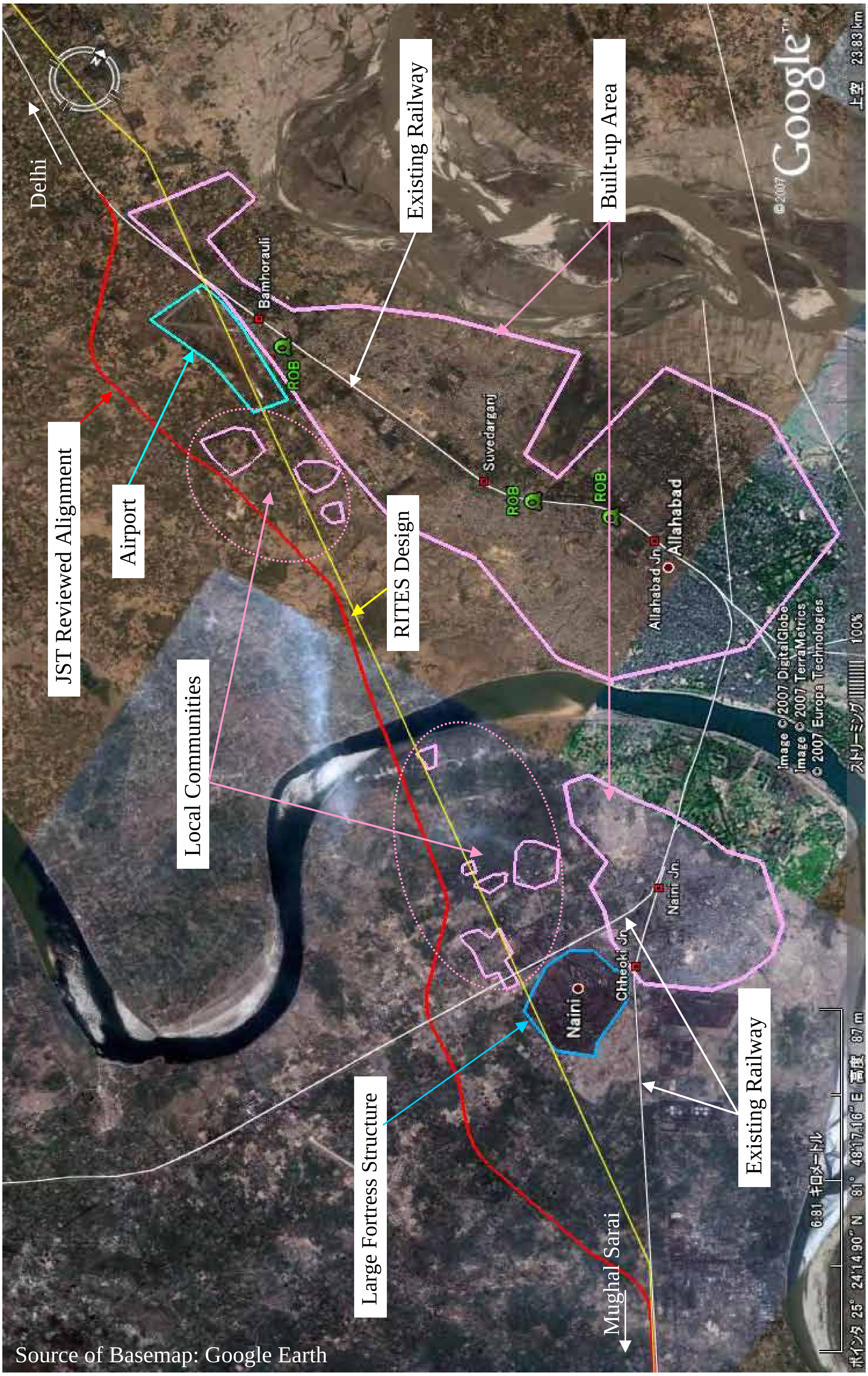


Figure 7-1 Allahabad Detour

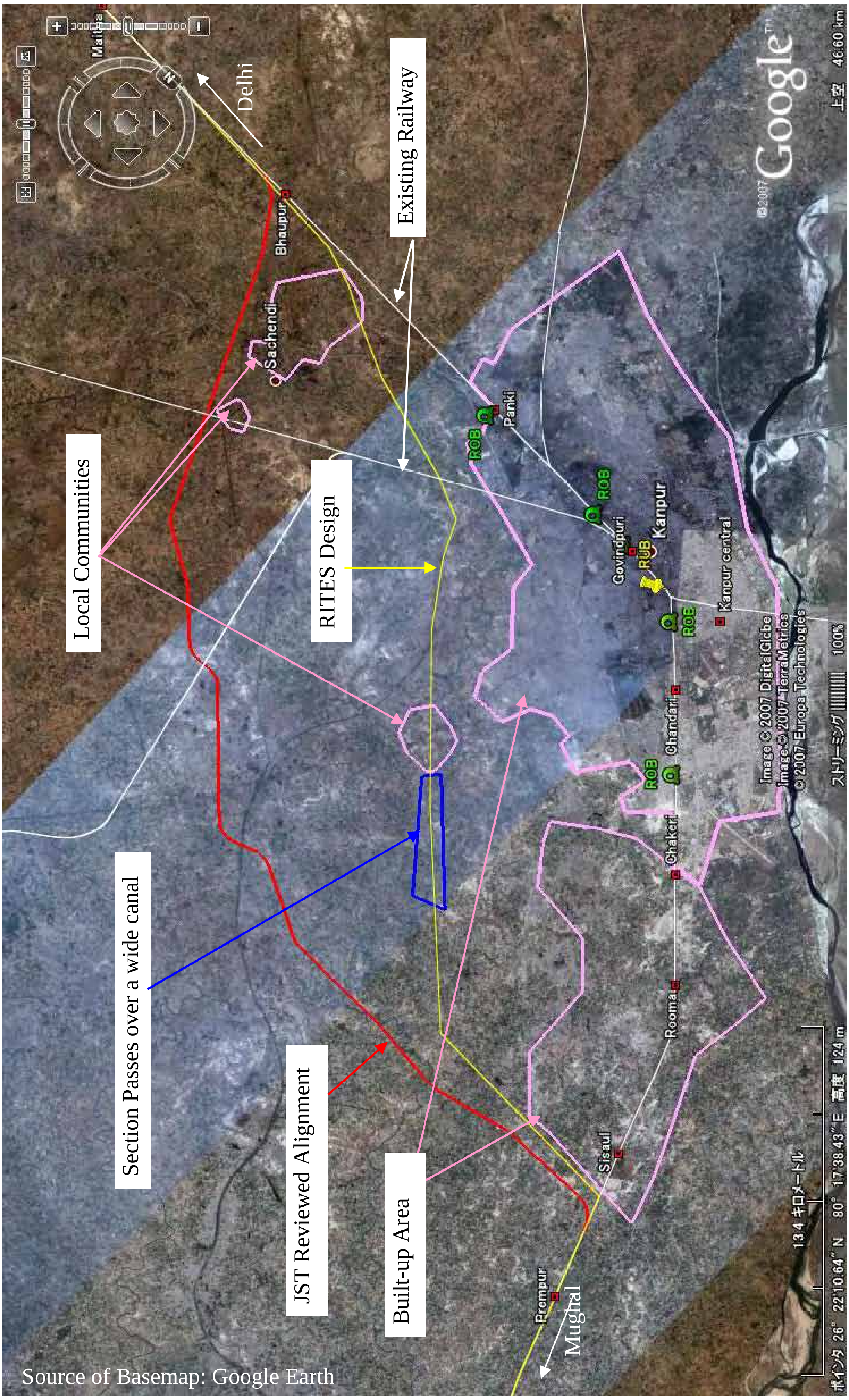


Figure 7-2 Kanpur Detour

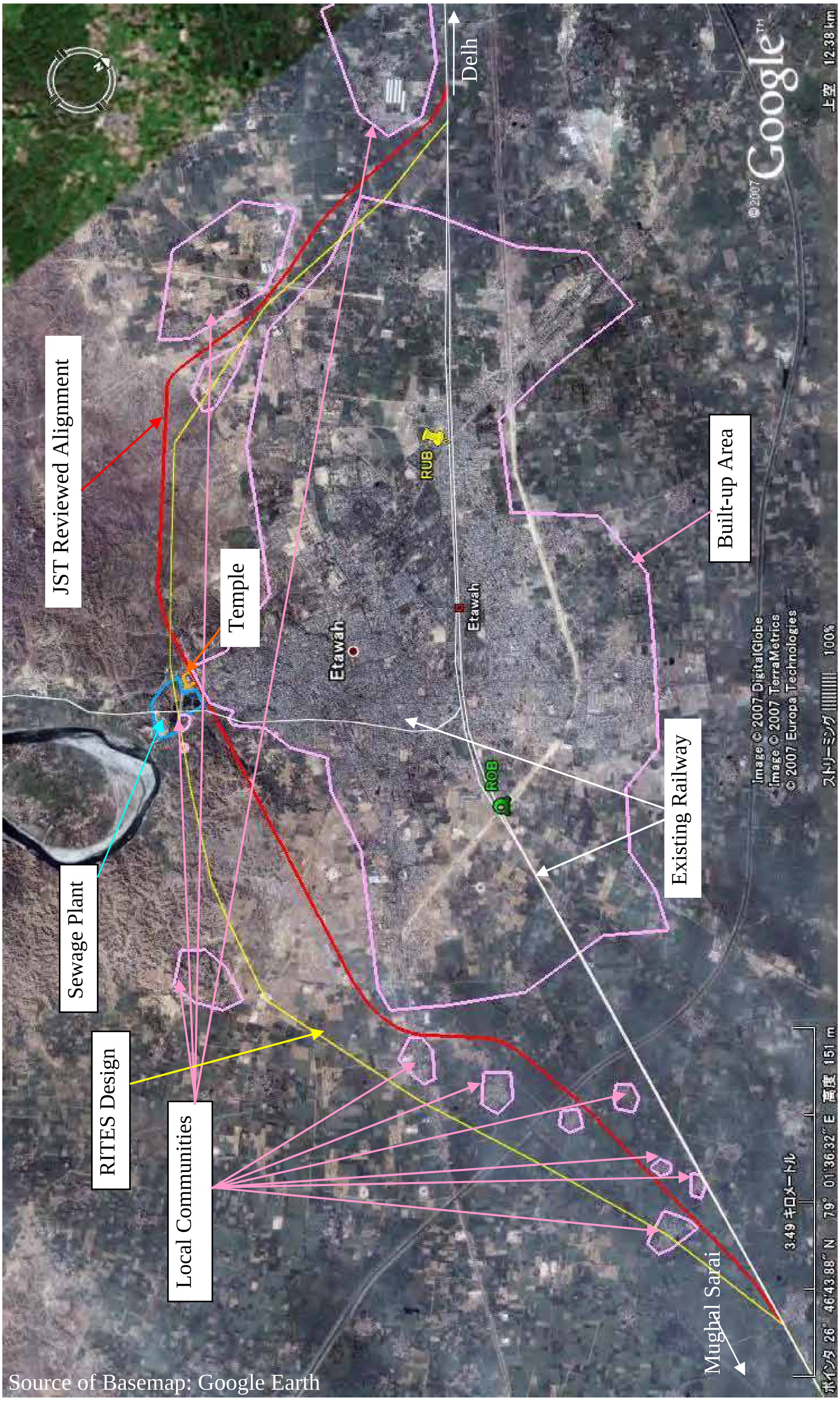


Figure 7-3 Etawah Detour

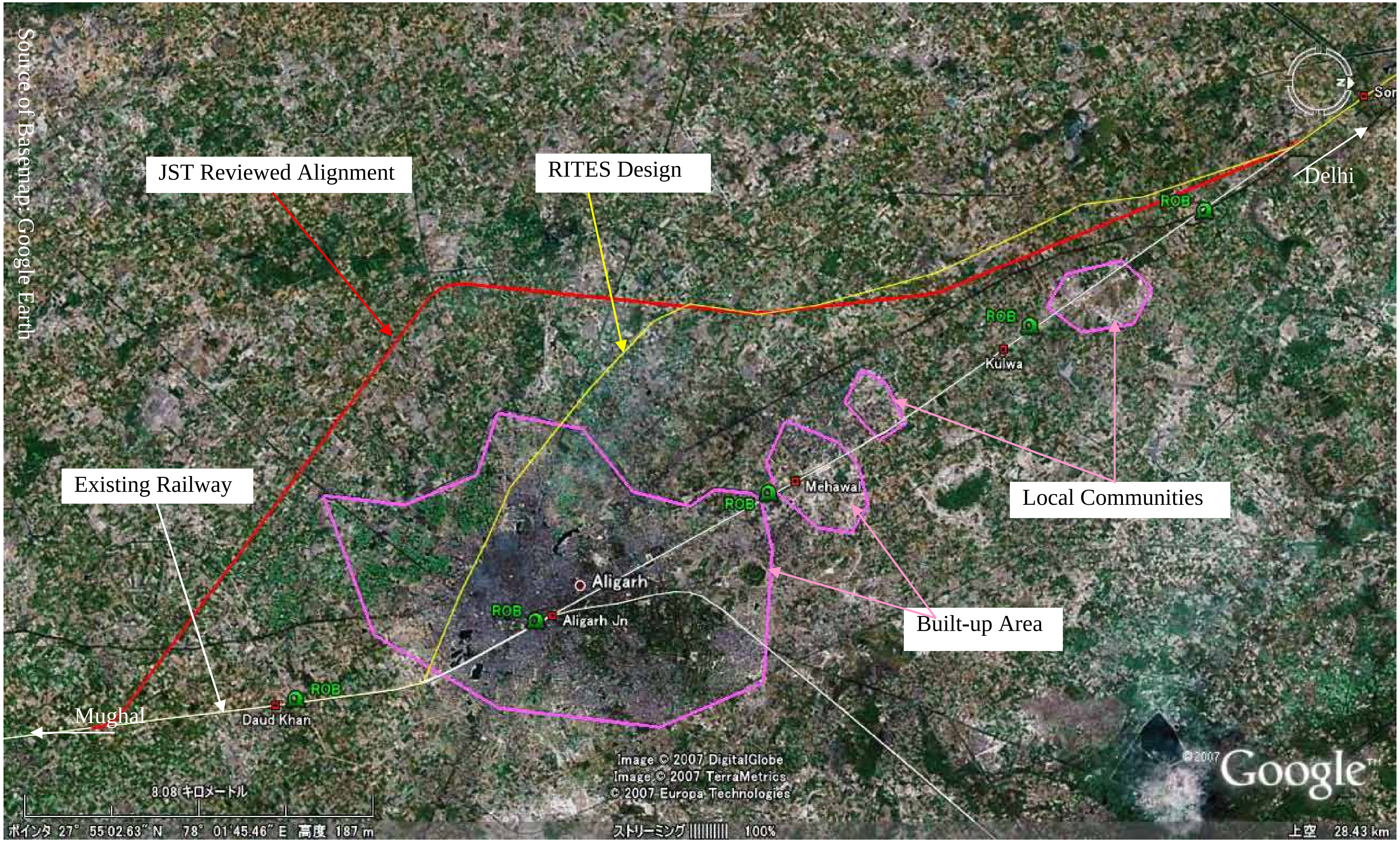


Figure 7-4 Aligarh Detour

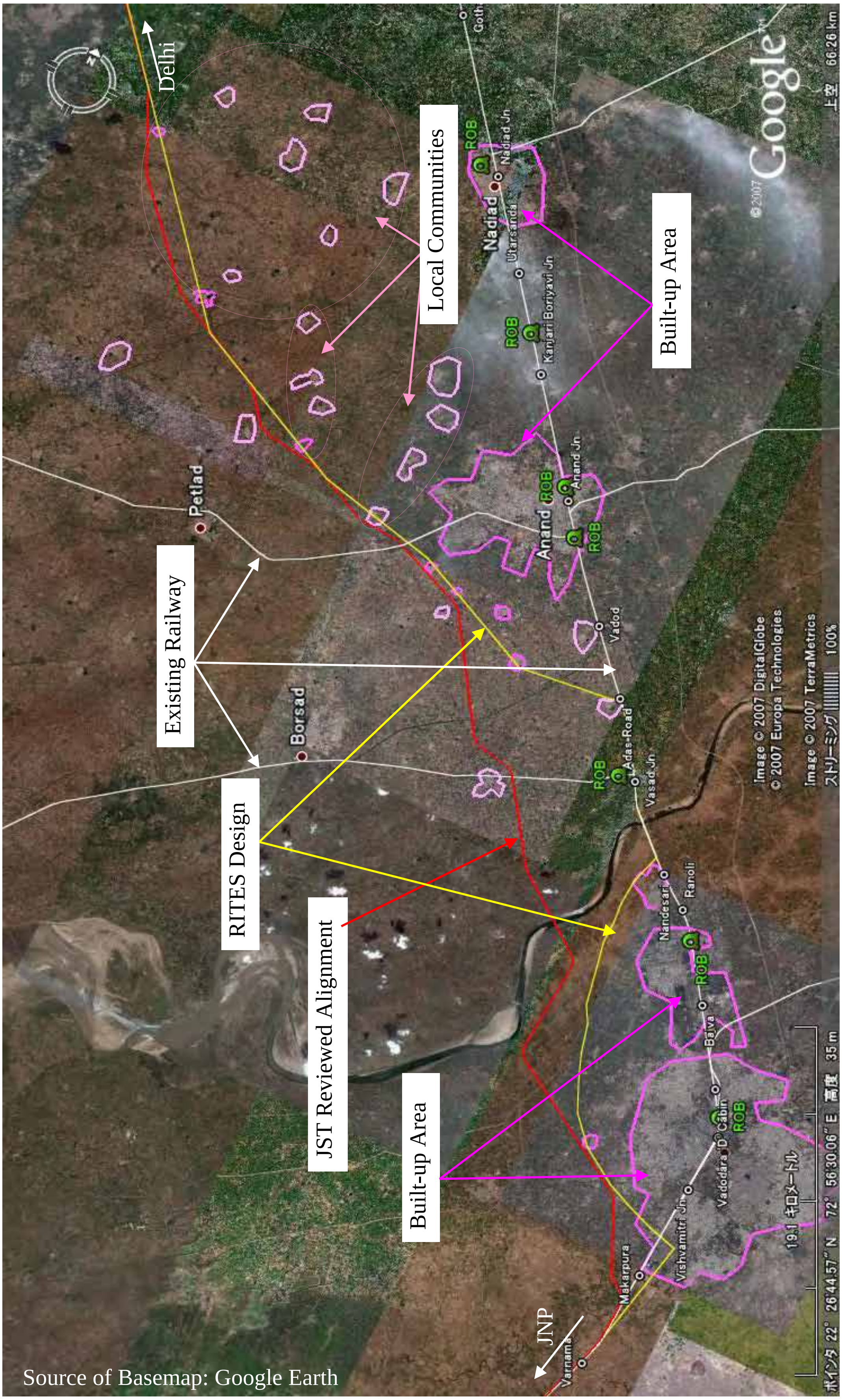


Figure 7-5 (1) Vadodara-Ahmedabad Detour (South)

