CHAPTER 5:
FACILITIES AND INFRASTRUCTURE DEVELOPMENT PLAN

5.1 Land Grading

5.1.1 Proposed Methodology for Land Grading

Due to the high cost of borrowing fill material for the embankments, it is important to design the land elevation so as to minimize the required volume of the embankments. In this regard, the elevations of primary and secondary roads need to be at the lowest possible level so as to comply with the minimum thickness of road pavements and the minimum depth of covering for piping works. Based on the planned road elevations, the elevation of the plots of land can be designed.

There are no detailed topographic maps available for the study area. In addition, land subsidence in the area makes it difficult to clarify the existing ground levels. In the flood protection master plan for the BMA area, the existing ground level was recorded at 0.4 – 0.8 m MSL for the undeveloped areas and 1.0 – 1.5 m MSL for the developed areas.

Outside the polder system, the high water level (HWL) in *khlong* Pravet, *khlong* Nung, and the *khlongs* which flow into *khlong* Pravet from the south, is set at 0.6 m MSL which is the existing 5-year return period level. Inside the polder system, the HWL in *khlong* Mae Chan and *khlong* Song is set at 0.4 m MSL, which is the lowest HWL thereof.

Based on the conditions given above, the standard elevation was planned for the main roads, plots of developed lands, parks, and polder dikes as detailed below.

(1) Road elevation:

1) Primary roads (type A, B, and C) within the polder system at 1.5 m MSL (= 0.0 m MSL (NWL in the dry season) + 1.0 m (embankment for sub-grade) + 0.5 m (road pavement)) higher than 1.0 m MSL based on the minimum depth of covering for drainage pipes (= 0.4 m MSL (HWL in *khlong*) + 0.6 m (covering))

2) Secondary roads (type D and E) within the polder system at 1.45 m MSL (= 0.0 m MSL + 1.0 m + 0.425 m (road pavement))

3) Primary roads outside the polder system at 1.50 m MSL higher than 1.20 m MSL based on the minimum depth of covering (= 0.60 m MSL (HWL in *khlong*) + 0.6 m (covering)).

(2) Elevation of plots on developed land: The land owner may decide the elevation of plots of developed land based on the balanced volume of embankment and excavation works. Therefore, the elevation of developed land in this study is defined as the standard level which may be required to secure the land for building coverage area above the HWL of the road surface retention.

1) Developed land along primary roads at 1.65 m MSL (= 1.5 m MSL (road elevation) + 0.15 m (water depth of road surface retention))

2) Developed land along secondary roads at 1.60 m MSL (= 1.45 m MSL + 0.15 m)

3) Developed land along primary roads outside the polder system at 1.65 m MSL (= 1.5 m MSL + 0.15 m)

(3) Crest elevation of polder dikes along *khlongs*:

1) Alternative 1 at 1.20 m MSL (= 0.6 m MSL (HWL in *khlongs*) + 0.4 m (land subsidence at the rate of 0.02 m/year for 20 years) + 0.2 m (freeboard))

2) Alternative 2 at 1.70 m MSL (= 1.5 m MSL (elevation of primary roads) + 0.15 m (water depth) + 0.05 m (freeboard))

3) Crest elevation of the polder dikes at 1.70 m MSL

(4) Public parks:

1) Average elevation of public parks at 0.9 m MSL (= 0.4 m MSL (existing GL) + 0.5 m (average depth of surface soil for plants which varies from 0.3 m for sodding to 1.5 m for higher trees with deep roots))

2) Minimum elevation of district parks at 0.6 m MSL (= 0.4 m MSL (HWL in retention pond) + 0.2 m (freeboard))

3) Riverside green areas at 0.6 m MSL (same as the HWL in the dry season in the *khlongs*)

The land elevation plan and typical cross-sections for the study area are given below.