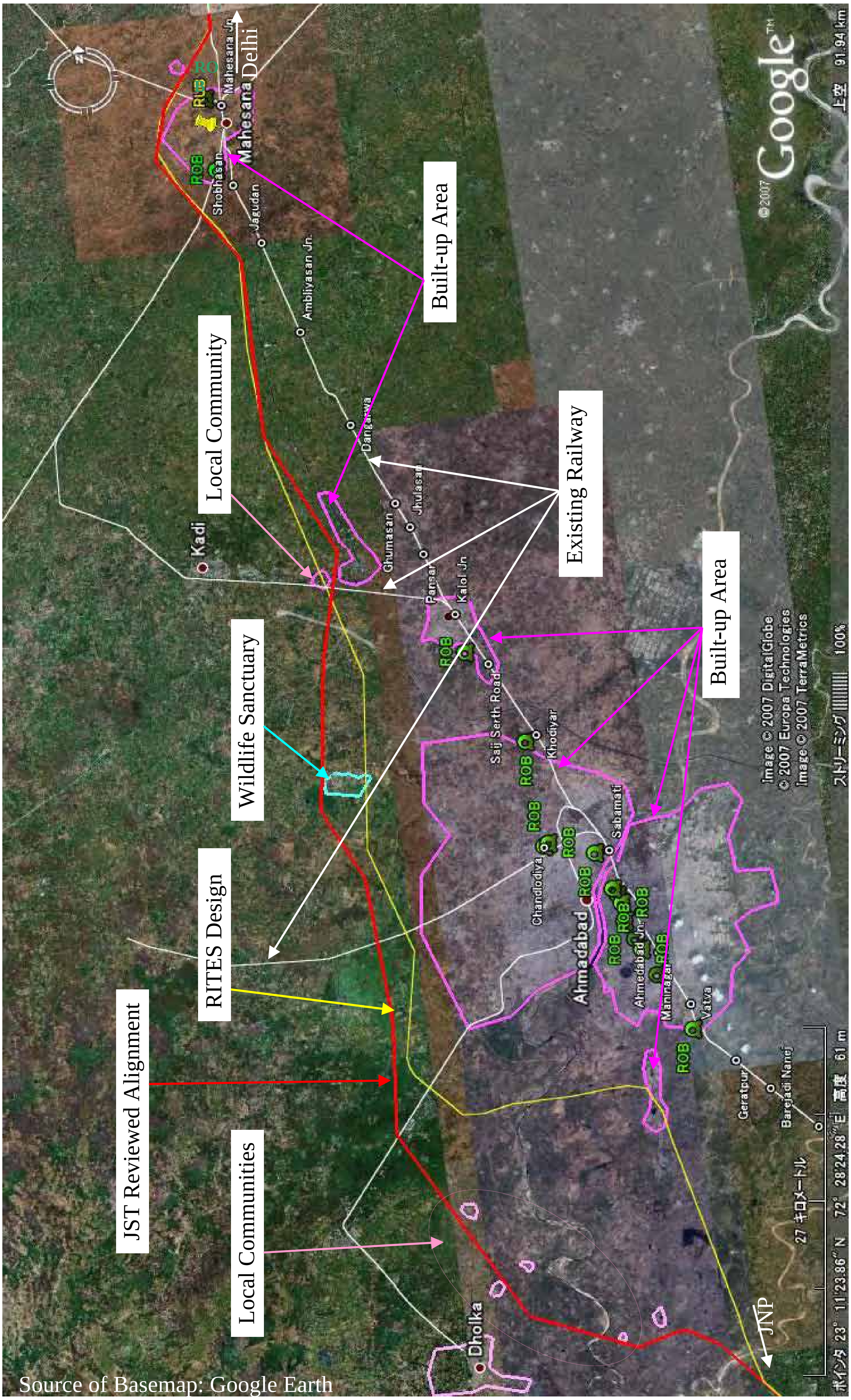
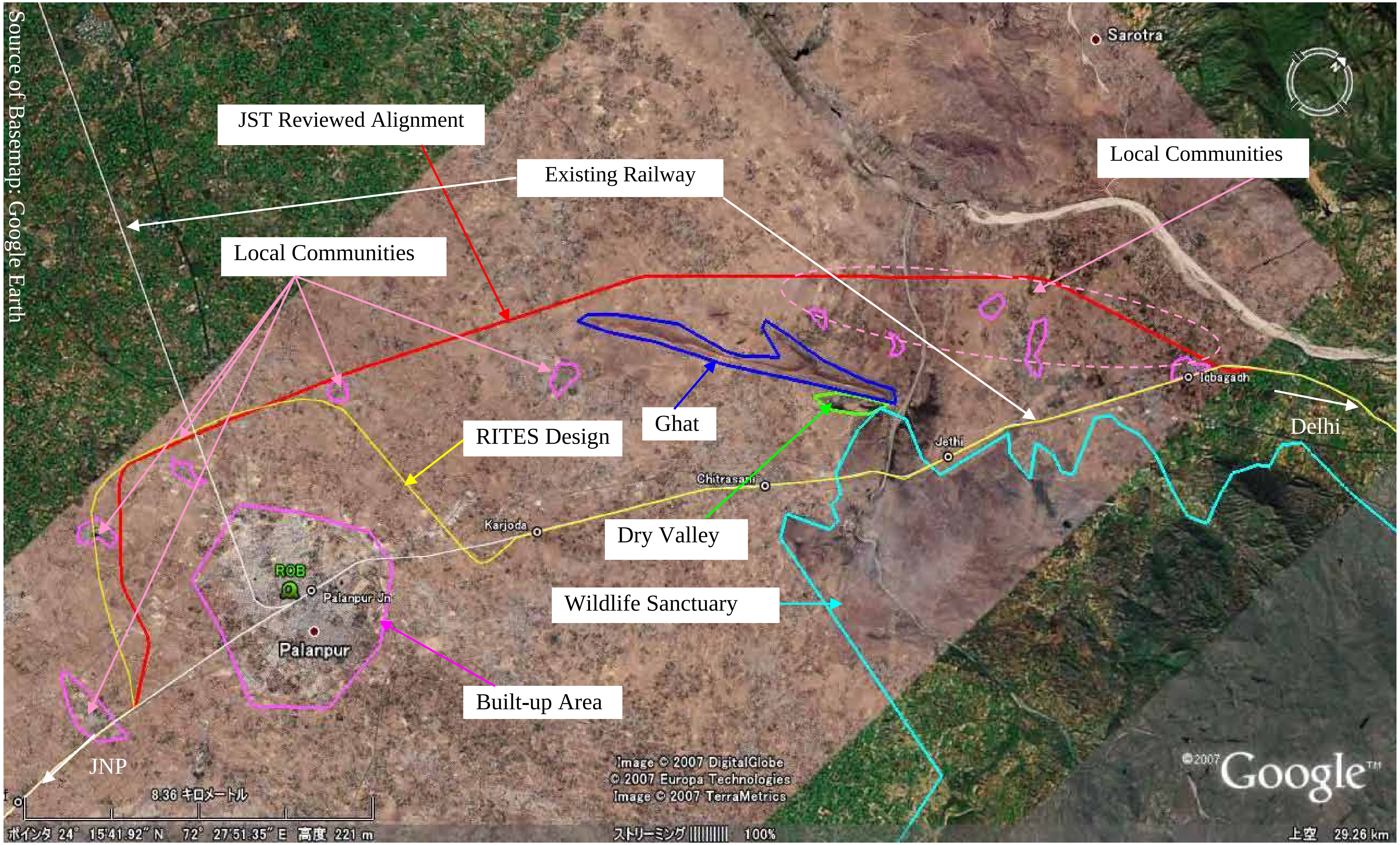


Figure 7-5 (2) Vadodara-Ahmedabad Detour (North)



Source of Basemap: Google Earth

Figure 7-6 Palanpur Detour

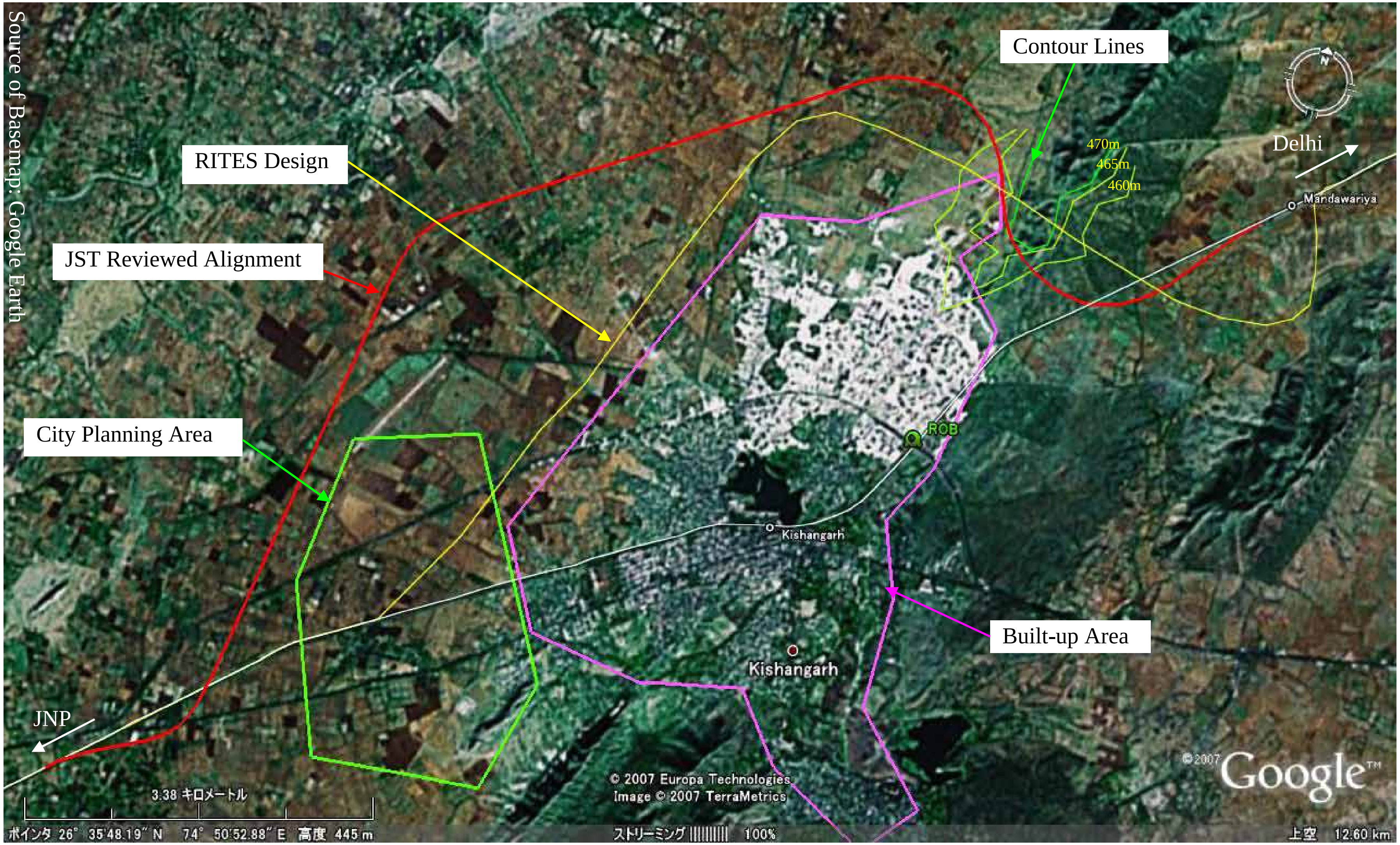


Figure 7-7 Kishangarh Detour

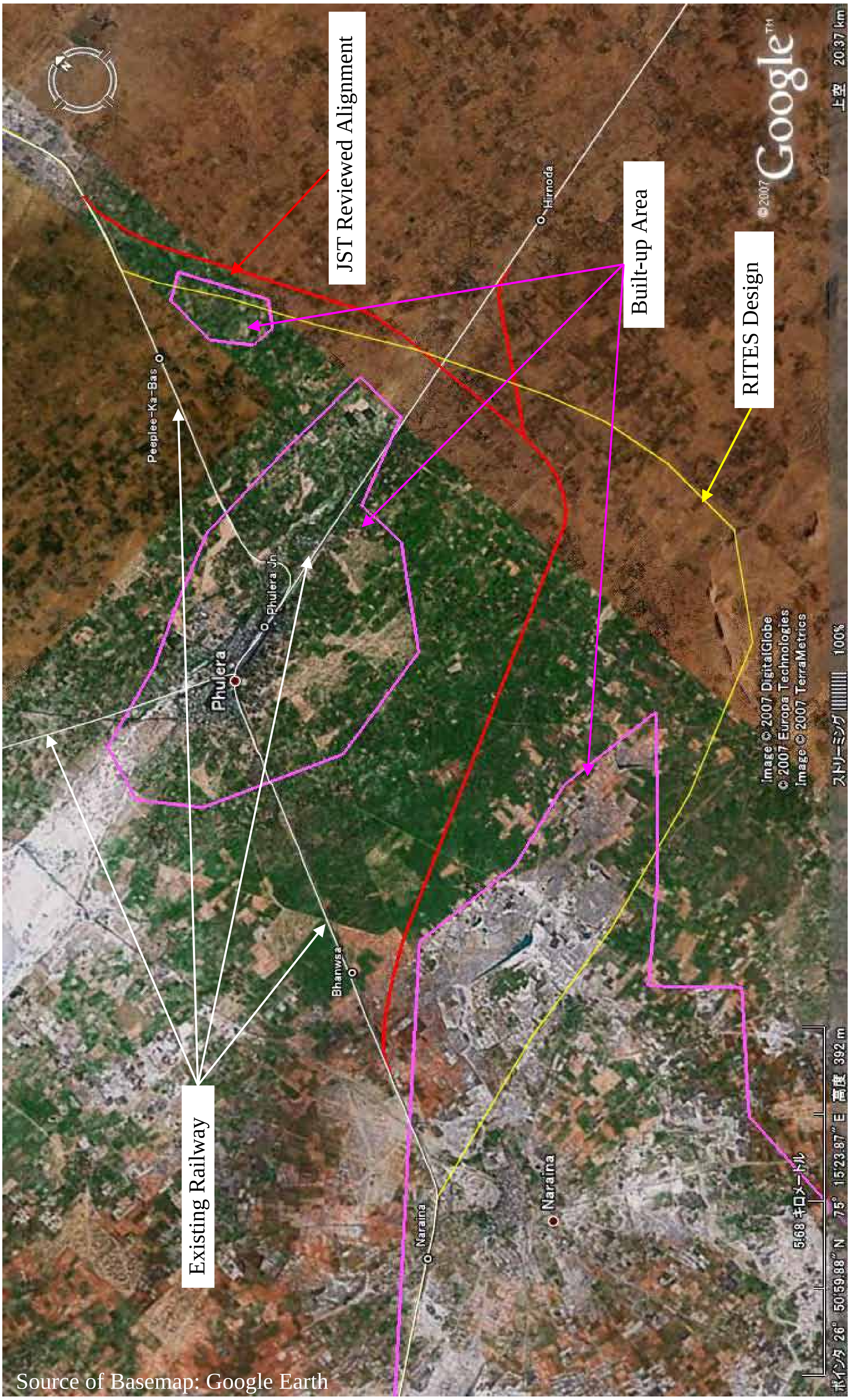


Figure 7-8 Phulera Detour

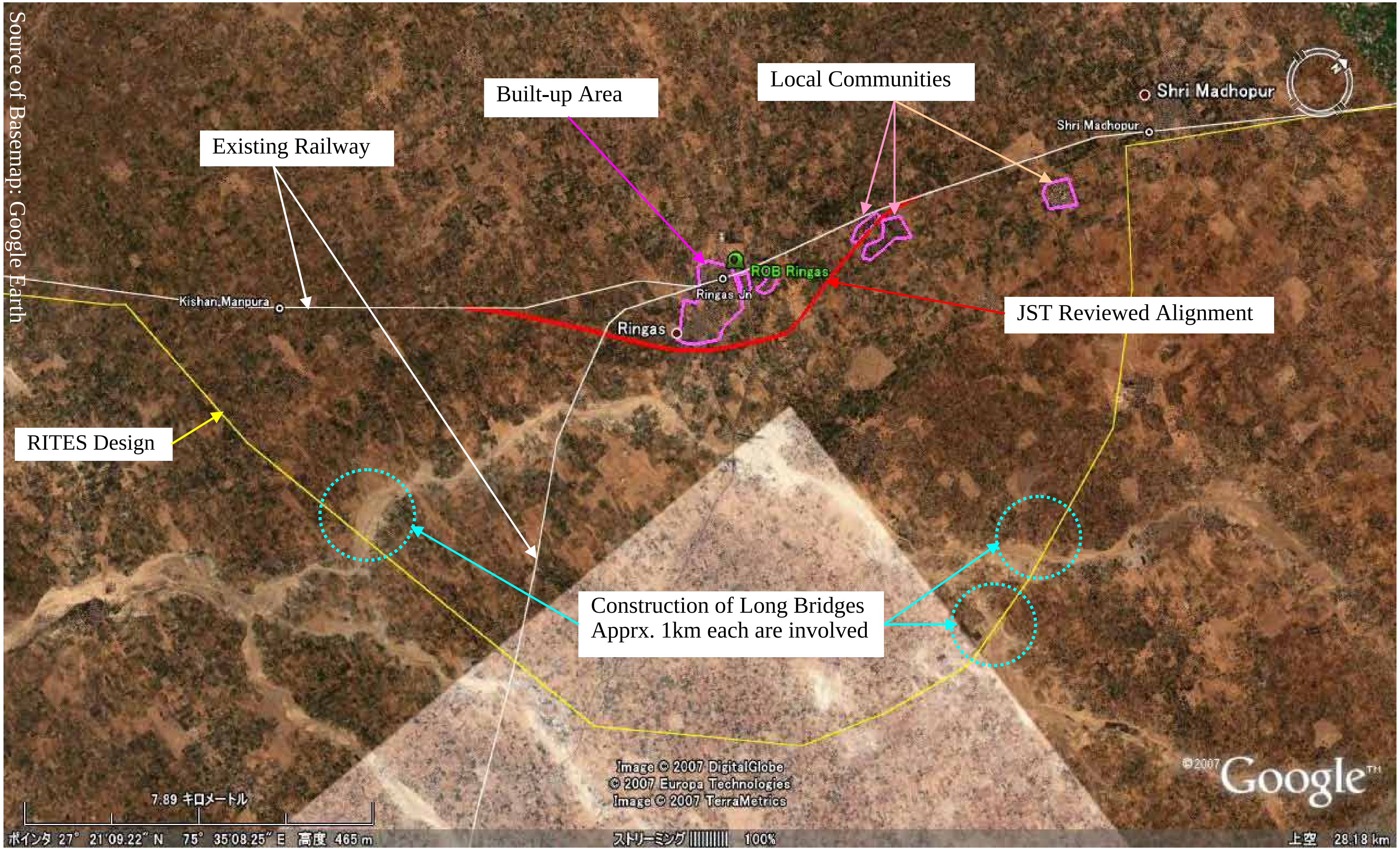


Figure 7-9 Ringas Detour

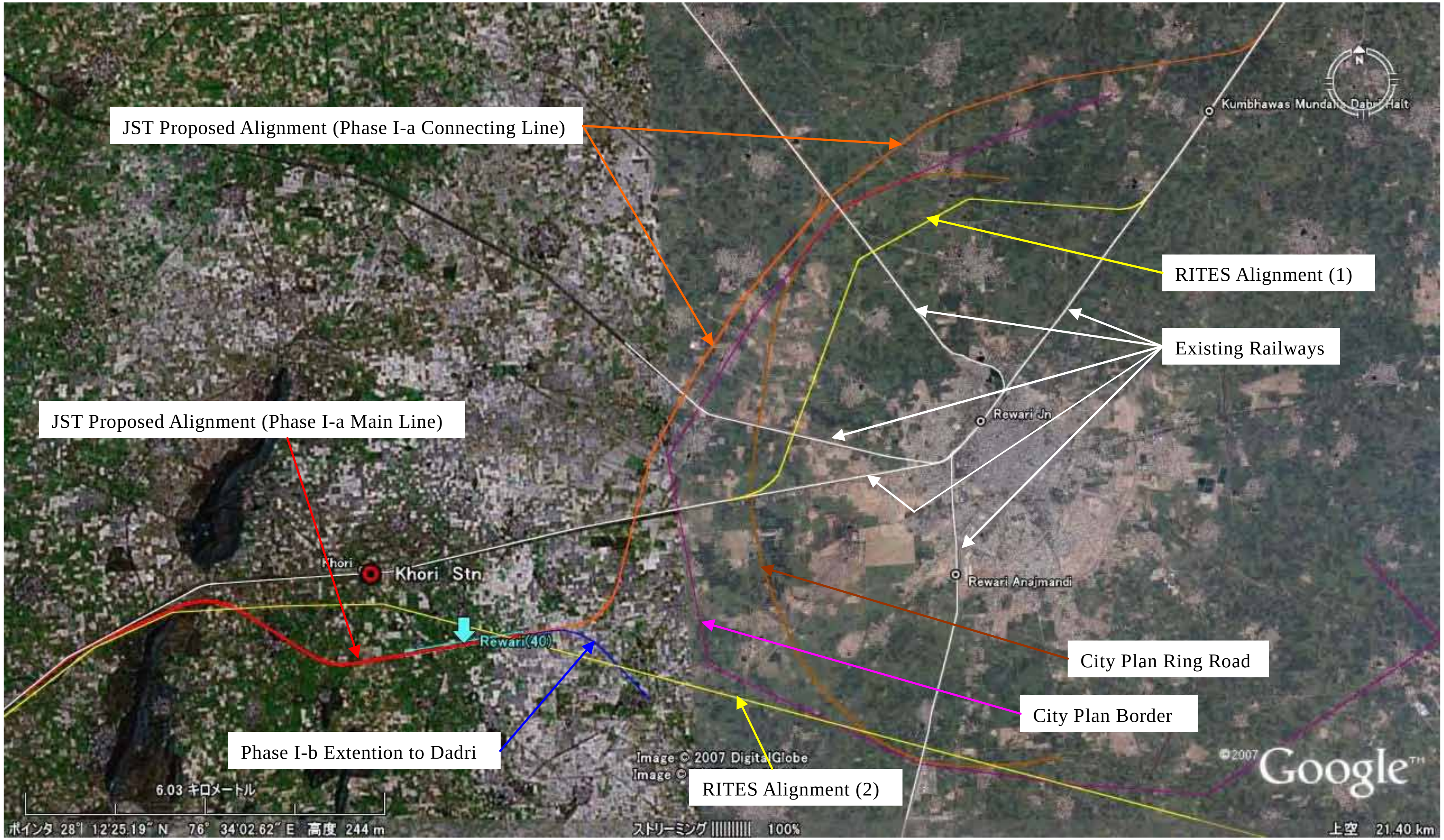


Figure 7-10 Rewari Alignment (Phase I-a Terminal)

7.2.6 Possible Modification of Route Alignment in Phase I-b & II Section

1) Eastern Freight Corridor

a) Khurja - Ludhiana

This section was added after PETS-I Report was submitted, therefore the study of route plan was not enough, and since the data of alignment and topographical maps were not shown to JST, it could not be reviewed. However, since the city area is developed around the railway tracks and many ROBs are also existing, it seems that a detailed survey including detour route alternatives is required.

b) Sonnagar - Mughal Sarai

Since the Mughal Sarai Station has a large scale and complicated alignment, the plan of DFC tracks connectivity as per RITES Study was not concluded. Moreover, as a result of third additional track, there is enough line capacity against demand for the near future. Therefore, regarding this section, since it is expected that it can be influenced to a large extent, it would be pertinent to note the overall position and plan (including DFC plan to connect to Howrah), will be required to be studied in detail, before preparing and concluding the complete future plan.

2) Western Freight Corridor

a) Jasai - Panvel

In the portion passing through the mountain valley between Jasai-Panvel, it became clear as a result of review of the vertical alignment that FL of DFC which is parallel to the existing line was in an extremely low position 10 m or more below from FL of the existing line. It seems as seen from the satellite photographical image that it is impossible to let it pass through any other lower area, because many high mountains nearby.

Hence, an alternative, it will be necessary to consider a tunnel alignment passing linearly towards Panvel from Jasai. This route may need further consideration and detailed viability based on the detailed survey for its approach and connection towards Vasai Road direction where highways, waterways and complicated topographical features exist.

b) Vasai Road - Virar

There are a number of built-up areas in between these stations, and the distance between sea coast and mountain ranges is also very close. In the surrounding area of Vaitarna River there are tracts of marshy land. Moreover, the railroad serves on four-track lines in this section, the urban city area has been developing rapidly along the railway, and there are three existing ROB's which seems very difficult to replace.

Therefore, it might be better to consider a detour route. The section between Virar – Bhilad, where also 3 ROB's exist, might also have to be redesigned on similar basis. Detailed topographical and geographical survey of the area will be required.

c) Jora Vasan - Navsari

Here also, many built-up areas exist in this section along the existing railway, and if the level crossings which should be grade separated in the near future, are all concentrated in this section. This section of 26 km length of existing line has 16 level crossings that are in operation, with 5 of them having TVU $\geqq$ 900,000 and 3 having TVU $\geqq$ 100,000 presently, hence alternative route or elevated DFC track might have to be considered. In case of construction of elevated DFC track along with the existing line, it should not fall on soft ground. Therefore, detailed topographical and geographical survey will be required.

7.3 LOCATION AND LAYOUT OF DFC STATIONS/YARDS

7.3.1 Classification and role of DFC stations/yards

The role of the DFC is specialized in ensuring passageway of freight trains. On the DFC lines only freight trains of unit train system which operate between stations/lead-in tracks on the existing lines will run. Therefore, neither so-called freight stations for loading/unloading nor depots for locomotives and wagons are provided.

Two kinds of stations/yards are provided for the DFC lines.

(1) Junction station and terminal station

Junction stations are provided corresponding to the major stations of the existing lines. They are connected with the existing lines by connecting tracks. At junction stations freight trains are let in/out between the DFC lines and the feeder lines/other existing lines and long distance freight transport is carried out through the DFC lines. Out of such stations, stations at the both ends (including the spur lines) are called terminal stations, but the role as stations are not so much different.

A junction station needs facilities of connecting tracks to/from feeder lines, auxiliary main tracks and sidings for such purpose, i.e. for trains to wait to adjust time, for crews and locomotives to change, to refuel and to uncouple/couple trains when trains corresponding to 1,500 m effective track length have to operate. Besides, facilities necessary as crossing stations mentioned below have to be provided.

(2) Crossing station

Crossing stations are provided to make up for too long distances between stations composed by junction stations/terminal stations only, which are approximately 50-200 km (237 km of the longest). They are required only for railway management to secure smooth train operation and facility maintenance such as taking in trains in case of accidents, turning aside broken down trains/rolling stock, waiting/passing of trains of different speeds, exchanging trains on a single track line, and stepping aside/temporally stabling of maintenance machinery.

Stations including junction stations/terminal stations are to be set up of distances less than 40 km. In the section between Khurja and Ludhiana where the DFC is constructed as a single track line for phase I-b, supplemental crossing stations only for train exchange are to be provided making distance between stations less than 10 km.

Crossing stations are provided only for the purpose of Railway management. Therefore, they have high flexibility for selection of locations and they can be constructed at any sites where land can be easily acquired within the extent, satisfying the condition of the maximum distance between stations.

(3) Maximum distance between stations

Any distances between stations of the DFC including junction/terminal stations and crossing stations are planned to be less than 40 km. However, if traction/rolling stock plan and operating plan have different speeds by type of trains, it requires frequent passing-by/ stepping-aside and such long distances between stations are insufficient and make transport capacity short or force all trains to operate with the same speed that is the lowest. Maximum distance between stations should be planned synchronously with traction/rolling stock and operation plan.

Under the plan currently being prepared, there would be differences in speeds in the beginning because the existing locomotives and wagons on hand will be utilised. However, during this time such long distances between stations can still be applicable because traffic volume is not so high.

For single track sections the distance between stations of about 10 km can make train operation of two pair-trains per hour possible and it is appropriate. As various types of trains including empty return trains operate, accelerations of trains on the line are varying even though the maximum speed is uniform. In addition, on a single track travelling time is different between the passing train and the stopping train. Therefore, headway cannot be equal and successive operation may have to be adopted. It is desirable to install automatic block signalling with block sections between stations to enable such a successive operation.

7.3.2 Standard for stations/yards

The standard of the DFC for stations/yards is prescribed as mentioned below.

(1) Station track effective length

The station track effective length (CSR: Clear standing room) of the BG (broad gauge) lines of IR (Indian Railways) is prescribed to be 686 m. Almost all the stations have been provided with this standard. The freight transport of IR is carried out efficiently only by direct transport by the unit train system corresponding to this CSR. (In recent improvement/ construction projects length of 716 m is applied, but it is a measure taking into consideration extension of the overrun margin). The DFC is planned to have CSR of 1,500 m. This is decided based on the view point on future transport enhancement and expansion of overrun margin, though for the present only trains corresponding to CSR of 686 m are to operate.

Within the period of project life of this Project, forecast demand will not reach to the extent that it requires coupled-train operation corresponding to the CSR of 1,500 m.

The IR regulations allow to operate trains of the length same as CSR i.e. 686 m. However, this allows no margin for stopping. Therefore, practical operation needs some margin and maximum train length is actually only 670 m approximately.

Trains corresponding to 1,500 m are to operate by coupling two trains on the DFC lines, because of traction/brake performance, coupler strength, effective track length of feeder/other existing lines. In the future when ICDs/logistics parks get connected directly with the DFC lines, they may have loops to receive/send out coupled trains.

(2) Hauling capacity

Hauling capacity of the DFC of 1,500 m CSR is expected to be 15,000 ton (gross). However, it changes based on permissible axle load, permissible load density, types of wagons, density of cargo. Hauling capacity for each condition is as follows (For the case of 30 ton axle load it is based on assumptions, because design of wagons is not yet decided.):

1) 25 ton axle load on 686 m CSR

Coal, ore, etc.	100 ton * 58 = 5,800 ton
Cement in bags, grain, etc.	100 ton * 40 = 4,000 ton

Container 4 TEU * 33 = 132 TEU

(Maximum weight) 100 ton * 33 = 3,300 ton (Double stack by well-type)

2) 25 ton axle load on 686 m * 2 CSR

Coal, ore, etc. 100 ton * 58 * 2 = 11,600 ton

Cement in bags, grain, etc. 100 ton * 40 * 2 = 8,000 ton

Container 4 TEU * 33 * 2 = 264 TEU

(Maximum weight) 100 ton * 33 * 2 = 6,600 ton

(Double stack by well-type)

3) 30 ton axle load on 686 m CSR

Coal, ore, etc. 120 ton * 62 = 7,440 ton (12 ton/m wagons)

Cement in bags, grain, etc. 120 ton * 40 = 4,800 ton

Container 4 TEU * 33 = 132 TEU

(Maximum weight) 100 ton * 33 = 3,300 ton

(Double stack by well-type, because of limitation of weight of containers, maximum weight same)

[Articulated type made up of 4 wagons with 3 axle bogies in middle, with limitation of loading]

4 TEU * 36 = 144 TEU (Double stack by well-type)

(Maximum weight) 374 ton * 9 = 3,370 ton

4) 30 ton axle load on 686 m * 2 CSR

Coal, ore, etc. 120 ton * 62 * 2 = 14,880 ton (12 ton/m wagons)

Cement in bags, grain, etc. 120 ton * 40 * 2 = 9,600 ton

Container 4 TEU * 33 * 2 = 264 TEU

(Maximum weight) 100 ton * 33* 2 = 6,600 ton

(Double stack by well-type, because of limitation of weight of containers, maximum weight same)

[Articulated type made up of 4 wagons with 3-axle bogies in middle, with limitation of loading]

4 TEU * 36 * 2 = 288 TEU

(Double stack by well-type)

(Maximum weight) 374 ton * 9 * 2= 6,740 ton

(3) Maximum gradient and track spacing within station area

Maximum gradient and minimum track spacing (minimum distance between centres of tracks) within station areas of the DFC is prescribed as mentioned below. Within station areas maximum gradient is restricted to lower slopes, to prevent flowage of stabled wagons and to assist trains to start easily.

- Maximum gradient 1/1,200 (0.83‰)

  (In exceptional case) 1/400 (2.5‰)

- Track spacing 5.5m

(This is enough for operational works in yards, because this spacing is as wide as the spacing out of yards which is prescribed taking into consideration passing of trains composed of wagons whose doors are left open.)

7.3.3 Necessary functions and facilities of DFC station

(1) Junction station and terminal station

Necessary functions and facilities for junction stations and terminal stations are described below.

1) Reception/departure tracks

In order to adjust a gap of operating time between the main tracks of the DFC and the feeder line, trains coming in/going out sometimes have to stop and wait. Auxiliary main tracks (reception/departure tracks) are necessary for such trains not to interfere with the successive trains on the main track.

In future when double coupled trains operate, it is necessary for a train going out of DFC to be uncoupled and for trains coming in to be coupled. These trains that need to stop and wait at the junction station, occupying loops (reception/departure tracks) for longer duration. This work can be carried out in a station in the existing line if its loop can be extended to 1,500 m CSR or on a connecting track described below if it can be provided with a level section longer than 1,500 m. For the operating direction requiring at-grade crossing with a main track, such type layout plan is preferable because number of at-grade crossings can be reduced.

On the DFC lines most of trains operate for more than 1,000 km. Changing of crew is inevitable. Junction stations where most of all trains stop and change crews and bases for them are provided need to be planned. Following junction station can be the candidates: Makarpura, Marwar, Phulera, Mughal Sarai/Mughal sarai Yard, Bhaupur, Khurja. At these junction stations, 2 tracks including main tracks for each direction are necessary in addition to loops provided for as mentioned above, because all trains occupy loops or main tracks for a long time

2) Connecting track between DFC and feeder line

Connecting tracks connect between DFC lines and feeder lines at junction/terminal stations. Connecting tracks are to be provided for double or single tracks and for grade separated or at-grade crossing with main tracks based on transport demand. For smooth train operation on each line, it is preferable that connecting tracks are connected through loops for both the lines except in cases of small traffic.

In case of direct connection with branch lines at the crossing point of the DFC main track and the line outside the main yard of the junction station, provision for the rear part of the train not to interfere with the main track is required, when the train stops before moving in. A section just before joining the main track should be level/gentle gradient because here the train often stops to wait for main track to be cleared, though only few trains operate.

Based on demand forecast classified according to direction, routes of larger traffic are to be provided with grade separation with the main tracks. As acceleration and deceleration of freight trains is small because of heavy haulage and besides length of trains is long, influence of level crossing on transport capacity is very high. Whether grade separation is to be applied or not, this decision can contribute significantly to the transport capacity.

Grade separations in yards vastly affect the social environment of the surrounding communities due to fragmentation and broad expropriation. This is because tracks are laid much farther apart from each other to make a large crossing axes angle with an at-grade and an elevated track laid side-by-side, making grade separation with roads for both “ROB” and “RUB” difficult. Moreover, the long approach banks cause complications for grade separation with roads. DFC is for transport of heavy haulage and requires severe restriction of gradients. This makes length of approach banks as long as 1,500 m to 2,500 m, giving rise to more difficulties. Factors that make approach banks longer are as follows:

Maximum gradient: 1/200

Curve compensation: R (degree) * 0.04%

As grade separations in yards are accompanied by curves, this has a significant effect. For example, in a curve of 4 degrees, the maximum gradient will be 0.034% (1/294).

Exclusion for coexistence of a vertical along with a transition curve:

In many cases this forces the beginning/end of a gradient to be moved backwards making the approach bank longer.

Double stacking: The construction gauge of DFC is very high to allow passage of double stacked container wagons. It also causes the approach banks for grade separation to be longer.

As freight trains of DFC are locomotive haul type, turn-back operation requires a lot of work at the yard such as locomotive run-round track and many other facilities. To avoid that, loop-type or triangle track layout as well as grade separation may be planned. However, it makes extensive areas to be enclosed by approach banks or high embankments and leading to inconvenient land utilisation.

PETS-II Study mainly proposes layouts of grade separation with loop-type/triangle track except few routes of lesser transport demand. Major junction stations of each corridor such as Sabarmati and Mugal Sarai Area (including 3 successive junction stations) are planned to have extensively developed clover leaf type track layout similar to interchange of highways.

Compared to the time when the existing railway facilities were constructed, the present social environment of land use, road traffic, etc. has changed and plans based only on the requirements of the railway can not be accepted. At-grade crossings with roads can no longer be constructed, except when they are extensions of the existing ones for the provision of additional tracks.

Grade separation and triangle/loop-type track layout in yards are favourable for smooth train operation. On the other hand, they not only require large construction cost but also bring large impacts to the relevant communities near by.

Whether grade-separation is adopted, needs to be decided based on careful and systematic examination of transport demand, construction cost and social environment, that affects selection of location of junction stations.

Some of these large-scale facilities need not be constructed in the beginning for small transport demand. They may be constructed as a part of a future development plan after sufficient time is available for discussion and consultation with those who are concerned. In order to execute successful future enhancement, it is necessary to take into consideration the future appropriate features. Land acquisition required for the future planning is necessary to be carried out and commenced together with the first stages of implementation.

3) Station office

At station staff for train operation, signal operation, engine run-round/shunting work, etc. and staff for other office work, such as operators of maintenance machinery will be required. Therefore office and other facilities for them may have to be provided.

4) Facilities for locomotive changing, crew changing, etc.

DFC trains run long distance on the line and require crew changing. In case different traction systems are applied to DFC and feeder lines, locomotive changing may also be necessary. Offices and other relevant facilities for them are to be provided. Such facilities are not necessary at all the junction/ terminal stations. Whether necessary or not is decided based on location and role of each station. In some cases the existing facilities and offices for DFC on some feeder lines can be utilised.

At present a brake van is used for a freight train on which a guard rides. However, in some cases this is absent. In this Study it is proposed to omit both guards and brake vans, and the station/yard planning is carried out on this premise. If they are not omitted, turn-around tracks to shunt brake vans, as well as staff and their offices have to be provided as additional facilities for switch-back train operation and for coupling/uncoupling trains for 1,500 m train operation. (A brake van is so light that it must not be placed between 2 train sets in order to prevent derailment due to lifting.)

As this Study proposes to electrify both DFC corridors, additional loops and facilities for refuelling and stopping are not proposed. Relevant trains come in from/go out to a feeder line that is not electrified, it is better to electrify the line up to the nearest major station and to change locomotive and crew here.

5) Facilities at crossing station

Facilities necessary at a crossing station described in the next portion such as refuge/ exchange tracks are also required as additional facilities usable exclusively for this purpose at a junction/terminal station. If it is difficult because of land acquisition, another crossing station may be provided to satisfy the maximum distances between stations.

(2) Crossing station

Function and facilities necessary for crossing stations are described below. These are also necessary to be provided at junction/terminal stations.

1) Refuge track

In order to take trains in case of accidents, especially for trains which cannot operate on set speeds because of failure caused by accident or trouble, low speed trains and maintenance machinery (off-duty moving speed is low) to turn aside and not to interfere other trains, refuge tracks at least one for each direction are to be provided.

If difference in operating speed among various kinds of trains is set in traction/rolling stock and operation planning, further refuge tracks become necessary because frequency of requirement of refuge tracks in normal operation increases. When number of trains of different speeds becomes large, the distances between stations of 40 km are too long and it is necessary to decrease this, in order to avoid lack of transport capacity and extension of travelling time. Allocation of crossing station also has to be examined systematically with traction/rolling stock planning.

Refuge tracks for functioning of crossing stations cannot serve, as the loops required as the function of junction stations, because their role is quite different and necessary to be used simultaneously. However, the number of loops in a junction station may include some margins and some loops may be used for this purpose.

In future a number of trains will increase and a number of trains running between stations will also increase. Therefore, it is preferable to expand capacity of taking in trains in case of accident. At least 6 tracks including main tracks need to be provided. Land for these is necessary to be acquired.

2) Exchange/refuge track in single track section

In the section where a single track line is constructed as Phase I-b (Khurja- Ludhiana), the requirement of train exchange maximum distance between stations is set to be 10 km. Out of 36 crossing stations in the single track section, 26 stations are provided only for train exchange and are planned to be made of one loop with 750 m CSR because in the future before extension of CSR to 1,500 m double-tracking will be carried out. The layout of one loop can be laid within the area allotted for future double track.

3) Stabling tracks for maintenance machinery and hot axle sidings

Maintenance machinery such as multiple tie-tampers, catenary’s work wagons cannot move fast after finishing their work, hence, it has to be sent to the nearest stabling tracks as soon as possible instead of coming back to their depots.

Axle boxes of freight wagons sometimes overheat because of their quality. If a wagon with an overheating axle box is found, the wagon should be pulled off from the train and stabled as soon as possible.

For this purpose stabling tracks and hot axle sidings of two sets for both the directions are to be provided. At a crossing station with only one loop one set is provided. These sidings are useful to store other broken down/damaged wagons.

7.3.4 Allocation of stations

(1) Allocation of stations

Allocation of stations for the DFC was only rough idea in the previous study (PETS-I) and locations, scale, track layout, etc. was not concretized, while, PETS-II Study has proposed schematic locations, scale, track layout based on demand forecast, transport plan and factors concerning land acquisition. However, details are neither decided nor finalized. The study is in progress together with route planning of the main tracks. It will not be available by October 2007.

Western DFC (Route length: Main line 1,483 km, Spur line to TKD 32 km) is made up of three terminal stations including TKD and nine junction stations; total 12 terminal/junction stations. Distances between stations are 54 km to 237 km (except spur line to TKD). Between these stations 32 crossing stations are inserted. Total 44 stations are planned on Western Corridor. The average distance between stations is about 35 km.

Eastern DFC (Route length: 1,279 km) is made up of three terminal stations including Dadri and 12 junction stations, total 15 terminal/junction stations. Distances between stations are 47 km to 212 km (except Mughal Sarai Area which consists of three stations). Between these stations 52 crossing stations are inserted. Total 67 stations are planned on Eastern DFC. The average distance between stations is about 33 km in the double track section (Sonnagar-Dadri: 867 km, 27 stations including Khurja) and about 10 km in the single track section (Khurja-Ludhiana: 412 km, 41 stations including Khurja).

The allocation of junction/terminal stations is basically appropriate in view of transport plan; however, there are some problems about detail of layouts and actual location of the sites.