Figure 5.1: Land Elevation Plan

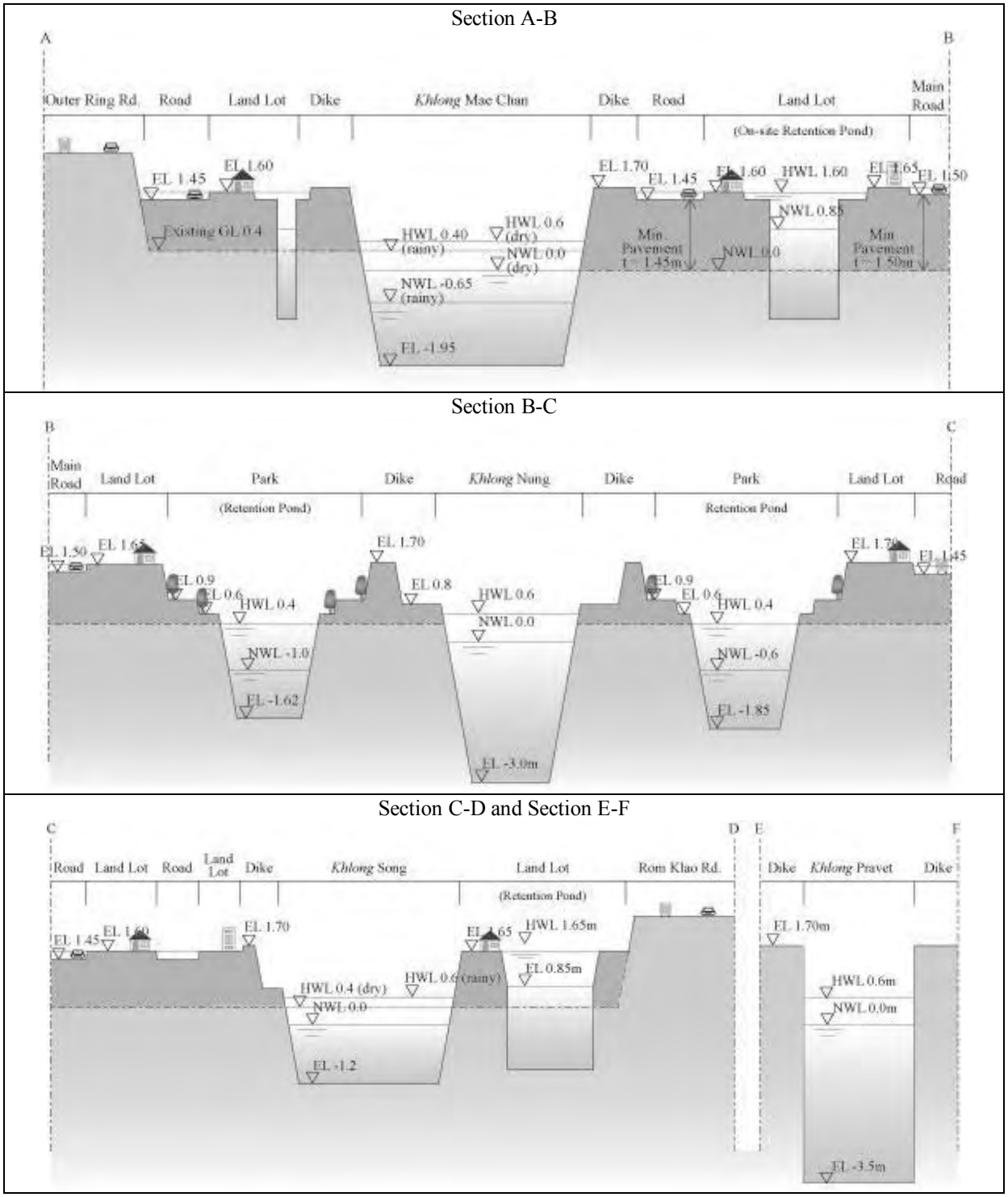


Figure 5.2: Typical Cross-sections of the Study Area (non-scaled)

5.1.2 Estimate of the Volume of Earthworks

The volume of earthwork for land grading in the study area was examined based on the conditions outlined below.

1) The sub-grade of primary and secondary roads is formed by the embankment of fine material to1 m in height on ground.

2) Roads within the land parcels are assumed to cover 10% of the land area in the new development area, while the feeder roads are assumed to cover 20% of the land area outside the new development area.

3) On-site and feeder roads will be raised by an embankment of 0.6 m in height.

4) The developers and/or land owners will decide on the elevation of the plots based on the balance of the embankment and excavation volumes, in order to mitigate the volume of borrowed material. In the earthwork volume estimate, it is assumed that the average elevation of the plots will be raised up to the level of the planned road elevation.

5) Land that has already been developed is excluded from the calculation of the land embankment area, as these areas have already been raised up to a level high enough for land use.

6) The elevation of the bottom of the on-site retention ponds is set at –1.0 m MSL which is similar to the bottom of the existing *khlongs*. Based on the existing GL (set at 0.4 m MSL), the depth of excavation work is estimated at 1.4 m.

The assumptions for the estimate of earthwork volumes are summarized in the table below.

Table 5.1: Height of Embankment and Depth of Excavation

Item	Excavation (m)	Embankment (m)	Note
Road	0.4 (existing GL - NWL in *khlongs*)	1.0 (for sub-grade embankment)	
Public Park	0.0	0.5 (for public park) 0.2 (for riverside green area)	
Land Parcel			
Within New Develop. Area	0.0	1.05 – 1.10	1) Excl. existing developed area 2) Land area at 90% of land parcels
Outside New Develop. Area	0.0	1.05 – 1.10	1) Excl. existing urbanized area 2) Land area at 80% of plots of land
On-site and Feeder Road	0.0	0.6	1) Land area at 10% of land parcels in the new development area 2) Land area at 20% of plots of land outside the new development area
Retention Pond	1.4	0.0	1) Excavation from the existing GL to a level similar to the existing *khlongs*

As a result, the excavation volume is estimated at 1,689,000 m^3 for an average excavation depth of 0.09 m, while the embankment volume is estimated at 14,743,000 m^3 for an average embankment height of 0.76 m. The required volume of borrowed material is 13,054,000 m^3 to achieve the total embankment volume.

Table 5.2: Estimated Volume of Earthworks

Item		Unit	Excavation	Embankment		Note
					Borrowed Material	
Primary & Secondary Roads		m^3	387,546	968,866	968,866	Borrowed material is used for the embankment.
Land Develop.	Plots of Land	m^3	0	11,781,792	10,092,622	Borrowed material and excavated material is used for the embankment.
	On-site and Feeder Roads	m^3	0	1,543,827	1,543,827	Borrowed material is used for the embankment.
	On-site Retention Pond	m^3	989,949	0	0	
	District Park	m^3	311,675	292,950	292,950	Borrowed material is used for the embankment.
	Neighborhood and Pocket Parks	m^3	0	46,400	46,400	Borrowed material is used for the embankment.
	Riverside Green Area	m^3	0	109,525	109,525	Borrowed material is used for the embankment.
Total		m^3	1,689,170	14,743,360	13,054,190	
Average Depth and Height		m	0.09	0.76	0.67	

5.2 Transportation facilities planning

5.2.1 Transportation Demand Analysis

(1) Introduction

The Lat Krabang Sub-center could not be a completely self-sufficient city. The sub-center will be a part of Bangkok and the transportation in the sub-center will depend on the transport infrastructure in Bangkok. As the sub-center is large, it will generate a huge traffic demand which will put additional load on the transportation system around the area. A transportation demand analysis was carried out to evaluate the traffic impact and to determine the required capacity of roads and public transport systems in and around the sub-center.

The findings of the transportation demand analysis were as follows:

1) Traffic volumes on major roads around the area will become very large regardless of whether the sub-center is developed. Traffic volumes on the exit ramp at the Rom Klao I/C from Bangkok to Rom Klao Road will reach the capacity of the ramp before 2022.

2) As the sub-center development will incorporate urban functions that are major traffic generators, traffic volumes will become heavier.

3) At the same time, the proposed road development (the north-south road through the Study Area) will accommodate the increased traffic demand, and the new road is expected to slightly decrease the traffic volumes.

4) A forecast of the number of passengers on the mass transit system (extension of the Sky Train from Onnut to the sub-center) shows that the volume of passengers on the

system will not be small: 86,700 passengers a day in total (boarding) and 6,000 passengers boarding at the new station in the Lat Krabang Sub-center.

5) Even if the mass transit system is introduced, the decrease in traffic volumes on the adjacent roads will be relatively small, as there will be a transfer of vehicles using other roads to the adjacent roads due to the decrease in volumes after the introduction of the mass transit system.

6) Ultimately, the northern part of the sub-center will generate approximately 19,900 PCU (8,700 entering and 11,200 exiting) during the evening peak hour.

7) Based on these passenger traffic volumes, the ground area needed for the "station plaza" in the Lat Krabang Station is calculated to be about 7,000 square meters.

(2) The Future Highway Traffic Volume

A forecast of future traffic volumes was carried out using the Bangkok Extended City Model (BECM1) for three scenarios (2022). The first scenario (Without the Lat Krabang Sub-center) is the case where the Lat Krabang Sub-center has not been developed and therefore the two arterial roads proposed in the SADP have not been constructed. This is almost the same scenario as in the URMAP. The second scenario is the case "With the Lat Krabang Sub-center". The last scenario is the case where the Lat Krabang Sub-center has been developed with the mass transit system. The results of the forecast are given in the figure below.

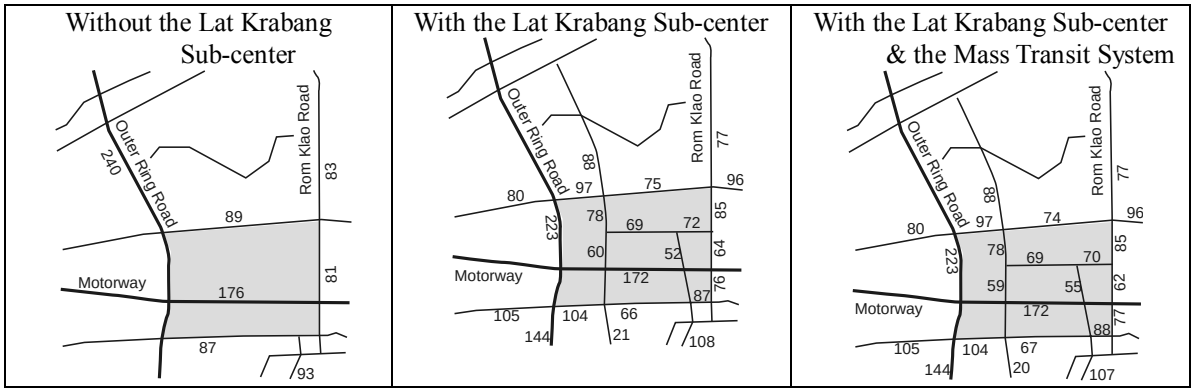


Figure 5.3: Forecast of the Volume of Daily Highway Traffic ('000 PCU)