The allocation of crossing station is not taking into account the various conditions of the sites such as urbanization, communities, roads, road crossings, important facilities, gradient/curve of the DFC track, etc., and it may be necessary to change location based on the above factor and number may also increase. Judging from the observed condition of the route, it can be said that it is possible to find appropriate location.

Allocation of stations of the DFC of both the corridor planned in PETS-II is shown as follows:

Table 7-2 Allocation of Stations of the DFC

Western DFC

No	Station Name	Chainage of DFC (km)	Dis-Tance (km)	Location (Note*)	Type and No. by type	Remarks
1	**JN Port**	**7**			**Terminal 1**	
2	Nilaje	45	38		Crossing 1	
3	**Vasai Rd.**	**79**	**34**		**Junction 1**	
4	Palghar	117	38		Crossing 2	
5	Gholvad	157	40		Crossing 3	
6	Vapi	197	40		Crossing 4	
7	Joravasan	237	40		Crossing 5	
8	Navasari	276	39		Crossing 6	
9	**Gothangam**	**316**	**40**		**Junction 2**	Corresponding to Surat
10	Sanjali	351	35		Crossing 7	
11	Varediya	389	38		Crossing 8	
12	**Makarpura**	**427**	**38**		**Junction 3**	Corresponding to Vadodara
13	Vasad	467	40		Crossing 9	
14	Changa	503	36		Crossing 10	
15	Nyka	538	35		Crossing 11	
16	**Sabarmati**	**572**	**34**		**Junction 4**	Corresponding to Ahmadabad
17	Ambaliyasan	608	36		Crossing 12	
18	Bhandumotidy	640	32		Crossing 13	
19	Siddhapur	676	36		Crossing 14	
20	**Palanpur**	**710**	**34**		**Junction 5**	
21	Shri Amirgadh	745	35		Crossing 15	
22	Bhimana	780	35		Crossing 16	
23	Keshavganj	815	35		Crossing 17	
24	Biroliya	850	35		Crossing 18	
25	Jawari	888	38		Crossing 19	
26	**Marwar**	**924**	**36**		**Junction 6**	
27	Chandawai	959	35		Crossing 20	
28	New Bar	988	29		Crossing 21	
29	Pipla	1,020	32		Crossing 22	
30	Saradhana	1,051	31		Crossing 23	

No	Station Name	Chainage of DFC (km)	Dis-Tance (km)	Location (Note*)	Type and No. by type	Remarks
31	Kishangarh	1,091	40		Crossing 24	
32	Sali-Sakhun	1,120	29		Crossing 25	
33	**Phulera**	**1,148**	**28**		**Junction 7**	Corresponding to Jaipur
34	Malikapura	1,187	39		Crossing 26	
35	Shrimadhopur	1,223	36		Crossing 27	
36	Bhagega	1,255	32		Crossing 28	
37	Dabla	1,288	33		Crossing 29	
38	Ateli	1,324	36		Crossing 30	
39	**Rewari**	**1,355**	**31**		**Junction 8**	
40	Dharuhera	1,391	36		Crossing 31	
41	**Pirthala**	**1,429**	**38**		**Junction 9**	Near Asaoti, Branching to TKD
42	Tigaon	1,450	21		Crossing 32	
43	**Dadri**	**1,483**	**33**		**Terminal 2**	
44	**Tughlakabad**	**1,461**	**32**		**Terminal 3**	Branch line from Pirthala

Eastern DFC

No	Station Name	Chainage of DFC (km)	Dis-Tance (km)	Location (Note*)	Type and No. by type	W /S	Remarks
	(Hawrah)			0			
1	**Son Nagar**			**549**	**Terminal 1**	W	
2	Shiuasgar Rd.-		39	588	Crossing 1	W	
3	Bhabua Rd.-		39	627	Crossing 2	W	
4	**Ganjkhwaja**		**39**	**666**	**Junction 1**	W	
5	**Mughal Sarai B.H. "K"**		**7**	**673**	**Junction 2**	W	Corresponding to Mughal S.
6	**Jeonathpur**		**8**	**680**	**Junction 3**	W	
7	Kailahat -		22	702	Crossing 3	W	
8	Vindhyachal		43	745	Crossing 4	W	
9	Unchidhi -		39	784	Crossing 5	W	
10	**Chheoki -**		**31**	**815**	**Junction 4**	W	Corresponding to Allahabad
11	Bamhrauli-		26	841	Crossing 6	W	
12	Shujatpur -		39	880	Crossing 7	W	
13	Sath Naraini -		40	920	Crossing 8	W	
14	Malwan -		40	960	Crossing 9	W	
15	**Prempur**		**31**	**991**	**Junction 5**	W	Corresponding to Kanpur
16	**Bhaupur**		**47**	**1,038**	**Junction 6**	W	Corresponding to Kanpur
17	Ambiapur -		38	1,076	Crossing 10	W	
18	Pata -		40	1,116	Crossing 11	W	
19	Ekdil -		36	1,152	Crossing 12	W	
20	Balrai -		38	1,190	Crossing 13	W	
21	Makanpur -		37	1,227	Crossing 14	W	
22	**Tundla**		**23**	**1.250**	**Junction 7**	W	
23	Barhan -		38	1,265	Crossing 15	W	
24	Hathras -		36	1,301	Crossing 16	W	
25	**Daud Khan**		**18**	**1,319**	**Junction 8**	W	Corresponding to Aligah
26	**Khurja**		**47**	**1,366**	**Junction 9**	W	
---	**Dadri**		**49**	**1,415**	**Terminal 3**	W	Belonging to Western DFC
	(Khurja)			0			
27	Khurja City -		10	10	Crossing 17	S	

No	Station Name	Chainage of DFC (km)	Dis-Tance (km)	Location (Note*)	Type and No. by type	W /S	Remarks
28	Maman -		10	20	Crossing 18	S	
29	Buland Shahar		10	30	Crossing 19	S	
30	Chhaprawat -		10	40	Crossing 20	S	
31	Hirdayapur K. -		10	50	Crossing 21	S	
32	Hafizpur -		10	60	Crossing 22	S	
33	Hapur Jn. -		10	70	Crossing 23	S	
34	KharKhauda -		10	80	Crossing 24	S	
35	Nurnagar -		10	90	Crossing 25	S	
	(Meerut City)		(-26)	92,75=>67.17(From Delhi)			
36	Meerut Cantt. -		10	74	Crossing 26	S	
37	Daurala -		10	84	Crossing 27	S	
38	Sakhoti Tanda -		10	94	Crossing 28	S	
39	Khatauri -		10	104	Crossing 29	S	
40	Mansurpur -		10	114	Crossing 30	S	
41	Muzaffar Nagar -		10	124	Crossing 31	S	
42	Baman Heri -		10	134	Crossing 32	S	
43	Rohana Kalan		10	144	Crossing 33	S	
44	Deoband -		10	154	Crossing 34	S	
45	Nangal		10	164	Crossing 35	S	
46	Tapri Jn. -		10	174	Crossing 36	S	
47	Saharanpur Jn. -		10	184	Crossing 37	S	
48	Sarsawa -		10	194	Crossing 38	S	
49	**Kalanaur**		11	**205**	**Junction 10**	S	
50	Jagadhari -		9	214	Crossing 39	S	
51	Darazpur -		9	223	Crossing 40	S	
52	Mustafabad -		10	233	Crossing 41	S	
53	Barara -		9	242	Crossing 42	S	
54	Kesri -		10	252	Crossing 43	S	
55	Dukheri -		11	261	Crossing 44	S	
56	Ambala City -		9	270	Crossing 45	S	
57	Sambhu -		10	280	Crossing 46	S	
58	**Rajpura**		10	**290**	**Junction 11**	S	
59	Rajpura Jn. -		8	298	Crossing 47	S	
60	Sarai Banjara		8	306	Crossing 48	S	
61	**Sirhind**		9	**315**	**Junction 12**	S	
62	Mandi Govindgarh. -		11	326	Crossing 49	S	
63	Khanna -		10	336	Crossing 50	S	
64	Chawapail -		11	347	Crossing 51	S	
65	Doraha		10	357	Crossing 52	S	
66	**Dhandarikalan**		**11**	**368**	**Terminal 2**	S	Corresponding to Ludhiana

Source: PETS-II

Note:
- Chainage of each station, distances between stations, total lengths of route are approximate and not continuous, because routes of diversion and main tracks in station areas have not yet been finalised.
- *) Locations are shown by chainages of corresponding stations of the existing lines or the nearest spots.
- A crossing station written as "Shiuasgar Rd.- " means that the station is located along the existing line between the written station and the next station.

7.3.5 Present situation and Issues of DFC station/yard planning

(1) Progress of examination

The plan of stations/yards of DFC has only been schematically proposed in PETS-II. Details are in progress together with the planning of the main track on detour routes. It is expected to be finalised by October 2007. Large-scale frameworks where clover-type/triangle layout and grade separation will be significantly applied have been proposed.

Especially, Sabarmati of Western DFC and Mughal Sarai Area of Eastern DFC which correspond to the major core station yards of the existing lines that are planned to be main junction stations of large scale to be developed mainly with clover leaf type layouts and grade separation.

Such large scale station yard plans greatly affect the social environment such as land use and road traffic in the community. Thus, detailed planning should be carried out with much attention and regard for these matters. The sites where junction stations are desired to be located that are already developed and it is difficult to define the main track routes together with station yards while coordinating the requirements of both railway and social environment. Thus finalization of the detailed plan is still in process.

In some sections, routes of main tracks especially the detour routes are not finalized and accompanying locations of junction stations may still be moved.

Rewari Junction Station of Western DFC may change entirely depending on the result of the examination of the tunnel route. Construction of the part of the connecting track bound for Bhiwani Jn. and Gurgaon should proceed.

Mughal Sarai area, one of the existing largest yards where wagon inspection and pick up of wagons to be repaired are made and where the four directions of the important main lines meet, has not yet been planned. The areas of Allahabad and Kanpur have urbanized so rapidly that it is necessary to change the detour routes and to move the crossing points with the existing branch lines. Connection with the branch lines needs to be changed throughout.

(2) Regard for social environment

As previously described, station yards that have many grade separations and loop-type/triangle layout tend to occupy large areas, this land gets surrounded by tracks making it inconvenient to utilize with long barriers for both “ROB” and “RUB” difficult to provide. They cause much effect and impact on social environment such as road traffic, communication and land use of the communities.

Unless careful selection of location and planning of layout/facilities are carried out, construction of junction stations may cause removal of the whole village, fragmentation of communities, etc., that will deter the smooth progress of the project. It is necessary to make plans of junction/terminal stations that take into consideration social environment and land use planning of the region.

7.3.6 Guideline Design of DFC station yard

The route of the DFC (necessity of detour, selection of detour route) and the plan of stations/yards is in progress at present, hence, it is necessary to review from the point of social environment and construction work issues. In order to make the project progress smoothly, this Study proposes “Guideline Design” with emphasis on social environment.

For the sections of Phase I-a which is slated for early completion of planning and start of construction work (Makarpura JS - Rewari JS in Western DFC and Jeonathpur JS - Khurja JS in Eastern DFC), Guideline Design is proposed.

(1) Basic policy of station planning

To ensure consideration of social environment planning for each junction station is carried out referring to the schematic framework in PETS-II.

The basic policy of planning is described as follows:

1) Layouts of station yards are planned based on the number of trains in 2031 for through traffic and entry/exit by direction as calculated in the demand forecast of this Study. Reference is made from the description of PETS-II.
2) At-grade crossing is planned in case the number of trains entering and leaving the station is low (less than 10 trains per day crossing the main tracks). In this case departure/arrival tracks between both main tracks are provided.
3) In case that the number of trains entering/leaving is less than 6 trains per day for the total of switch-back operation, switch-back operation is adopted and an engine turn-around track is provided. If the number of such train is very few, a main track can be used for engine turn-round.
4) In order that the trains entering and leaving will not interfere with the smooth operation on the main tracks as they wait for clearing of the forward route, a departure/arrival track is provided for each direction. In addition, at least one refuge track is provided to accommodate malfunctioning trains.
5) At junction stations where the crew of almost all trains change, necessary stopping times are considered in calculating the required number of loops. (In such stations the main tracks can be used for trains to stop for crew change, since almost all trains stop at this station.)
6) In case that apart from the main yard area turn-outs are installed for entry /exit between the DFC line and a crossing feeder line, a waiting track at the entry side is provided (A signal station under the junction station).
7) Effective track length is to be 1,500 m. At stations where at-grade crossing is planned, a loop for uncoupling is provided out of the DFC main yard so that two uncoupled trains will not cross the main track.
8) Track layout for grade separation at the station yards is to be planned to minimise outstanding. For this purpose the crossing axes angle is to be minimized. If both tracks are to be newly constructed, the angle should be 15 degrees using reinforced concrete tunnel-like structures seen from the track below. If the track is constructed over operating tracks, the angle should be 30 degrees using through-type steel girders/trusses. For both can case the structures of upper tracks to be designed as low as possible.
9) In order to prevent lengthening of approach banks due to curve compensation for maximum gradient and exclusion of coexistence of a vertical curve with a transition curve, curves are to be applied to the tracks on the ground as far as possible to make the alignment of the tracks on the fly-over suitable for steeper gradient. Vertical curves are to be located on the over bridge in order to shorten approach banks, although this will make the highest point even higher.
10) It is taken into consideration that road traffic within the area will not worsen.
11) Width of formation of yard is to be 100 m for space for various works and for locating buildings. At some junction stations located on detour route and elevated, buildings are

to be constructed on the existing ground if suitable based on their purpose.

12) The planning is to be carried out with due consideration to future grade separation of the at-grade crossings with roads of existing lines.

13) The planning is to be carried out keeping it in mind keeping the possibility of future construction of crossing roads in long sections.

14) Even though station yards are planned following the above policy, station yards require long and wide areas, and therefore, making selection of the sites for junction stations is very important and requires serious examination. Locations which will involve resettling the whole community or dividing a village should be avoided.

(2) Guideline design of each junction station in Phase I-a

Following the above policy the "Guideline Design", which has functional, location and layout and fits in requirement from social environment issues, is prepared for each junction station to be constructed under Phase I-a.

This guideline design is only for the part which is constructed in Phase I-a, however it is taken into account the feature of the part of Phase I-b and Phase II in order to secure necessary land for the final feature and to make the whole construction work easy.

As previously mentioned the construction work is to be executed of 750 m CSR; however, this guideline design is drawn up of 1,500 m CSR because it is necessary to secure necessary land and to select suitable location for future requirement of 1,500m CSR.

Junction stations to be constructed in Phase I-a are as follows:

1) Western DFC
   - Makarpura JS
   - Sabarmati JS
   - Mahsana JS (Accompanied with changing route at Mahesana to detouring, Mahsana JS is added to shift traffic between DFC Dadri direction and Pipavav (Viramgam Jn.) from Sabarmati JS.)
   - Palanpur JS
   - Marwar JS
   - Phulera JS
   - Rewari JS (Only the connecting route bound for Bhiwani Jn., Gurgaon and the part of yard related to the above in Phase I-a)

2) Eastern DFC
   - Jeonathpur JS (Only Jeonathpur and connecting routes between Jeonathpur and the west end of the existing Mughar Sarai Yard)
   - Chheoki JS (Direct connections between Allahabad-Manikpur line Manikpur side and DFC both side are provided.)
   - Manauri JS (West side of Allahabad area, added accompanied with changing detour route)
   - Prempur JS
   - Bhaupur JS (Direct connections from Kanpur-Khairar line Khairar side to DFC Dadri side and from DFC Sonnagar side to Kanpur-Jhansi line Jhansi side are provided.)

- Tundla JS
- Daud Khan JS
- Khurja JS

Allocation of junction stations and crossing stations for the section of Phase I-a Project is shown in Table 7-3.

The outline of the guideline design of each junction station to be constructed in Phase I-a including typical schematic drawings is described in *Volume4 Technical Working Paper Task2, 7-(1).*

Table 7-3 Proposed Allocation of Stations of the DFC in Phase I-a by Guideline Design

Western DFC					
No.	Name	Type	Parallel / Detour	Chainage	Distance
13	**Makarpura JS**	**Junction Station**	**Detour**	**420.0**	
14	Vasad West	Crossing Station	Detour	454.0	35
15	Nadiad West	Crossing Staiton	Detour	491.6	37.6
16	Barejadi West	Crossing Station	Detour	522.0	30.4
17	**Sabarmati JS**	**Junction Station**	**Detour**	**560.0**	**38**
18	Ghumasan West	Crossing Station	Detour	590.0	30
19	**Mahesana JS**	**Junction Station**	**Detour**	**611.0**	**21**
20	Sidhapur	Crossing Station	Parallel	632*	21*
21	**Palanpur JS**	**Junction Station**	**Detour**	**673.0**	**41**
22	Shri Amirgadh	Crossing Station	Parallel	701*	28*
23	Swarupganj	Crossing Station	Parallel	740.5	39
24	Nana	Crossing Station	Parallel	778.0	37.5
25	Falna	Crossing Station	Parallel	814.0	36
26	Jawali	Crossing Station	Parallel	844.0	30
27	**Marwar JS**	**Junction Station**	**Parallel**	**881.0**	**37**
28	Chandawal	Crossing Station	Parallel	919.0	38
29	Sendra	Crossing Station	Parallel	959.0	40
30	Mangaliyawas	Crossing Station	Parallel	997.0	38
31	Gegal Akhri	Crossing Station	Parallel	1037.0	40
32	Sakhun	Crossing Station	Parallel	1073*	36*
33	**Phulera JS**	**Junction Station**	**Detour**	**1100.0**	**27**
34	Renwal	Crossing Station	Parallel	1132*	32*
35	Ringas	Crossing Station	Parallel	1160.0	28
36	Bhagega	Crossing Station	Parallel	1197.7	37.7
37	Jhilo	Crossing Station	Parallel	1229.0	31.3
38	Nizampur	Crossing Station	Parallel	1269.0	40
39	Kund	Crossing Station	Parallel	1291.0	22
40	**Rewari JS**	**Junction Station**	**Detour**	**1310.0**	**19**

Source: Guideline Design of this Study
Remarks: Chainage* includes brake metre.
Name of each crossing station is tentative and applied the nearest existing station.

Eastern DFC

No.	Name	Type	Parallel / Detour	Chainage	Distance
6	**Jeonathpur JS**	**Junction Station**	Parallel	**684**	**8**
7	Dagmagpur	Crossing Station	Parallel	713	29
8	Birohe	Crossing Station	Parallel	749	36
9	Unchadih	Crossing Station	Parallel	778	29
10	**Chheoki JS**	**Junction Station**	Parallel	**811**	**33**
11	**Manauri JS**	**Junction Station**	Parallel	**846**	**35**
12	Sirathu	Crossing Station	Parallel	885	39
13	Rasulabad	Crossing Station	Parallel	923	38
14	Malwan	Crossing Station	Parallel	960	37
15	**Prempur JS**	**Junction Station**	Parallel	**998.5**	**38.5**
16	Kanpur South	Crossing Station	Detour	1031	32.5
17	**Bhaupur JS**	**Junction Station**	Parallel	**1050.5**	**19.5**
18	Parajani	Crossing Station	Parallel	1088	37.5
19	Achalda	Crossing Station	Parallel	1120	32
20	Ekdil	Crossing Station	Parallel	1151.2	31.2
21	Balrai	Crossing Station	Parallel	1185	33.8
22	Makhanpur	Crossing Station	Parallel	1224	39
23	**Tundla JS**	**Junction Station**	Detour	**1258**	**34**
24	Pora	Crossing Station	Parallel	1290	32
25	**Daud Khan JS**	**Junction Station**	Parallel	**1318**	**34**
26	Kulwa	Crossing Station	Parallel	1349	25
27	**Khurja JS**	**Junction Station**	Parallel	**1374**	**25**

Source: Guideline Design of this Study
Remarks: Name of each crossing station is tentative and applied the nearest existing station.

7.4 CIVIL ENGINEERING FACILITIES

7.4.1 General

As was mentioned above, due to non-availability of horizontal alignment plans on topographical maps and the available information/accuracy of vertical alignment plan of PETS-I, it is very difficult to ascertain whether or not the civil engineering facilities planned in the RITES report are appropriate.

In spite of the lack of information referred above, the following sections bring out the comments, views and proposals of the JICA Study team (JST) based on the analysis of information, the check by satellite photograph image (Google Earth), along-the-line GPS based video photography pictures which were taken by JST, information that could be provided by each expert in the relevant fields through supplemental site surveys, together with the information provided in the RITES PETS-II Report i.e. the cost estimation documents and discussions with RITES Team members.