Without the Lat Krabang Sub-center Case: It is estimated that in 2022 the daily traffic volumes on Rom Klao Road and Onnut Road will reach 81,300 and 86,500, respectively. The estimated volume of traffic will be more than two times higher than the present level. The daily traffic volume on the Krung Thep Kritha – Rom Klao Road will be 88,800. With six lanes each, these roads can theoretically handle the traffic volumes but will suffer from heavy congestion.

With the Lat Krabang Sub-center Case: The result shows that this case does not significantly differ from the "Without the Lat Krabang Sub-center" case in terms of traffic volumes on the roads around the sub-center. Accordingly, the increase in traffic for the sub-center can be handled by the additional roads.

1 BECM is the generally accepted demand forecast model in Bang

With the Lat Krabang Sub-center & the Mass Transit System: This case reduces the volume of traffic on the adjacent roads, however the impact is small. Although a mass transit system would reduce the traffic on adjacent roads, such decongested roads would begin to accept traffic from other congested roads.

(3) Forecast of Passenger Volumes on the Sky Train Extension

Extension of the BTS line along Onnut Road from Onnut Station to the Lat Krabang Sub-center was proposed in order to provide a good public transportation service to the sub-center. The volume of passengers on the extended BTS line was estimated by the BECM for three scenarios as shown in the figure below.

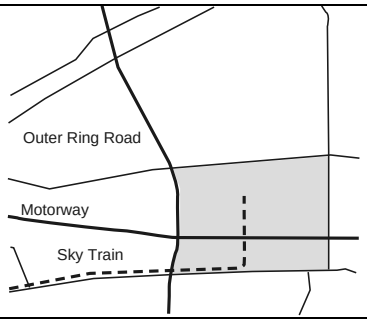
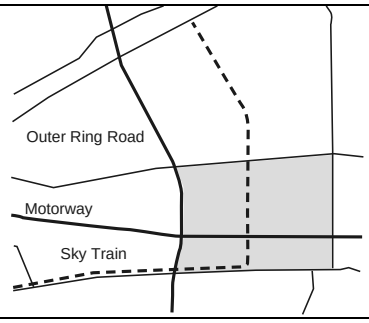
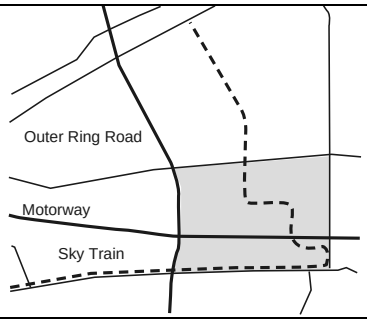
Scenario A	Scenario B	Scenario C
		
The line terminates in the sub-center.	The line goes through the sub-center and reaches the Minburi area.	The line connects to the SA Rail Line at Lat Krabang Station and goes up to Minburi.

Figure 5.4: Three Scenarios of the Forecast of Passenger Volumes

The extended Sky Train will have the highest volume of passengers at 97,900 (Scenario C), followed by Scenario B at 86,700 (boarding). Scenario A will have the lowest volume of passengers at 72,300. These scenarios would decrease the number of passengers on the SA Rail Link to some extent (7,800 in Scenario A, 9,700 in Scenario B and 5,400 in Scenario C). Therefore, Scenario C is the best of the three in terms of passenger volumes (highest volume of passengers and lowest impact on the SA Rail Link). However, there are difficulties with Scenario C in terms of the route alignment and integration of the three Lat Krabang Stations (SA Rail Link, Red Line and Sky Train Extension). Considering the urban structure and development strategy for the sub-center, Scenario B is considered to be the most recommendable.

The figure below illustrates the section loading for Scenario B. The line will have about 70,000 passengers near Onnut Station, and about 25,000 between the ORR and the sub-center.