7.4.2 Earthworks

(1) Earthwork Structure Plan

The earthwork structural design referred in the RITES Report is based on the standards of the existing line shown in Guidelines for Earthwork in Railway Projects (Guideline No.GE: G-1, July 2003) by RDSO and with directions of Railway Board of MOR. With this as background, there is no room to comment on the design in the RITES Report.

However, one issue that needs mention here, is that the thickness of blanket, which was at first based on the Guidelines of RDSO and was reduced in PETS-II Report to 60 cm based on suggestions by Railway Board. Although it is explained that this value is based on the past experience, making such a change increases the risk of cost enhancement during the actual construction.

At this present juncture, since neither the necessary geological surveys nor investigation of the materials to be used for sub-grade/blanket has been carried out, making such an assumption about the thickness of blanket is not premature because it has the potential to cause cost overruns in the future. Unfortunately, at this time there are no decisive facts available that can be used to comment on this suggestion by the Railway Board.

Therefore, it is better to recognize the potential cost of this blanket during this F/S stage, and thereby prepare a financial contingency for it, rather than argue whether or not to run the risk of experiencing an unexpected cost overrun while the construction is in progress.

The earthwork standard by RITES is shown in Figure 7-11 to Figure 7-14 below.

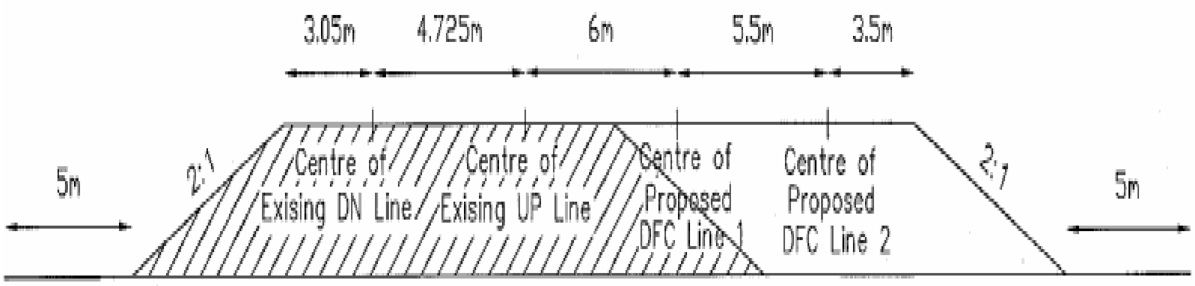


Figure 7-11 Typical Section in Filling for Track Parallel to Existing Line

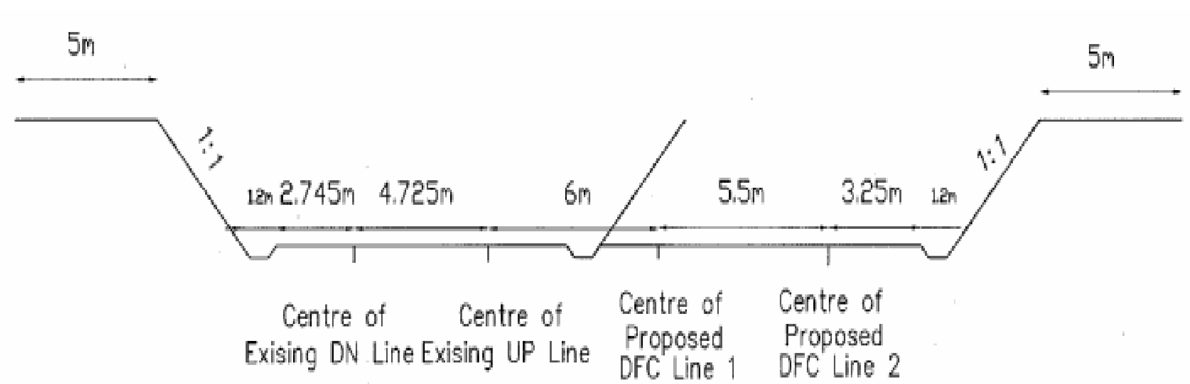


Figure 7-12 Typical Section in Cutting for Track Parallel to Existing Line

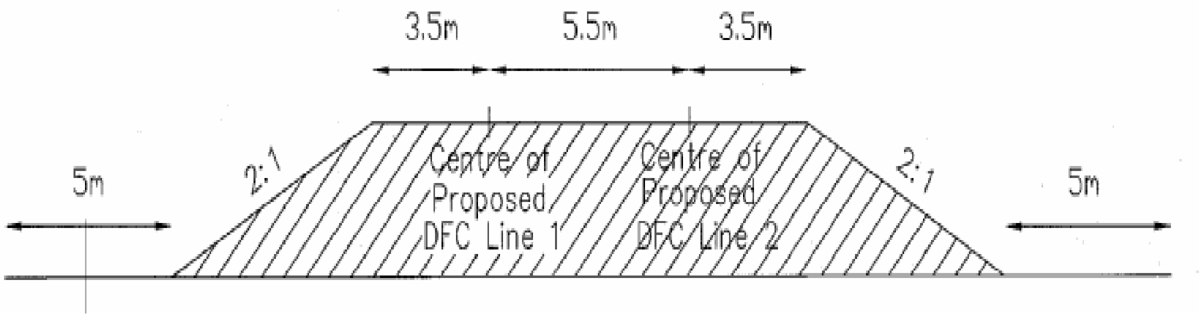


Figure 7-13 Typical Section in Filling for Track on Diverted Portion

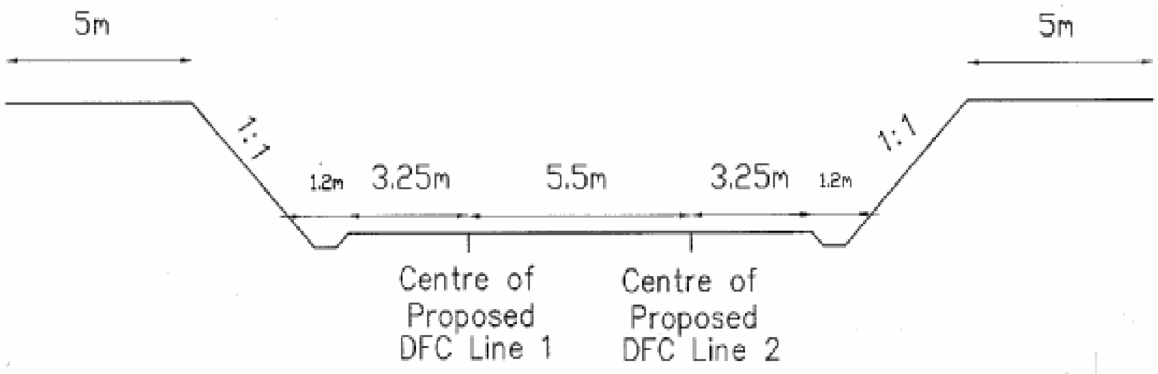


Figure 7-14 Typical Section in Filling for Track on Diverted Portion

(2) Earthwork Implementation Plan

For large-scale earthwork, it is more important to make the most optimum plan on how to work systematically by combining more efficient earthwork machines, rather than to make optimum general design. The general plan of earthwork is shown in *Volume4 Technical Working Paper Task2, 7-(2).*

Since most of the portion in total length of 2,763 km for DFC is earthwork, i.e. embankment and cutting. The total quantities of the earthwork are shown in the table above.

Since earthwork duration and machine requirement have not been studied in PETS-II Report, earthwork completion plan was made based on an assumption as per sample site as presented in *Volume4 Technical Working Paper Task2, 7-(2)*

7.4.3 ROB and RUB

The Railway Ministry has mooted a policy to remove all level crossings along the DFC Lines and plans to construct either ROBs and RUBs. In line with this policy, ROBs and RUBs were planned by RITES.

However, the estimated cost for ROBs including land acquisition, accounts for 28.8% of the civil construction cost. Moreover, some adverse environmental and social impacts are caused by the ROBs. A radical solution is therefore needed.

(1) Review of ROB Design

The following 9 bridge types, consisting of 18 m span RCT girders and 30m span PC girders, were considered in RITES PETS-II Report as shown on Table 7-4. There were no drawings available, however. The JST had sought to clarify the concept of each type from RITES but no reasonable answer was given.

Intrinsic, planning and design for ROB needs to be carried out considering each site conditions and its characteristics. Therefore, it is not important to study a lot of different cases of ROB types. Therefore, for practical purposes, the JST established two general types of ROB for this study, one for urban and the other for rural areas.

The total length of ROB is estimated to be 1.1 km.

Table 7-4 TYPE of ROB（Prepared by RITES）

Sr. No.	Details	Spans
1	TYPE(A): LX TO ROB WITH 3.75m WIDE VILLAGE ROAD ON BRIDGE AND APPROCHES + Bank Width = 7.5 m	2x18 m RCC T-Beam+1x30 m PSC Girder+2x18 m RCC T-Beam
2	TYPE(B):LX TO ROB WITH 7.5m ROAD WIDTH ON BRIDGES AND 3.75m ON APPROCHES+ BANK WIDTH=7.5m	2x18 m RCC T-Beam+1x30 m PSC Girder+2x18 m RCC T-Beam
3	TYPE(C):LX TO ROB WITH 7.5m ROAD WIDTH FOR BRIDGES AS WELL AS APPROCHES IN OPEN AREA	2x18 m RCC T-Beam+1x30 m PSC Girder+2x18 m RCC T-Beam
4	TYPE(D): LX TO ROB FOR 7.5m CARRIAGE WAY IN URBAN AREA WHERE LAND IS CONSTRAINT	5x18 m RCC T-Beam+1x30 m PSC Girder+5x18 m RCC T-Beam
5	TYPE(E): REPLACING DOUBLE LANE FOR 7.5 m CARRIAGE WAYIN OPEN AREA WITH EARTHEN APPROACHES	2x18 m RCC T-Beam+1x30 m PSC Girder+2x18 m RCC T-Beam
6	TYPE(F): REPLACING DOUBLE LANE ROB IN URBAN AREA FOR 7.5m CARRIAGE WAY WHERE LAND IS CONSTRAINT WITH RE WALL AND VIADUCT	5x18 m RCC T-Beam+1x30 m PSC Girder+5x18 m RCC T-Beam
7	TYPE(G):LX TO ROB FOR 7.5m CARRIAGE WAY WITH CLOVER LEAF FOR LINKING PARALLEL HIGHWAY	5x18 m RCC T-Beam+1x30 m PSC Girder+5x18 m RCC T-Beam
8	TYPE(H):LX TO ROB WITH 3.75m WIDE VILLAGE ROAD ON BRIDGE AND APPROCHES WITH RE WALL FOR LINKING PARALLEL HIGHWAY	2x18 m RCC T-Beam+1x30 m PSC Girder+2x18 m RCC T-Beam
9	TYPE(I): LX TO ROB WITH 7.5m ROAD WIDTH ON BRIDGES AND 3.75m ON APPROCHES FOR VILLAGE ROAD USING RE WALL FOR LINKING PARALLEL HIGHWAY	2x18 m RCC T-Beam+1x30 m PSC Girder+2x18 m RCC T-Beam

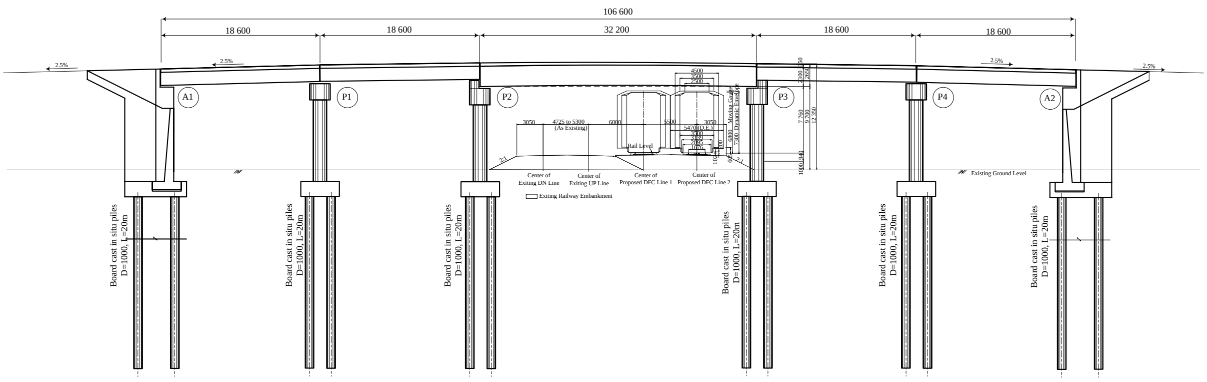


Figure 7-15 General Profile of ROB by JST

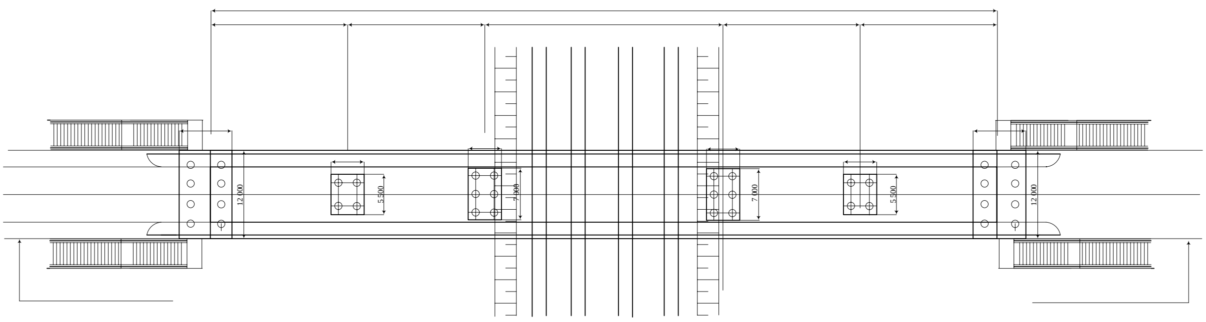


Figure 7-16 General Plan of ROB in urban area by JST

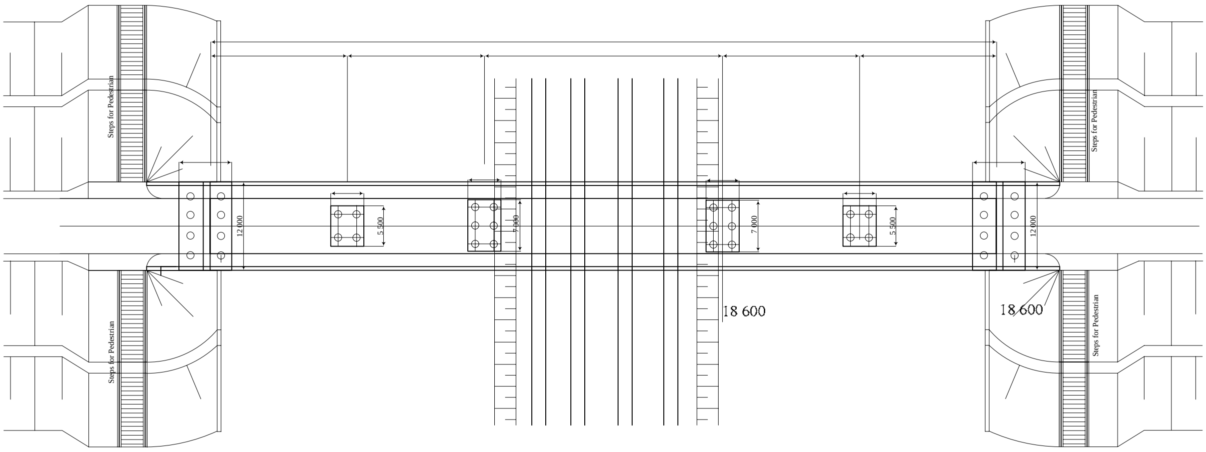


Figure 7-17 General Plan of ROB in Rural area by JST

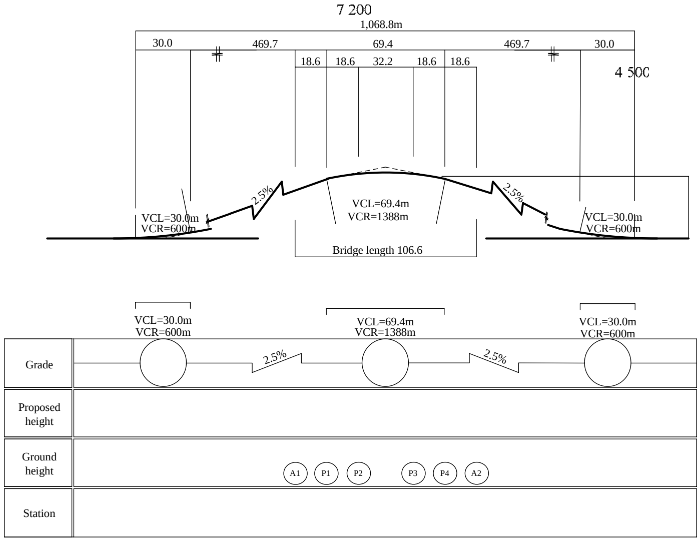


Figure 7-18 General Elevation of ROB by JST

Based on the review of RITES design, the following impacts on the Project will be affected, if all the bridges are constructed:

1) Increase in project cost

   As indicated in the RITES PETS-II Report, more than 900 ROBs are planned to be constructed, with a total 900 km of road length and 100 km of bridges.

   In the case that all the ROBs are built, the construction cost of DFC Project will increase by almost 30%.

2) Bottleneck of the construction

   Since the construction period for one ROB is estimated to be about 2 years, simultaneous construction of the 900 ROBs will form a bottleneck for the project.

3) Environmental and Social Impacts

   The ROB is designed to be constructed with 2.5% of slope climbing to approximately 12 m over the DFC for double-stacked container trains. The length of each ROB is estimated to be approximately 1,068 m long including a 107 m long concrete girder bridge over the railway. If the ROB is constructed in built-up areas, about 100-200 households will be subject to resettlement. Furthermore, it would form a 500m long barrier dividing the community. This issue should be a subject for further debate and discussions at stakeholder/public consultation meeting.

In addition, replacing all the level-crossings to ROB will inconvenience non-motorized users such as pedestrians, hand pulled carts, bicycles, tricycles, and buffalo/horse/camel carts.

Considering all of abovementioned impacts, it is recommended that all the existing level crossings be improved to automatic signalling type level crossings at the beginning of the DFC operation. After completion of the DFC, whenever the traffic exceeds the capacity of any level crossing, then that level crossing should be recommended to be replaced by a ROB under another project.

(2) Existing ROBs

Existing ROBs located on the parallel sections could cause obstructions during the DFC construction. A detailed survey is therefore required for each ROB to check its horizontal and vertical clearances, and to decide whether to re-construct or to re-use the existing ROB. The items of the required detailed survey are described below.

1) Number of existing ROBs

There are forty nine existing ROBs on the Eastern DFC; of which fourteen ROBs are on the parallel section. Two are under construction.

On the other hand, there are 60(sixty) existing ROBs on the Western DFC, with twenty five ROBs on the parallel section. Two are under construction. There are five existing ROBs between Asaoti and TKD, one is under construction. Details of the numbers of existing ROBs are shown on the Table 7-5

Table 7-5 Numbers of existing ROB

	Parallel Section	Detour Section	Total
Eastern DFC	14	35	49
Western DFC	24	36	60
Total	38	71	109

	Parallel Section	Total
Asaoti- TKD	5	5

Source: JICA Study Team

2) Methodology

a) Horizontal clearance

Most of old and existing ROBs have their abutments beside the existing railway, thus these don't have enough horizontal space for the DFC. These ROBs need to be reconstructed.

On the other hand, some relatively new ROBs have their side spans with the space wide enough to be utilized for the DFC. After conducting the detailed study as recommended below, the space under the side spans may be considered to be used for the DFC.

b) Vertical clearance

Based on the visual inspection conducted, all ROBs have vertical clearances of at least 6250 mm under the main span. While, new ROBs under construction, have vertical clearances of 6500 mm.

However, DFC requires vertical clearance of 7,900mm (according to RITES) for the Western DFC, therefore, all ROBs on the parallel section of the Western DFC are found necessary to be reconstructed.

For the Eastern DFC, since it has been suggested to operate single stack container trains as an interim measure, all ROBs has enough vertical clearance.

Referring to the above, in case of newly constructed ROB on the Western DFC, the height of the girder at the side span is smaller than that of the main span and thus, the vertical clearance is found to be larger and sufficient for the DFC.

If after detailed investigation, it is inferred and decided that the space under the side span could be used for the DFC, then the project cost will reduce and social/environmental impacts will be minimized.

Figure 7-19 Example of ROB for reconstruction

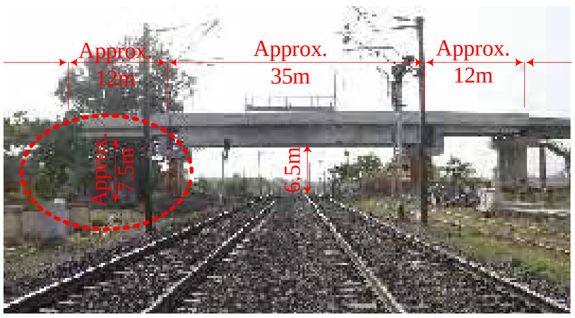


Figure 7-20 Example of ROB for potential re-use

Source: JICA Study Team

3) Findings and observations of the survey

In this study, visual inspection of existing ROBs was conducted. The major findings are as follows:

a) Eastern DFC

There are fourteen ROBs located on the parallel section on the Eastern DFC, of which two are under construction. Considering the seven ROBs which need to be reconstructed, because less horizontal space, while the other seven have possibility to be used as is basis.

Figure 7-22 shows the location and proposed countermeasure for each existing ROB.

b) Western DFC

There are twenty four ROBs located on the parallel section on the Western DFC, with two under construction. Since the required vertical clearance for the Western DFC is 7,900 mm (according to RITES), all the ROBs appear to have lesser clearance than that required for DFC. After being subjected to the recommended detailed study however, some existing ROB could still have the potential to be used traction power facilities at the ROB location. One ROB located between Mahesana and Palanpur which is under construction is already jack-up and a clearance of 7,370 mm was observed.

In addition, for areas where several ROBs exist within a short distance, such as between Vasai Road and Virar, and between Virar and Bhilad, a detour route is worth considering.

Figure 7-23 shows the location and estimated countermeasure for each existing ROB.

c) Asaoti-Tuglakabad (TKD)

There are five ROBs located between Asaoti and Tuglakabad, with one under construction. Three of them are four traffic lane ROBs. According to the information from construction site engineer, the ROB is designed for the clearance of 6500mm. If double stuck container is required to pass through this section, the ROB will need to be reconstructed. Because of the urbanization of this area, the traffic on the ROB is heavy, hence, there would be a lot of difficulties such as social impact and financial viability for its reconstruction.

Figure 7-24shows the location for each existing ROBs.

4) Construction Sequence for ROB Reconstruction

Although the construction method and sequence is to be studied for each ROB, taking into consideration the social/ environmental effects, the general sequence of reconstruction of existing ROBs in rural areas will be is as follows;

a) To construct a new ROB and approach road near the existing ROB.

b) Existing traffic passes through the existing ROB.

c) After completion of the new ROB, divert the traffic.

d) Removal of existing ROB.

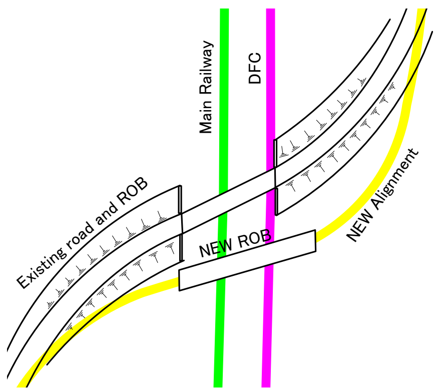


Figure 7-21 Plan for reconstruction of ROB

5) Recommendation for detailed study

Prior to the decision of necessary countermeasure for the ROBs, a detailed study should be conducted. The required work items for the detailed study are as follows

a) Detailed topographic survey, review of existing drawings, measurement of existing ROBs

b) Detailed design of DFC alignment

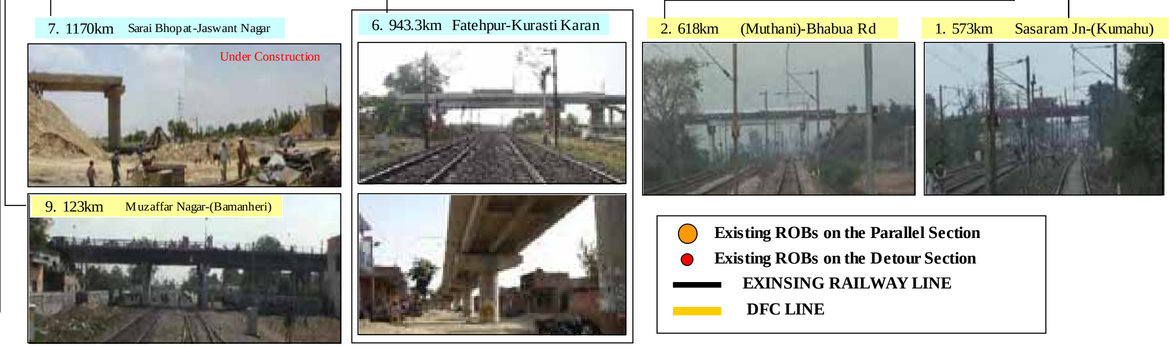
c) Stability check for existing foundations and piers

d) Study for reinforcement of existing ROBs, if required

Existing ROBs on the Parallel Section -Eastern Corridor

No.By JST	No.By Rites	KP (Existing)	Station	Possible Countermeasure	Type of ROB for Reconstruction
1.	-	573km	Sasaram Jn-(Kumahu)	Reconstruction	Type F
2.	-	618km	(Muthani)-Bhabua	Reconstruction	Type F
3.	1	686.3km	Jeonathpur-Ahraura Rd	Reconstruction	Type E
4.	2	735.1km	Jhingura-MizapurJN	Reconstruction	Type E
5.	-	788km	Meha RD-Bheerpur	Use the space under Side Span	-
6.	3	943.3km	Fatehpur-Kurasti Karan	Use the space under Side Span	-
7.	-	1170km	Sarai Bhopat-Jaswant Nagar	Use the space under Side Span	-
-	4	1344km	Detour section(Somna)	-	-
8.	-	92km	Sakhoti Tanda-(Khatauli)	Reconstruction	Type F
9.	5	123km	Muzaffar Nagar-(Bamanheri)	Reconstruction	Type F
10.	6	127km	Bamanheri-(Rohana Kalan)	Reconstruction	Type E
-	7	180km	Detour section	-	-
-	8	182km	Detour section	-	-
11.	9	213km	(Jagadhri)-Jagadhri WS	Reconstruction	Type F
12.	-	246km	Tandwal-Kesri	Use the space under Side Span	-
13.	-	334km	Khanna-(Chawapail)	Use the space under Side Span	-
14.	-	367km	(Sanehwal)-Dhandri Kalan	Use the space under Side Span	-

Type E :Replacing ROB in rural area with earthen approaches — Type E :3Bridges
Type F :Replacing ROB in urban area with reinforced embankment approaches — Type F :5Bridges

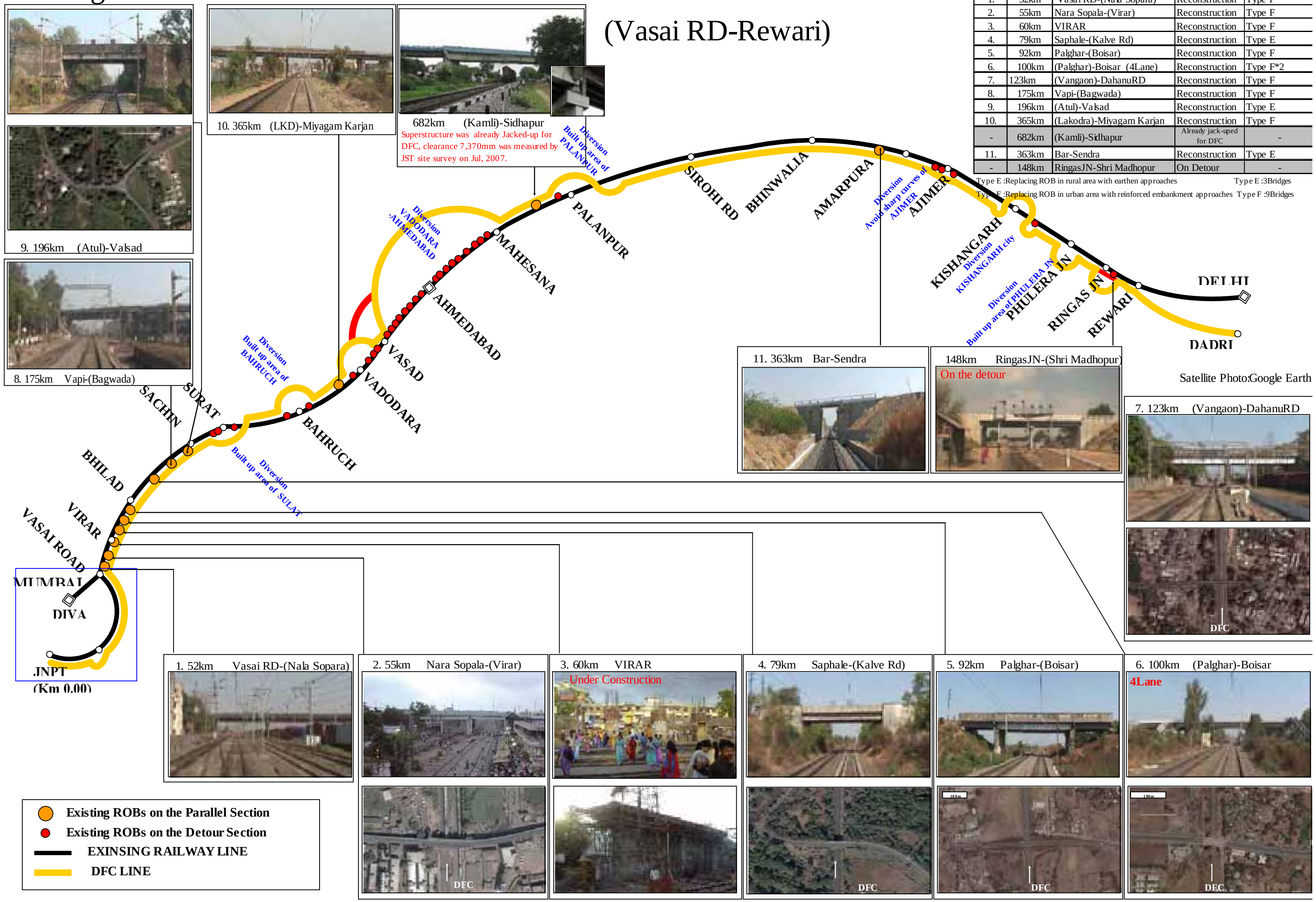


Source: JICA Study Team

Figure 7-22 Existing ROBs on the parallel section on the Eastern DFC

Existing ROBs on the Parallel Section Western Corridor

(Vasai RD-Rewari)



No.By JST	KP (Existing)	Station	Possible countermeasure	Type of ROB for Reconstruction
1.	52km	Vasai RD-(Nala Sopara)	Reconstruction	Type F
2.	55km	Nara Sopala-(Virar)	Reconstruction	Type F
3.	60km	VIRAR	Reconstruction	Type F
4.	79km	Saphale-(Kalve Rd)	Reconstruction	Type E
5.	92km	Palghar-(Boisar)	Reconstruction	Type F
6.	100km	(Palghar)-Boisar (4Lane)	Reconstruction	Type F*2
7.	123km	(Vangaon)-DahanuRD	Reconstruction	Type F
8.	175km	Vapi-(Bagwada)	Reconstruction	Type F
9.	196km	(Atul)-Valsad	Reconstruction	Type E
10.	365km	(Lakodra)-Miyagam Karjan	Reconstruction	Type F
-	682km	(Kamli)-Sidhapur	Already jack-uped for DFC	-
11.	363km	Bar-Sendra	Reconstruction	Type E
-	148km	RingasJN-Shri Madhopur	On Detour	-

Type E :Replacing ROB in rural area with earthen approaches Type E :3Bridges

Type F :Replacing ROB in urban area with reinforced embankment approaches Type F :9Bridges

Source of Satelite Photo: Google Earth

Source: JICA Study Team

Figure 7-23(1) Existing ROBs on the parallel section on the Western DFC (1/2)

Existing ROBs on the Parallel Section Western Corridor (JNPT-Vasai RD)

1. 91kp JNPT

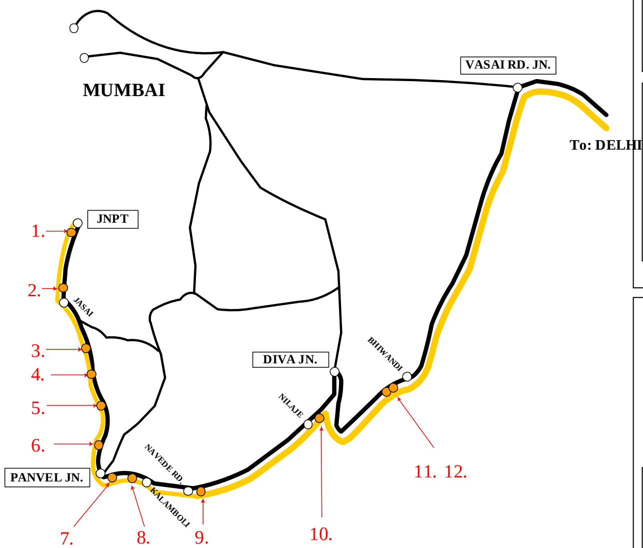
4. 80kp Jasai-Panvel JN

2. 89kp JNPT-Jasai

5. 78.7kp Jasai-Panvel JN

3. 81kp Jasai-Panvel JN

6. 74.5kp Jasai-Panvel JN

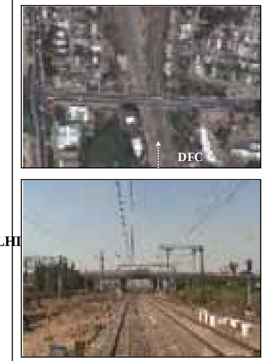


List of ROB

No.By JST	KP (Existing)	Station	Possible Countermeasure	Type of ROB for Reconstruction
1.	91km	JNPT	Reconstruction	Type E
2.	89km	JNPT-Jasai (4Lane)	Reconstruction	Type F*2
3.	81km	Jasai-Panvel JN	Reconstruction	Type E
4.	80km	Jasai-Panvel JN	Reconstruction	Type E
5.	79km	Jasai-Panvel JN	Reconstruction	Type E
6.	74km	Jasai-Panvel JN (4Lane)	Reconstruction	Type E*2
7.	67km	Panvel JN-(Kalamboli)	Reconstruction	Type F
8.	65km	Panvel JN-(Kalamboli) (4Lane)	Reconstruction	Type F*2
9.	60km	Navade Rd-(TPND)	Reconstruction	Type F
10.	48km	Nilaje-(Dativli)	Reconstruction	Type E
11.12.	59km	Kopar RD-Bhiwandi, NH3	Reconstruction	Type E*2

Type E :Replacing ROB in rural area with earthen approaches   TypeE: 9 bridges
Type F :Replacing ROB in urban area with reinforced embankment approaches   TypeF: 6 bridges

- Existing ROBs on the Parallel Section
- Existing ROBs on the Detour Section
- EXINSING RAILWAY LINE
- DFC LINE



7. 67kp Panvel JN-(Kalamboli)

10. 47.5kp Nilaje-(Dativli)

8. 65kp Panvel JN-(Kalamboli)

11.12. 59kp Kopar RD-Bhiwandi

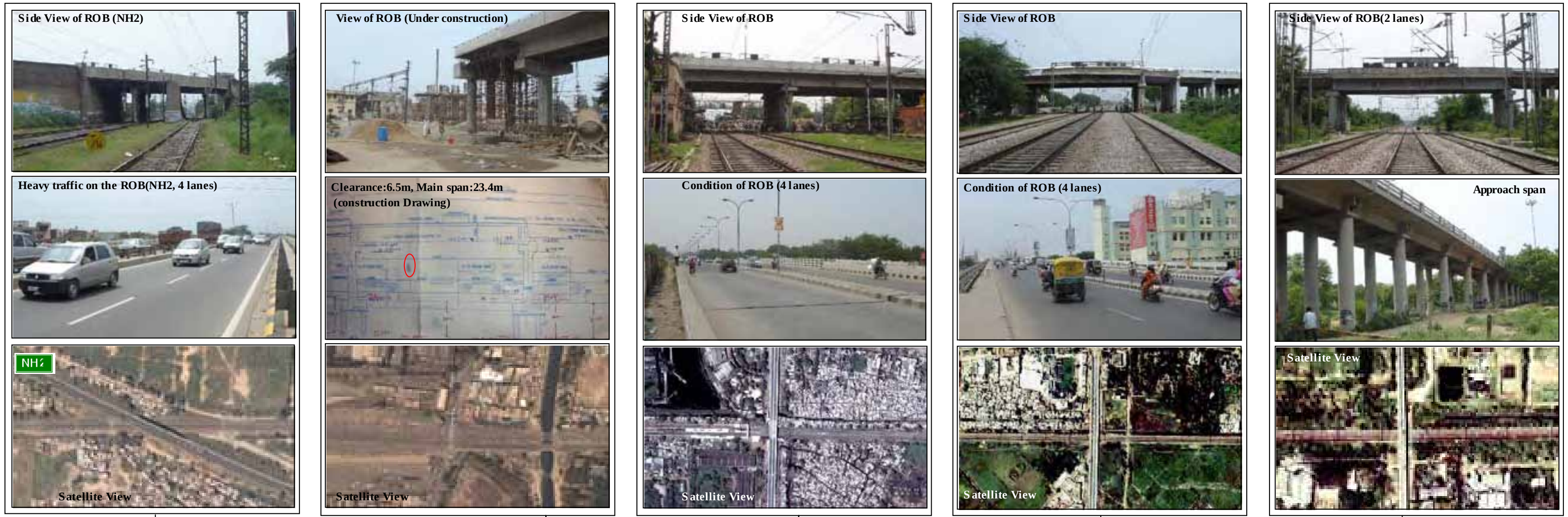
9. 60.3kp Navade Rd-(TPND)

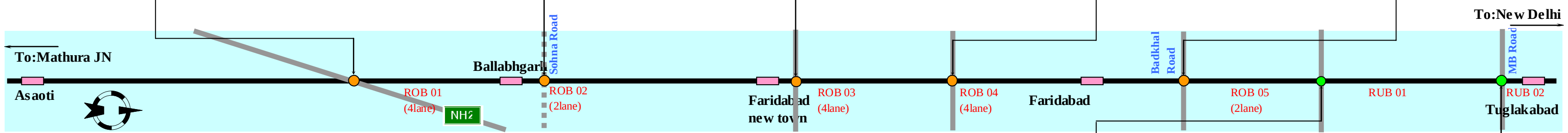
Satellite Photo:Google Earth

Source of Satelite Photo: Google Earth
Source: JICA Study Team

Figure 7-23(2) Existing ROBs on the parallel section on the Western DFC (2/2)

Existing ROB and RUB between Asaoti and TKD





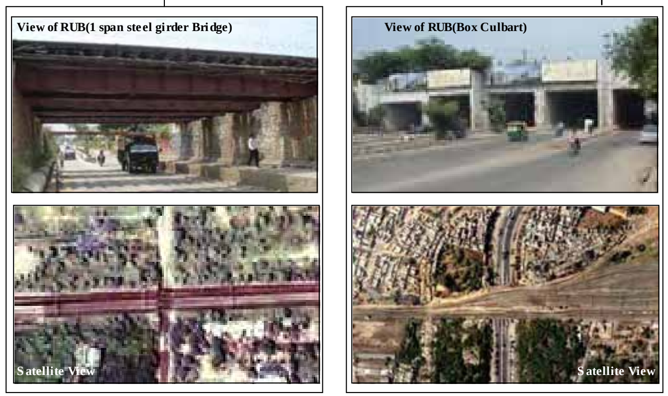
LIST of ROB

	Locatin	Bridge length(m)	No. of lanes	Bridge Type	Remarks
01	Asaoti-Ballabhgarh	110m(Skew Length)	4 Lanes	Steel Girder	NH2, 4 spans
02	Ballabhgarh	Unknown	2Lanes	PC Girder	Sohna RD, Under construction
03	Faridabad New Town	460m	4 Lanes	PC Girder	
04	Faridabad N.T.-Faridabad	320m	4 Lanes	PC Girder	
05	Faridabad-Tuglakabad	320m	2Lanes	PC Girder	Badkhal RD

LIST of RUB

	Locatin	RUB length(m)	No. of lanes		Remarks
01	Faridabad-Tuglakabad	12m	2Lanes	Steel Girder	
02	Tuglakabad	55m (longitudinal leangh)	8Lanes	RC Box (6 box)	MB Road

Structural length was measured on the satellite Photo, not accurate.