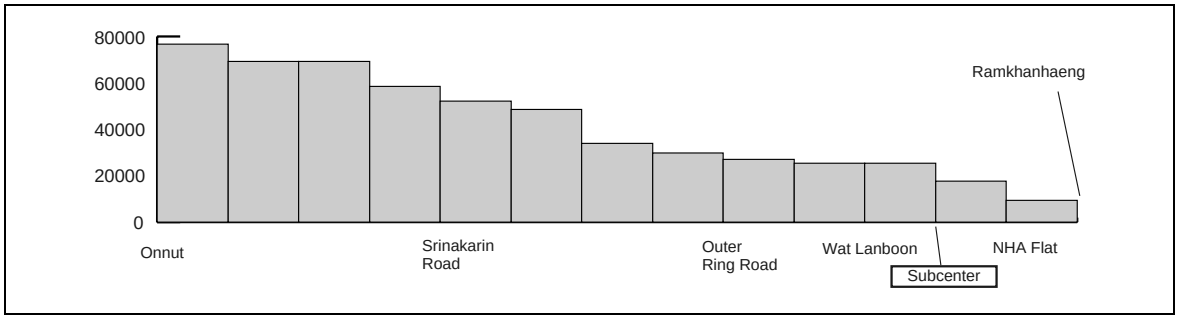


Figure 5.5: Section Loading (both directions) Forecast (Scenario B)

Passengers boarding and alighting at the station in the sub-center is estimated at 12,000 per day, while the estimate is 2,000 per day at the station near Wat Lanboon. Daily boarding and alighting at stations is illustrated in the figure below.

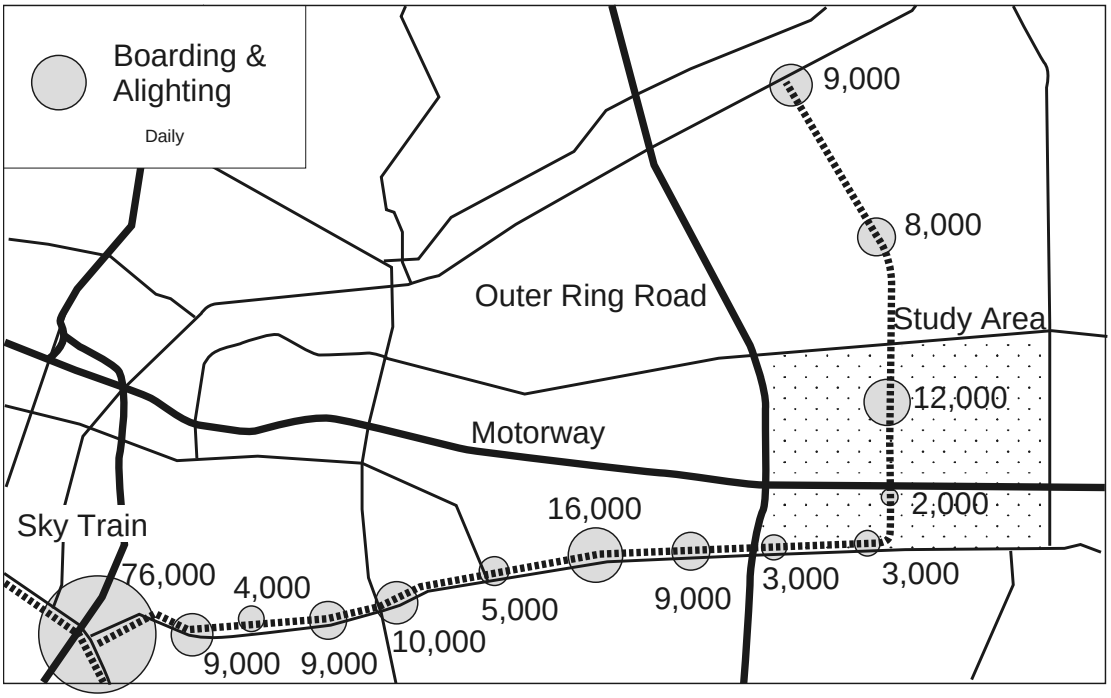


Figure 5.6: Forecast of Passenger Volumes for the BTS Extension (Scenario B, 2022)

(4) Ultimate Transportation Demand

The BECM has neither the socio-economic framework nor the transportation network for the year 2035, which is the target year for the sub-center development. Therefore, further analysis for the period after 2022 is difficult because it will involve vague assumptions and uncertainties. However, estimating the volume of passengers generated by the Lat Krabang Sub-center is possible because the socio-economic framework and land uses are clearly set out.

As the sub-center includes a commercial area, the traffic will be heavier in the evening peak than in the morning peak. The ultimate passenger volumes generated by the sub-center are estimated at 95,000 person trips during the evening peak hour in the northern area, and external trips (trips that cross the boundary of the area) are estimated at 19,900 PCU (8,700 entering and 11,200 exiting). This means that at least 12 lanes should be provided for exiting the area if all of the intersections are at-grade. Therefore, if 4-lane arterial roads are constructed in the sub-center, more than six intersections with adjacent roads would be required at a minimum. Alternatively, 6-lane roads would be required. These requirements are based on the case where no mass transit system is introduced.