Legend:
- Existing ROB
- Existing RUB
- Station
- EXINSING RAILWAY LINE
- Road across the Railway

Satellite Photo:Google Earth

Source of Satelite Photo: Google Earth
Source: JICA Study Team

Figure 7-24 Existing ROBs between Asaoti and Tuglakabad

(3) Construction schedule

Construction schedule for a typical ROB is shown on the Table 7-6. Construction period for one ROB requires approximately 24 months.

Table 7-6 Construction schedule for ROB

Activity Description	Year 1												Year 2												Remarks
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	
Mobilizations	■																								
Pile Load Test & Casting Yard		■	■																						
Piling & Pile Cap				■	■	■	■	■	■																
Columns & Piers						■	■	■	■	■	■	■													
Precast Girders & Hand Rails				■	■	■	■	■	■	■	■	■	■												
Erection of Girders & Hand Rails								■	■	■	■	■	■	■	■										
Deck Slab Casting										■	■	■	■	■	■	■	■								
Earth Work including Reinforced Embankment				■	■	■	■	■	■	■	■	■	■	■											
Road Surface Pavement incl. Road Connection												■	■	■	■	■	■	■							
Miscellaneous Works																		■	■	■			■	■	
Demolition of Existing ROB																			■	■	■	■	■	■	

Source: JICA Study Team

7.4.4 Bridges & Culverts

(1) Guide Line Design of Bridge – Bridge Length

Along the proposed DFC alignment in Phase I-a portion, there are eighteen important bridges in the Western DFC and two important bridges in the Eastern DFC as listed in Table 7-7 and Table 7-8.

Table 7-7 List of Important Bridges on the Western DFC

S.No.	Section	Length of Bridges (m)	River Name	Dist.from R.Mouth (km)	Catchment Area (km2)	Average River Gradient
1	ALL-PNU	550	Mahi River	65	34,100	1/1,035
2	ADI-VG	2,800	Sabarmati River	90	10,400	1/545
3	ADI-VG	2,290	Sabarmati River2	90	10,400	1/545
4	ADI-PNU	330	Saraswati River	N.A.		

Table 7-8 List of Important Bridges on the Eastern DFC

S.No.	Section	Length of Bridges (m)	River Name	Dist.from R.Mouth (km)	Catchment Area (km2)	Average River Gradient
1	Unchadih	460	River Tons	N.A		
2	Allahabad Detour	1,160	River Yamuna	N.A		

The determination of appropriate bridge length is one of the most crucial processes in the course of bridge design, especially in the flood prone area. If enough length of bridge is not provided, the flood situation would get aggravated due to bridge construction and thus the constructed bridge itself could collapse due to turbulent flood flow. Accordingly, JST introduces the methodology to determine the bridge length in the flood prone area by hydrological and hydraulic analyses as a guide design of bridge.

The targets of guide line design, important bridges of Phase I-a section, which are proposed in *Chapter 3*, were selected since an early project implementation is expected for this section. During various inspections and interviews by JICA Study Team, it was revealed that the downstream area of Sabarmati River is the most severe flood-prone area among the above mentioned important bridges in Phase I-a section, due to its flat and low-lying topography and the absence of embankment. Once large discharge comes on this river during monsoon season, the flood water overflows from river channel and inundates large area significantly. If bridge length is not properly designed with consideration of hydrological and hydraulic aspects, the flood situation would get extensively deteriorated.

On the other hand, as the rivers under the other important bridges, except for Sabarmati River in the Phase I-a section are confined by dykes or natural topographies according to the site inspection by JST, the river channels are clearly formulated and overflows from river channel have seldom occurred even during the flood period.

Therefore, the method determining the appropriate bridge length by applying hydrological and hydraulic analysis was introduced to Sabarmati River and the bridge length of other bridges besides Sabarmati River bridge has been determined considering the existing river width and additional margins in this study.

The following hydrological and hydraulic analyses have been undertaken to determine the appropriate bridge length of Sabarmati River.

1) Specific discharge analysis to estimate design flood discharge;
2) Non-uniform flow calculation to estimate the appropriate design length.

The above analyses resulted in design discharge of 25,000 m^3/s and bridge length of 5,000 m in the downstream of Sabarmati River, respectively. The details of analyses are presented in *Volume 4 Technical Working Paper Task 2, 7-(3)*, as guide line design of bridges.

It is noted that the collected data, related to the river and its flooding, in this study is still at a very preliminary level. Further data, relating to the river and the flood shall be collected, including cross section surveys and further analyses using the above procedure will be followed during the detailed design stage.

(2) Consideration of Span length and Type of bridge

Bridge construction period will become the critical path for the whole construction period. From this view point, the construction period of Sone River Bridge in the Eastern DFC is studied considering the span length and bridge type.

Comparison of construction period of PC-T girder with 30 m span and Open web girder (Truss bridge) with 90m span is shown on Table 7-9. According to this table, construction period of open web girder is 2.5 years that is 1.5 years shorter than PC-T girder of 4 years.

The reasons of it are,

1) For the substructure, number of pier is reduced to 1/3.
2) For the superstructure, only erection period shall be considered at site because the members are pre-fabricated at work shop. On the other hand, in case of PC-T girder, the fabrication period at site shall be considered.
3) Replacing of members of Open web girder is easy because of its lighter weight than PC-T

girder.

As the bridge erection cost is a major part of the whole project cost, shortening the erection period can induce reduction of the total cost relating to man-power and equipment.

From the above consideration, span length and bridge type which can shorten the erection period should be finalized, not to replace the existing span length and bridge type.

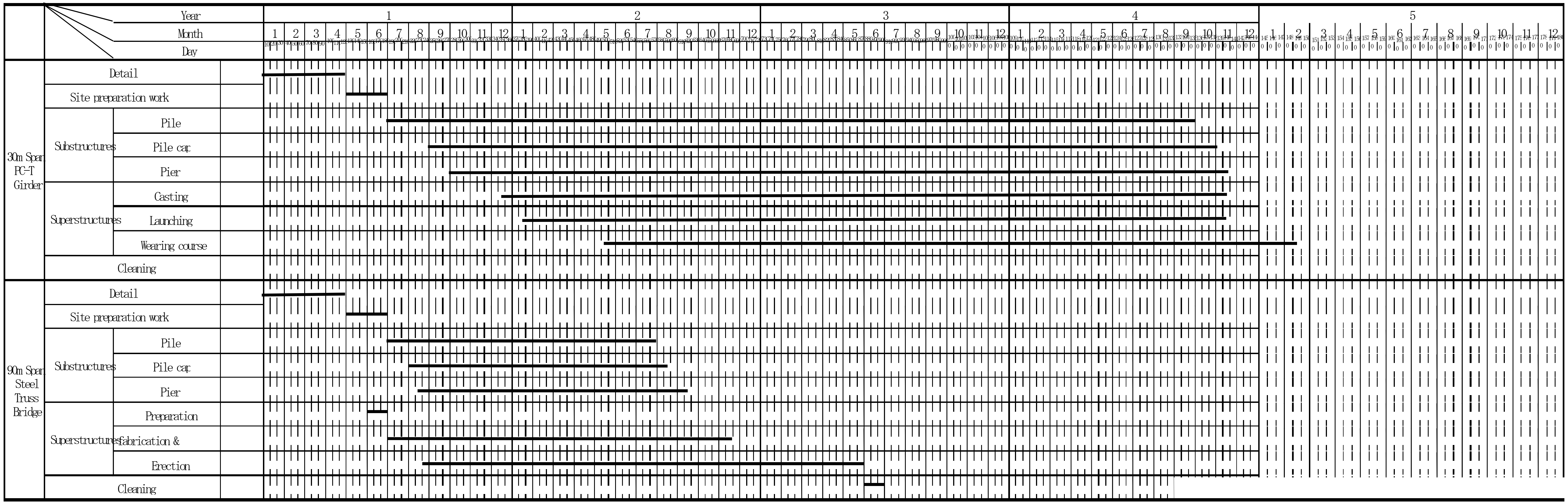
(3) For future power up of locomotive

For future power up of locomotives, three connected 130tonne locomotives or two connected 240tonne locomotives will be planned. For the first one, if the design will be carried out with HM loading, problems, if any, are not expected because HM loading shown on current specification specifies three connected 130tonne locomotive already, as shown on Figure 7-25.

For the second one, as the axle arrangement is not available, it is difficult to comment. But as 8 axles of 30tonne will be applicable, which will greatly influence the structural design does not arise.

Table 7-9 Sone River Bridge – Erection schedule

Comparison of Span 30.0m PC-T Girder and Span 90m Steel Truss Bridge



Note : Schedule of 30m Span PC-T Girder is based on the actual construction schedule issued by EAST CENTRAL

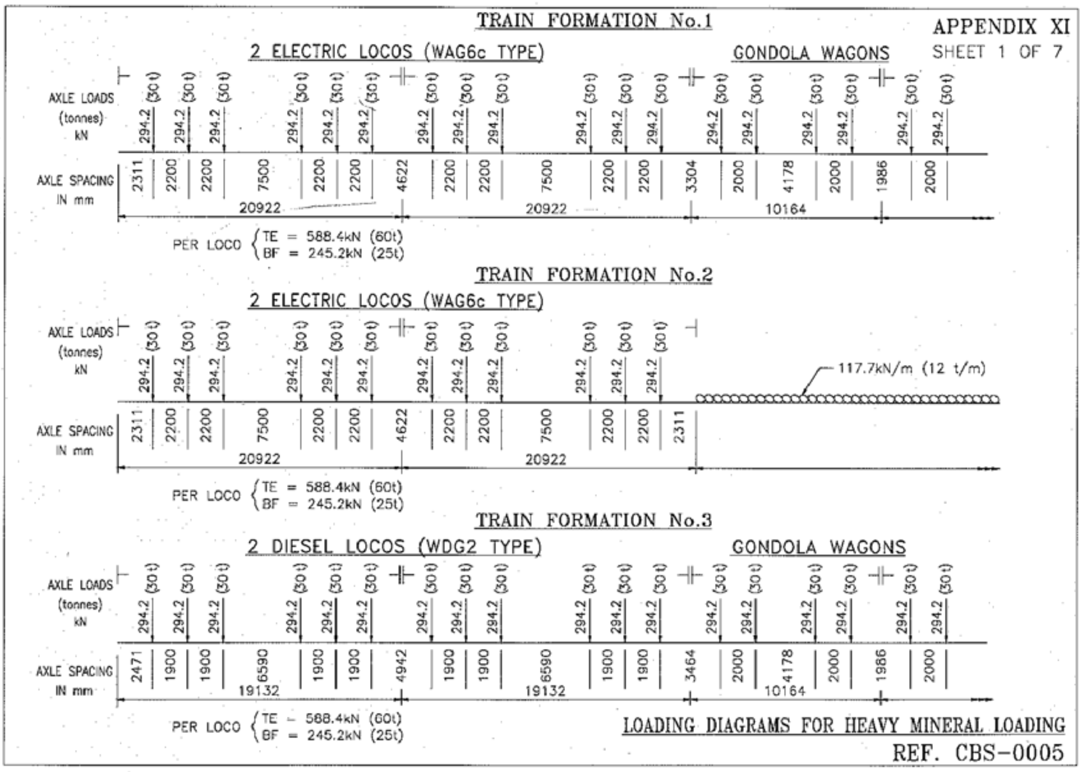


Figure 7-25 Axle load and arrangement of HM Loading

7.4.5 Diversion Route

The section between Rewari and Dadri in Western DFC was proposed for new diversion route, because Delhi is not only the centre of National Capital Region of India, but also the heavily-populated, built-up and historical area. The volume of container cargo from/ to the center of Delhi, by Western DFC will be little in the future since there is no large industrial estate and Delhi is designated as ‘no heavy factory zone’.

Geological formation along the new diversion route is as follows;

- First 30km section in an easterly direction from center of Rewari is a plateau with first a gentle ascent and then a vertical drop of 30m from 250m elevation to 280m elevation.
- Second 2.5km section in an easterly direction from end of first section is mountainous area with steep cliff over a mountain, having a vertical drop 100m from 300m elevation.
- Final section is plain land, with an elevation of about 200m.

Based on the above geological condition, about 4.0km length tunnel in second section was proposed in PETS-II, since proposed maximum gradient is 0.5% in DFC and vertical interval is 80m from 280m elevation to 200m elevation.

However, there is no natural condition survey for tunnel design like, geological survey and underground water survey etc., and no a proper alternative route study was found available in PETS-II report. Hence, the preliminary alternative route study avoiding the tunnel section is done, based on satellite photo and site investigation. This study shall be used as reference in next survey and study by RITES.

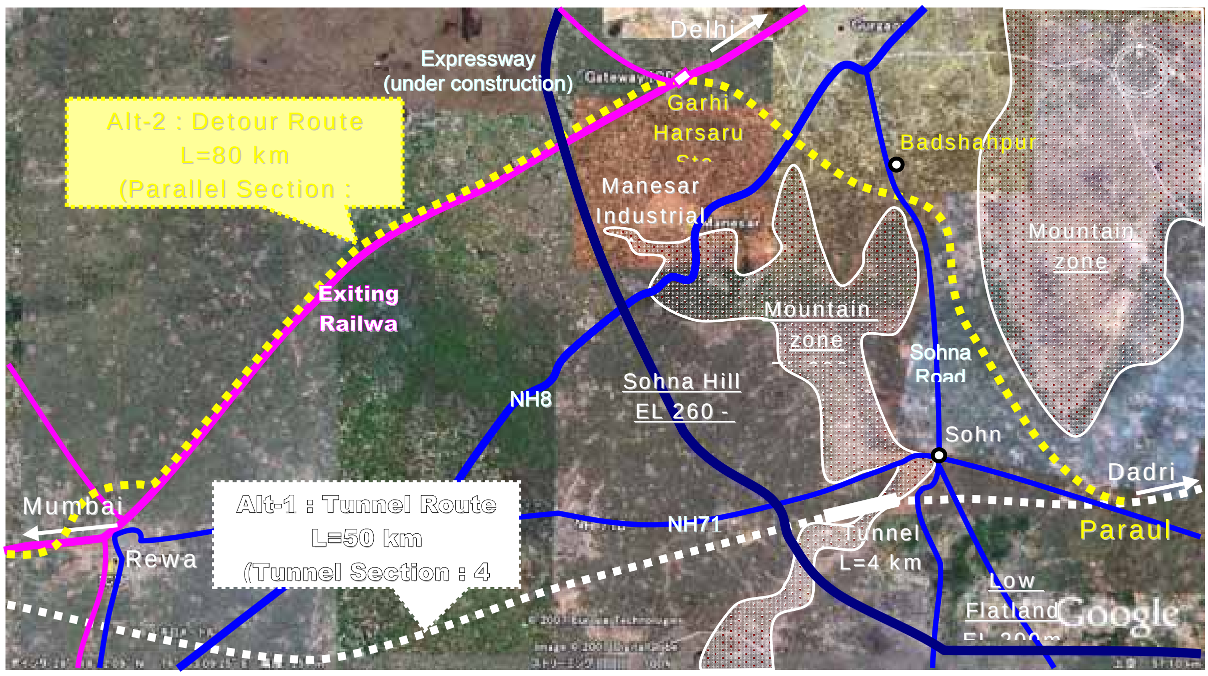
(1) Alignment of the Diversion Route

The diversion route, which detours the PETS-II route plan towards the north, connecting directly with the existing railway line in the vicinity of Garhi Harsaru Station is planned for avoiding any disturbance to the natural conditions in the Aravalli Hill area.

Advantage of this plan is;

- To minimize the environmental impact of the Aravalli hills caused by the construction works.
- Saving the construction cost by widening of the existing railway between Rewari to bifurcation point near Garhi Harsaru station.
- Utility value of DFC will increase as the distribution channel of the east-west logistics corridor to connect directly to the future ICD planned in the vicinity of Garhi Harsaru station.

However, land acquisition cost along to the NH 8, especially around Manesar industrial area, is escalating upwards rapidly and will influence the construction cost of DFC.



Source of Base Map: Google Earth

Figure 7-26 Plan View of Diversion Route

A diversion route, as shown in above figure, starts from a survey control point of RITES in Paraul village located between Rewari-Faridabad, runs toward northwest, passing east of Sohna, while avoiding foot of a mountain. Then, changes the course to the west in the vicinity of Badshahpur and crosses the Sohna Road at the north side of the transformer substation. After changing again the direction, towards the northwest at the vicinity of Paira and passing through the north side of the quarry site. Then, cross NH8, and reach the existing railway line near to the Garhi Harsaru Station, after that go to Rewari along the exiting railway line. Total length of diversion route is estimated 80 km (40km parallel section and 40km to be newly constructed section) on the satellite photo, and it includes the crossing of the Gurgaon Canal, Gurgaon-Sohna Road and NH8 where the embankment and a bridge is required. Manesar industrial area spreading on both sides of NH8 from Keruke Daura to Manesar is already under part operation with many factories under construction.

The area from Manesar to Gurgaon is planned as the future industrial district in the metropolitan area by the NCR (National Capital Region Planning Board) and it will bring about huge profit to DFC as it will contribute to the transportation of east and west region by connecting the DFC railway line to the ICD terminal. It must be considered that the railway line will interrupt the road network inside the industrial area and have some possibility of hinderance to the development of the Metropolitan Region. Therefore, railway route prefers to be constructed on the viaduct/elevated bridge and/or the underground subway with cut and fill.

According to the information from the internet, the land prices around the NH8, from Manesar to Gurgaon, is rising up by two times than the official price and is estimated as 7,000Rs./m^2 - 10,000Rs./m^2. It is evident that the inflation of the land price will continue and early land acquisition would help in reduction of the future construction cost.

(2) A rough estimation of construction of the diversion route

Main roads, rivers located on the diversion route are NH8 and Gurgaon canal and a total 18 numbers of local roads are crossing the railway alignment.

In accordance with the regulation of "Lateral and Vertical Clearance at Underpasses for Vehicular Traffic"(The Indian Road Congress, 1987), the vehicle clearance beneath bridge must keep 5.5 m and the embankment length for the bridge access is estimated as 2,200 m in both sides. Local and small road cross for connecting villages will be a grade separated crossing. A simple steel bridge with low height embankment is planned for the crossing of the Gurgaon canal as the width of the canal is only 10 m to 15 m.

The viaduct/elevated bridge about 8 km long is planned for passing the Manesar industrial area. Construction cost of the diversion route with the elevated bridge and without the elevated bridge (embankment) are estimated Rs. 20.7 billion, Rs. 3.65 billion, respectively. The construction time for the bridge to be completed is estimated to be nearly 8 years. However, the unit price referenced from the PETS-II price may not reflect the actual price in the present stage. Especially, the land price in between Manesar and Gurgaon is only 5 % of the price mentioned above. The embankment plan is more than 5 times lower priced than the viaduct/elevated bridge plan, but embankment will definitely interrupt the regional transportation and it will extremely decrease the advantages of the industrial area and future planned ICD.

NCR proposes the passenger railway to connect the Bhiwadi industrial area and Rewari in their report of the “Regional Plan-2021 National Capital Region”. The DFC tunnel route is planned near to this proposed route. Furthermore investigation is required to decide the final DFC route from Rewari to Faridabad to avoid double burden cost of the railway financial recourses. This should be discussed at length in future.

7.4.6 Tunnel

(1) Review of Tunnel of PETS-II Report

The objective of this para is to review the progress and PETS-II report, that is, to re-examine the details of the railway tunnel route plan for the purpose of advancing and increasing the effectiveness of DFC. The suitable alignment including cost evaluation, safety, environmental protection and proposal for necessary inspections and investigations for the detail design for constructing this railway tunnel is strongly recommended.

1) Abstract of the PETS-II Tunnel Plan and Necessary Studies

Summary of the tunnel plan written in PETS-II report is shown in Table 7-10.

Table 7-10 Abstract of PETS-II Tunnel plan

Length (m)	Gradient (%)	Portal Elevation)		Access Length for East Portal		Cut Length for West Portal	Tunnel Construction Cost Excluding Access Works	
		East (Dadri side)	West (Rewari side)	Bridge (m)	Embankment (m)			
4,000	0.5	230	250	2,000	4,000	4,000	¥2.25millon/m	Total ¥9billion

Major items pointed out in the PETS-II reports are;

a) Geological survey and inspection of underground water seepage.

b) Tunnel section for the double and/or single truck considering ventilation and other facilities.

c) Comparison of the total construction time and a cost of tunnels, bridges and embankment, etc.

d) Safety and environmental measures during and after tunnel construction

e) Study of the alternate diversion route of the tunnel section

Tunnel plan, such as alignment, structural design, construction schedule, and its cost including viaduct/bridge and embankment are re-examined considering designation as the “Geophysical Sensitive Area” of the “Aravalli Hills”.

2) Natural Condition of the Tunnel Route

Topography around Sohna city is characterized by flat low ground and hilly area named “Aravalli Hills”. The elevation of low ground and the Aravalli Hills are around 200 m and 270-300 m respectively and they are separated by the steep cliff with 60 m high. Agriculture area is widely spread in a lower ground. Aravalli Hill is designated as the “Geo-physical Sensitive Area” where any developing activities are normally rejected without official approval. Geology of the Aravalli Hills is mainly composed of hornfels. Geological structure of Aravalli Hill is controlled by the folding structure which is plunging nearly vertical and opening toward to the west. Underground water in this area is the major source of the irrigation water. Shallow water reservoir available for irrigation in hilly area is observed from -15 m to -30m deep from the ground surface, and the deep water exists more than 50 m deep from the ground surface, but this is not suitable for agriculture use.

3) Review of PETS-II Tunnel Alignment and Proposal of Alternative Tunnel Alignment

The main planning issues for review of the tunnel alignment of PETS-II are;

a) Maintenance cost and cost for safety measure will increase due to high and wide cut slope at the east portal.

b) More than 30 m high embankment is required for the access route at the tunnel east portal.

c) Nearly 30 m deep open cut is necessary for the west portal.

d) Open cut length at the west portal will be longer than 4 km.

Considering the environmental conservation of Aravalli Hills, the length of tunnel is amended to 6 km as shown in Figure 7-27.

Long tunnel will definitely increase the total construction cost. To decrease the total construction cost, the new tunnel alignment is studied and proposed. Tunnel portal of the new alignment tunnel is planned to shift the east portal of PETS-II by nearly 1.5 km towards Sohna city. Elevation of the east portal of the new alignment tunnel is planned at E.L. 250 m and the tunnel length is 3 km (see Figure 7-28). Detail of these tunnel plans will be discussed hereunder.

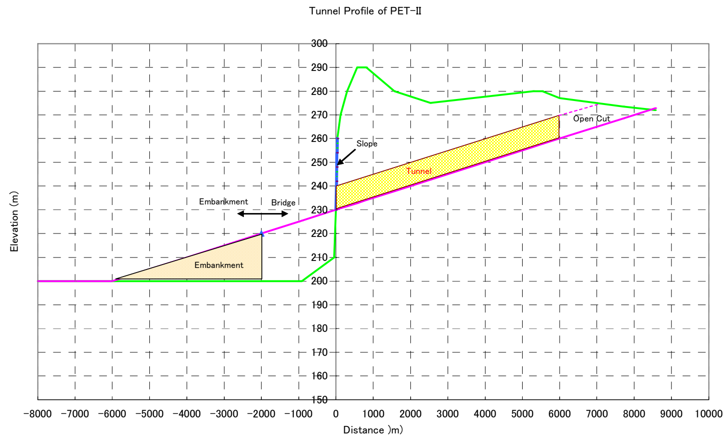


Figure 7-27 Tunnel Profile of PETS-II

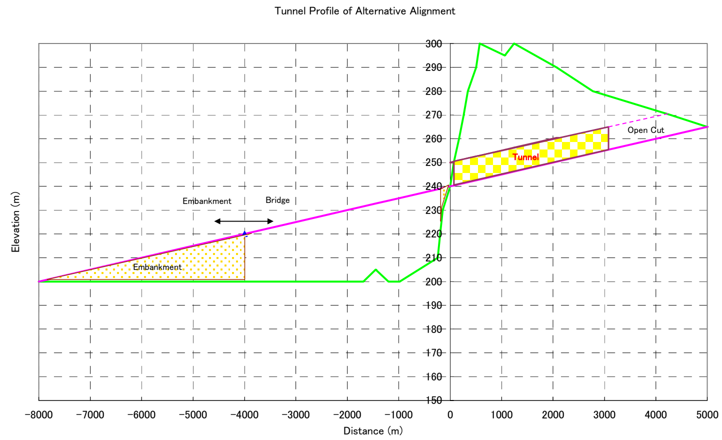
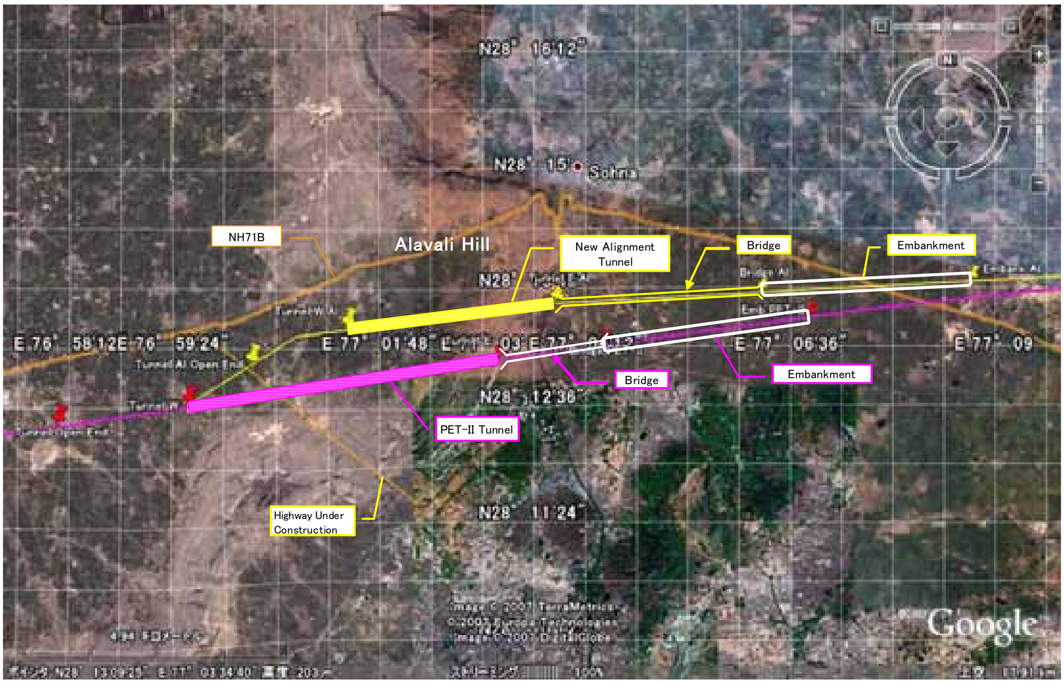


Figure 7-28 Proposed New Tunnel Profile



Source of Base Map: Google Earth

Figure 7-29　Plan View of Tunnel Alignment of PET-II and New Alignment Tunnels

4)　Construction Cost and Construction Schedule

Tunnel support pattern and the quantity of support are roughly assumed as shown in Table 7-11 for calculation of its cost and its construction time.

Table 7-11　Support Pattern and Quantity of Support

		Double Track	Single Track
Rock Class (JR)		IVN	IVN
Support Pattern (JH)		B-CI	B-CI
Advanc Length	Upper Half	1.5	2
	Lower Half	3	2
RB Pattern		Chess Board	Chess Board

Support Member	Unit	Double Track	Single Track
Shotcrete	mm	150	100
Lining Concrete	mm	400	300
Upper Half Section	m2	84.9	25.0
Lower Half Section	m2	48.1	37.9
Rock Bolt Nos.	Nos.	21	16
RB Length (Upper)	m	6.0	3.0
RB Length (Lower)	m	4.0	—
Steel Rib		—	—

Bridge is assumed as PC structure with height of pier 20-30m, span 30m, deck 15-20m in width. Embankment is based on a specification of the "Guidelines for Earthwork in Railway Project"

The time estimation of works and the cost of construction are listed in Table 7-12 in comparison with PETS-II plan and the new alignment tunnel plan. Unit price per meter of the double track tunnel and the parallel single track tunnel is estimated as 3,660,000 yen, 2,900,000 yen, respectively. Construction time of the parallel single track tunnel is shorter than the double track tunnel, but unit price is estimated approximately 27 % higher. As a result, from evaluation of the total construction cost the double track tunnel is more economical. The total construction cost and the construction time for PETS-II and the new alignment tunnel including access route is estimated 22.7 billion yen and 36 month, 17.4 billion yen and 48 month, respectively. The new alignment tunnel has some superiority to the PETS-II proposal, from the point of view of the construction time, cost, workability and the environmental impact.

Table 7-12 Cost of the Tunnel Route

Items		PET-II (Revised)		Amended Alignment	
		Single Track Tunnel	Double Track Tunnel	Single Track Tunnel	Double Track Tunnel
Length of tunnel		6,000	6,000	3,000	3,000
Section for exc. (m2)		62.8 x 2	133	62.8 x 2	133
Gradient (%)		0.5	0.5	0.5	0.5
Railway separation (m)		18,650	5,500	18,650	5,500
Width of tunnel (m)		26,010	14,700	26,010	14,700
Portal Ele. (m)	East	230		241	
	West	260		256	
Height of portal slope (m)	East	more than 30	more than 30	less than 15m	
	West	17		22	
Length of open cut (m)	East	6,000		7,800	
	West	2,500		1,850	
Length of portal structures (m)	East	Bridge 2km, Embankment		Bridge 3.8km, Embankment	
	West	–	–	–	–
Assessment of portal		・Width of the portal slope will be huge as the portal is planned the cliff. ・Heavy machine excavation is difficult to apply. Blasting will required. Environmental problem by blasting must be take account. ・Slope protection will be ・Protection of embankment will be necessary as the height embankment is estimated around ・Parallel works with other structures will be difficult construction period will be		・Gradient of portal slope is moderate and adequate for excavation. ・Right slope protection such as rock bolt and shotcrete wi sufficient. ・Height of embankment will be enough for the parallel work other structures.	
Portal yard		Portal yard will be wider double Track tunnel due to clearance in between tunnels.	Width of the tunnel s fixed easy for access.	Portal yard will be wider double Track tunnel due to clearance in between tunnels.	Width of the tunnel s fixed easy for access.
Tunnel construction works	Upper exc.	Blasting			
	Lower exc.	Blasting	Blasting. Machine will be partly applicable.	Blasting	Blasting. Machine will be partly applicable.
	Monthly advance	less than 225m	less than 100m	less than 225m	less than 100m
	Construction period	34.5 month	68 month (estimated)	21.5 (estimated)	39 (estimated)
	Total Cost	¥22 billon	¥17.3 billon	¥11billon	¥8.65 billon
Construction works		・Mucking of upper section interrupt activities of section. ・Width of the tunnel F.L. is enough for the driving capacity dump ・Exc. amount at lower is big. Exc. level should considered. ・Rapid transfer system required for mucking.	・Effective arrangement machines and detail construction schedule should planned. ・Big machine should be used mucking. ・Adequate excavation is proposed for hard	・Mucking of upper section interrupt activities of section. ・Width of the tunnel FLU. is enough for the driving capacity dump ・Exc. amount at lower is big. Exc. level should considered. ・Rapid transfer system required for mucking.	・Effective arrangement machines and detail construction schedule should planned. ・Big machine should be used mucking. ・Adequate excavation is proposed for hard
Impact to condition		・Environmental impact of ・Depletion of underground ・Environmental effect of noise, vibration and air ・Decoupling of local community of the open cut		・Environmental impact of ・Depletion of underground ・Environmental effect of noise, vibration and air ・Decoupling of local community of the open cut	
Bridge construction	Length (m)	2,000		3,800	
	Period	¥36 month or more		¥48 months or more	
	Cost	¥4.1billion (estimated)		¥7.8 billion (estimated)	
Embankment	Length (m)	4,000		4,000	
	Period	–		–	
	Cost	¥730 million		¥750 million	
Cut	Length (m)	–	4,000	–	1,850
	Period	–		–	
	Cost	–	¥150 million	–	¥1500 million
Slope work (east		–	¥300 million	–	–
Slope work (west		–	¥100 million	–	¥100 million
Total cost		–	¥22.7 billion	–	¥17.4 billion

The details of above results are presented in *Volume4 Technical Working Paper Task 2, 7-(4).*

5) Future Investigation

Following detailed investigations are recommended for finalizing the plan of the tunnel route.

a) Investigation for Tunnel

Topographic maps with scale of 1/5,000, 1/1,000, 1/500, detailed geological survey and an investigation of discontinuities, inspection of geology and underground water condition, geo-physical prospecting such as the seismic prospecting, electrical prospecting, and so on, should be carried out to obtain high accuracy data available for the detail design.

The borehole scanner with a borehole television has high accuracy to grasp the distribution of discontinuities and an investigation of underground water seepage. The electrical logging using boreholes and a tracer test are effective for the estimation of the subsurface water distribution.

Seismic prospecting which is commonly applied for geological survey of tunnels may not be permitted in the "Geo-physical Eco-sensitive Area". A high density electrical prospecting system and electrical resistivity tomography are suitable for the investigation of the geological disturbed zone and the subsurface water distribution.

b) Environmental Assessment

Research for the social environment, the land occupation, the land use, surface and subsurface water condition, plantation and associated regulation should be carried out under consideration of the influence of tunnel construction.

Agriculture area spreads out and a Government forest area exists at the east portal. The groundwater increment system is proposed in this area. Subsurface water security is an inevitable problem in this area. Appropriate subsurface water cultivation method must be examined.

Construction of tunnel access will affect the social community and transportation in this area. Necessary countermeasures should be taken for keeping the living condition for habitants without any disturbance.

7.4.7 Review of Asaoti – TKD Section

Asaoti station is located at the junction of proposed Western DFC (i.e. Rewari-Dadri section) on the existing line running south from Delhi. Indian Railway (IR) is tripling the track of the existing branch line of 32 km between Asaoti and TKD. According to PETS-II, this section will be upgraded to double-double line (4-track line) and another track will be further added for DFC construction, as a result, 5- track line is planned to be constructed in the future. However, the studies for neither additional branch line nor TKD yard improvement have been conducted. Hence JST has undertaken the field survey and preliminary study utilizing satellite image in this section

(1) Site Investigation for Exiting ROB and RUB in Asaoti – TKD Section

Existing structures such as ROBs and RUBs on the existing branch line have been mainly investigated during the field survey. The existence of large number of ROBs and RUBs as shown inFigure 7-24 and Table 7-13 have been confirmed by field survey.

Table 7-13 Result of existing structure by field survey

Type No	Bridge length (m)	No. of lanes (Lanes)	Location	Remarks
ROB01	110	4	10.3km north from Asaoti stn,	NH2, 4 span
ROB02	Unknown	2	North of Ballabhgarh stn.	PC Girder Under construction
ROB03	460	4	North of Faridabad New Town stn.	PC Girder
ROB04	320	4	1.9km south from Faridabad stn.	PC Girder
ROB05	320	2	1.9km north from Faridabad stn.	PC Girder
RUB01	12*	2	5.8km north from Faridabad stn.	Steel Girder
RUB02	55*	8	South of TKD	RC BOX(6 box)

As mentioned above, the double-double tracking and additional DFC construction is planned in this section. Considering this future plan, it is observed that some of existing and under-construction bridges have enough length of spans for new proposed tracks. However the ROB01, whose traffic volume is significantly large and on which NH2 is passing over the existing railway, has 4 spans and horizontal clearance is not enough to accommodate the 5-track width. Furthermore, the vertical clearances of all ROB’s are less then 6.5 m and replacements are needed to accommodate the Double Stack Container (DSC) trains. The construction of temporary bridges is also required for replacement of ROB01, ROB03 and ROB04 since it is hard to prepare the detour route utilizing the existing road during the construction period.

The extension of RUB width will be also needed when new DFC line is added.

Due to the above issues, the significant cost for ROB and RUB replacement is required if new DFC line for DSC is constructed in this section. Moreover, the urgent EIA study is indispensable to upgrade this section since the social environmental impact by ROB and RUB replacement is expected to be significantly large.

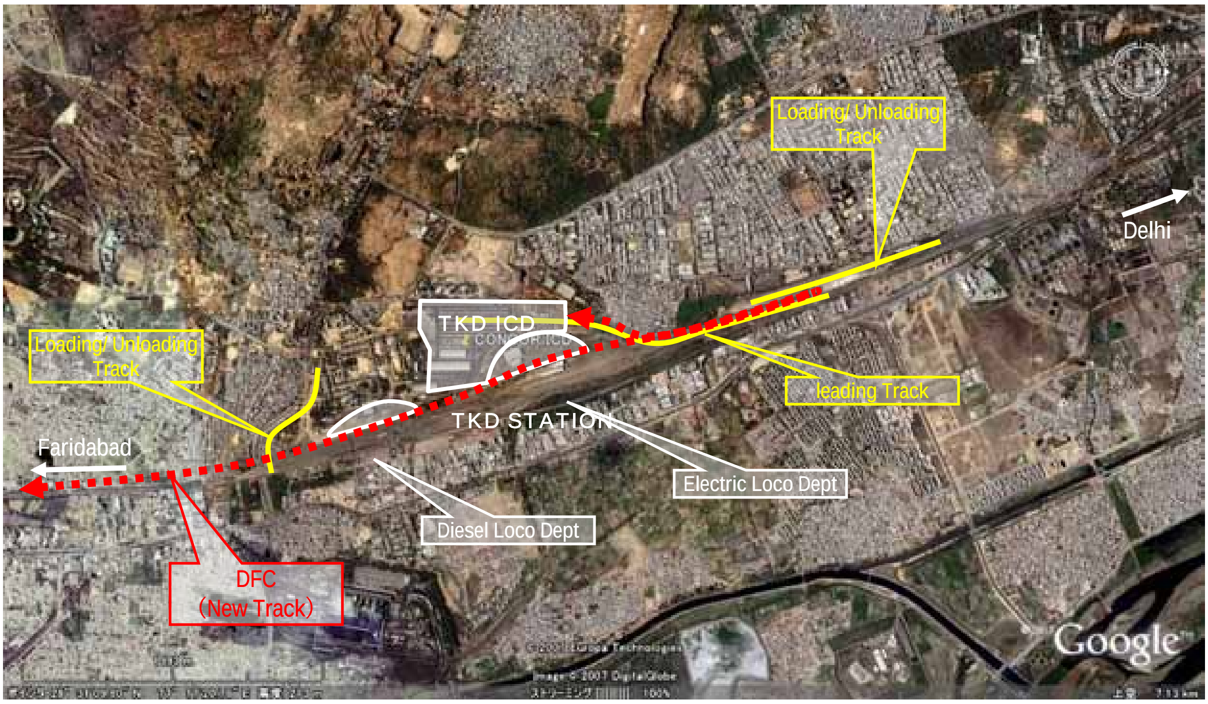
(2) Future Development Plan in TKD Yard

The future extension plan of TKD yard corresponding to upgraded 5-track line by DFC construction is not prepared. The height of OHE on the existing line can not accommodate the DSC on either well type or flat type wagon. One of the following provisions is required but the investment cost would significantly increase due to these provisions.

1) Track layout improvement for the provision of a dedicated route on the western side of station.

   - Shunting operation require trains to move out to the north and switchback to the south.. The track layout improvement of the station is proposed to provide a dedicated route on the west side of the TKD station that stretches approximately 3km.
   - Trains are required to cross over two unloading lines located on the west side, the entrance/exit of the diesel loco depot and the electric loco depot. Three measures are presumed to be taken at the entrance/exit of the electric loco depot, which are: 1) modification of pantographs of locomotives that do not operate on DFC lines, into pantographs are capable of running on DFC line (having high stroke distance); 2) adopt shunting operation using diesel loco.; 3) reroute the DFC route to the rear of the electric loco depot.

2) To increase the height of Overhead Equipment (OHE) to accommodate DSC. It may be noted that, not only the height of OHE would need modification, but also changing the pantograph of locomotive to adapt the higher OHE.



Source of Base Map: Google Earth

Figure 7-30 Present Condition of TKD Yard

The capacity of TKD ICD has already saturated, with additional land acquisition of surrounding area becoming significantly difficult so planning for future extension is not feasible. If the DFC branch line is added and additional containers are taken to TKD ICD, TKD ICD can not receive these additional containers.

(3) Land Acquisition and Squatter

This section is located in the urbanized area near Faridabad and southeast area of Delhi. In the urbanized area, DFC is generally planned to be a detour line to avoid the urbanized area, however alternative routes can not be found in this section, hence parallel to existing line is planned.

The existing line has been already improved to 3-track or 4-track line. For the existing 3-track, upgrading to 4-track is on the anvil. Therefore, there is little room for additional land acquisition for DFC construction.

The land acquisition is difficult and social environmental impact is considerably large in this section as mentioned above. The problems to be taken care of are many than the benefit which may accrue.

(4) Conclusion

As a result of the above study, JST proposes to connect the existing line by SSC and does not propose the enhancement of branch line of this section. TKD ICD may be utilized for the small scale ICD for Delhi urban area considering its geographic advantages.