5.2.2 Planning of the Transportation Network

(1) Functional Linkage of the Lat Krabang Sub-center

The sub-center will have strong links to central Bangkok because the sub-center will function as not only as a residential area for those who commute to central Bangkok, but also as an office and business area where people commute to from central Bangkok. In addition, the sub-center provides a commercial core for residents to the east of the Outer Ring Road. This kind of functional relationship defines the basic function of the transportation system. The major functional linkage is summarized in following table.

Table 5.3: Major Functional Linkage of the Lat Krabang Sub-center

Major function	Major Linkage (from/to)	Desirable Transportation Mode
A residential area for workers from Central Bangkok	Central Bangkok	- Expressway in radial direction (motorway) - Commuter train
An office area	Central Bangkok and surrounding areas (north & south)	- Expressway in radial direction (motorway) - Expressway in the form of a ring road (ORR) - Commuter train
The regional center of the eastern area of Bangkok	Minburi, Latkrabang (east), Chachoengsao	- North- south arterial road - East-west arterial road - Intermediate Capacity Transit - Bus network
A commercial core in the region	Minburi, Latkrabang (east), Chachoengsao	- North- south arterial road - East-west arterial road - Intermediate Capacity Transit - Bus network
A residential area for people who work in the SBIA	SBIA	- East-west road in the sub-center - Shuttle bus
An airport related industrial area	SBIA	- East-west road in the sub-center - Shuttle bus
Tourism attraction (cultural town)	SBIA	- East-west road in the sub-center - Shuttle bus - SA Rail Link

The future road network (under the committed project) will provide the major connections to these linkages. However, the transportation demand analysis implies the necessity for additional roading projects and some modifications to the committed plan. Furthermore, the development of sub-center requires additional investments in the transit system.

(2) Road Network Plan around the Lat Krabang Sub-center

The SADP determines the future road network projects around the sub-center. As the projects have been approved by the Cabinet, the sub-center development should follow the plan. However, the modification of some of the projects is proposed in order to improve the development of the Lat Krabang Sub-center, as follows:

1) Realignment of the A5 is required in order to fit with the ongoing Krung Thep Kritha – Rom Klao Road.

2) Realignment of the A4 (Ram Kham Haeng Road – A12) is necessary because the proposed road runs through a high density residential area where land acquisition will be very difficult.

3) The A3 should be extended up to Onnut Road and should be connected to the A12, so that it can form a north-south access between the Outer Ring Road and Rom Klao Road.

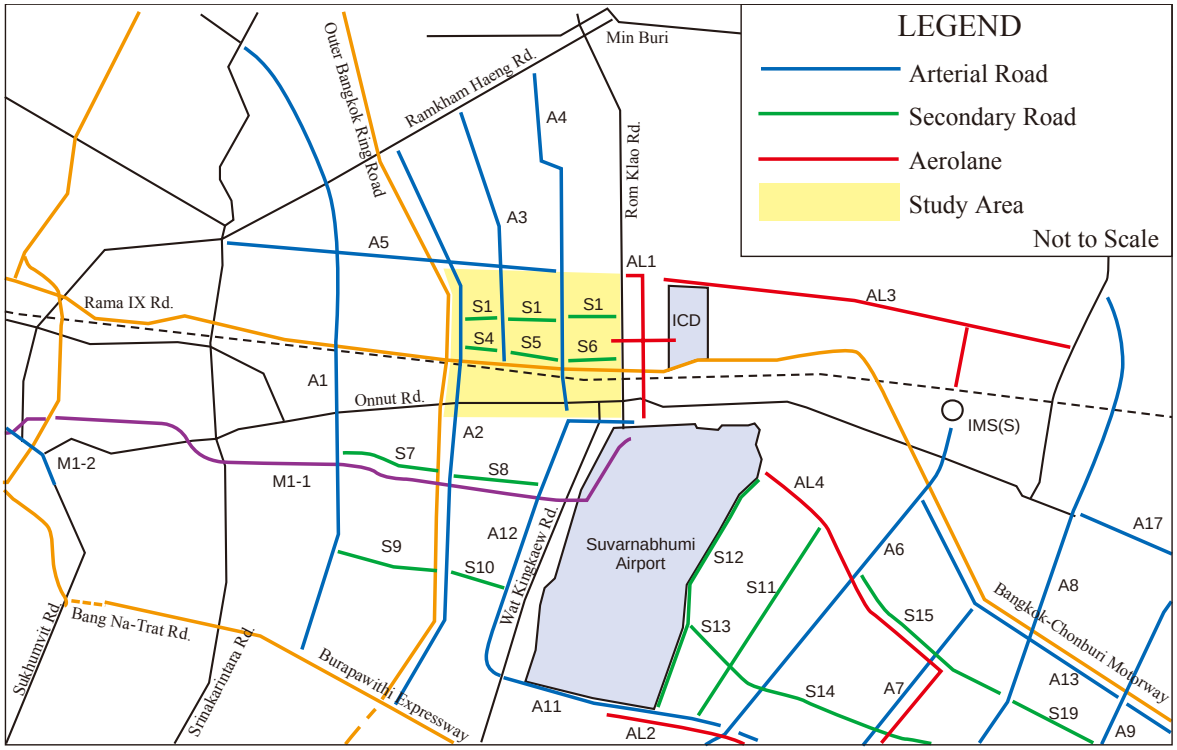


Figure 5.7: Road Network Plan in the SADP

As has been stated in the transport demand analysis, the north-south road is expected to play an important role in diverting heavy traffic from Rom Klao Road. The other requirements for the road projects for the sub-center development are:

1) The sub-center needs access from Krung Thep Kritha to Rom Klao Road in order to divert the traffic concentrated at the Rom Klao IC.

2) The main carriageways of the Krung Thep Kritha to Rom Klao Road and the OBRR should be directly connected.

The major road network is proposed as shown in the figure on the next page and is based on the following policies:

1) The major road network shall conform to the SADP as much as possible;

2) The area to the north of the Motorway and Onnut Road shall be directly connected by major roads to provide alternative access to the sub-center;

3) Routes shall be set so as to minimize negative social impacts, such as resettlement and dividing of local communities; and

4) Intersection/junction points shall set to ensure smooth traffic flow.

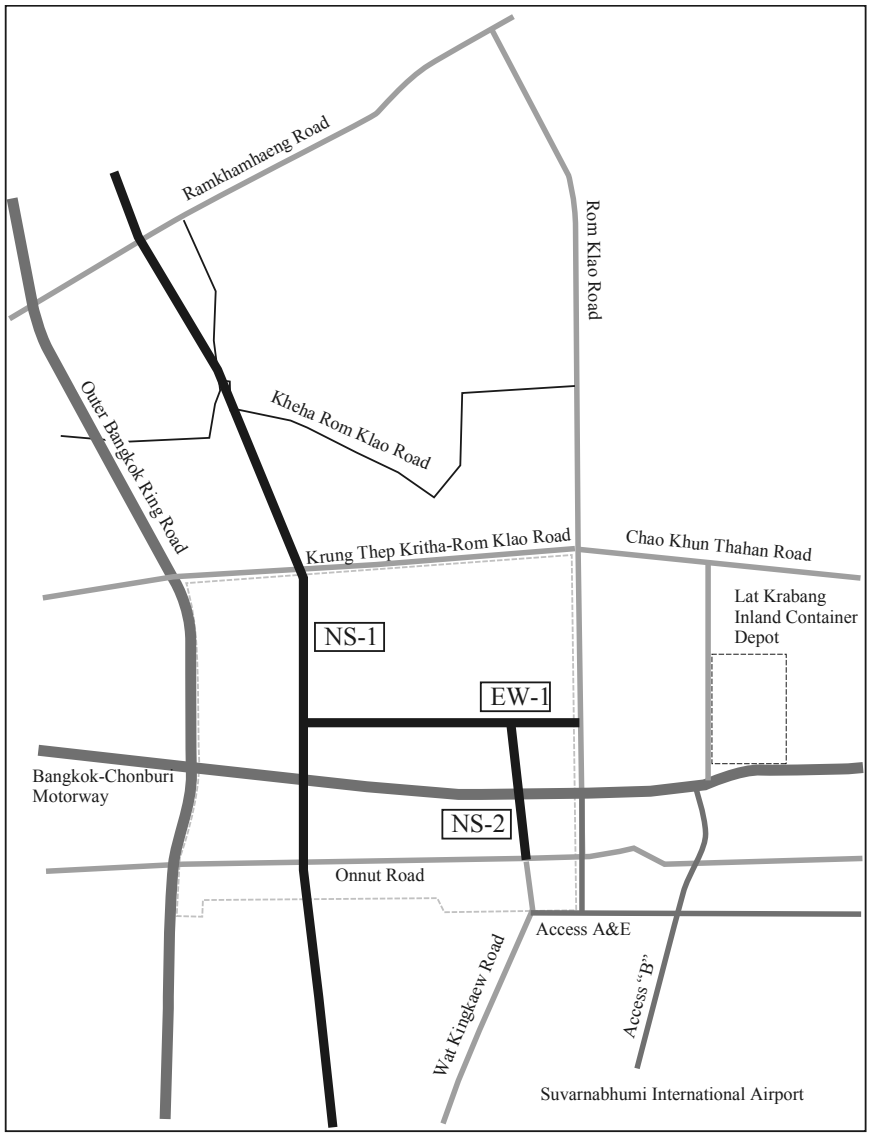


Figure 5.8: Major Road Network

5.2.3 Planning of Public Transport

(1) Access to Mass Transit System

The Lat Krabang Sub-center will have a population of 168,000 and 100,000 workers in an area of about 1,900 ha in its ultimate stage. This will generate commuter and business traffic between the sub-center and central Bangkok. The transportation demand analysis indicates the necessity for a mass transit system to support the traffic demand, but also implies that the number of passengers may not be sufficient in terms of financial viability. Due to this situation, the following three alternatives have been analyzed:

(A) Medium Transit System

(B) Feeder Transit System from SRT lines

(C) Express Bus

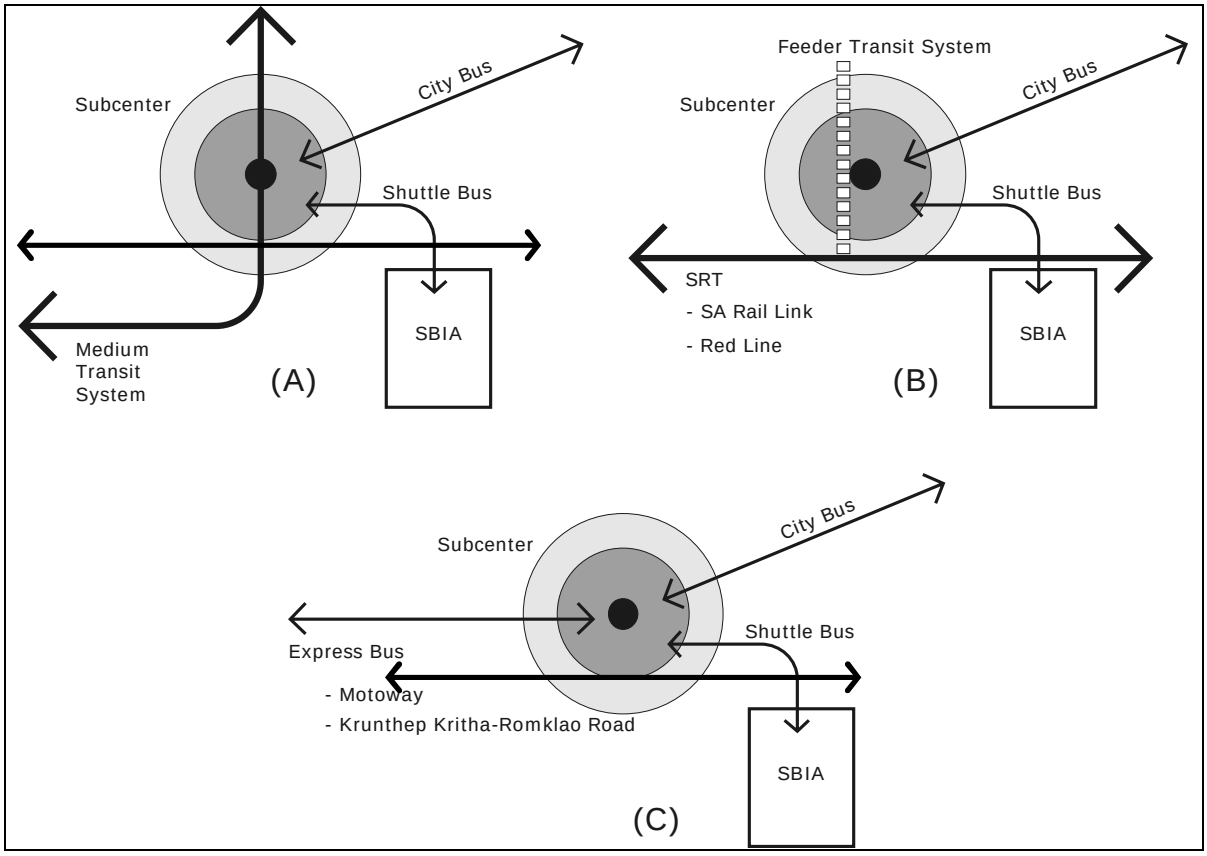


Figure 5.9: Access to Mass Transit

Medium Transit System: The Medium Transit System is a transit system with intermediary features between bus and heavy rail such as:

1) Capacity: larger than bus, lower than heavy rail;
2) Distance between stops: longer than bus, shorter than heavy rail;
3) Initial investment: larger than bus, smaller than heavy rail;
4) Frequency and reliability: same as heavy rail;
5) Speed: faster than bus, slower than heavy rail.

Currently, a study is in progress on the introduction of a segregated bus lane including elevated sections along Onnut Road. Although the segregated bus lane would increase the capacity of the public transport system, it might not be enough to meet the estimated traffic demand. Instead of the bus lanes, the introduction of a Medium Transit System along Onnut Road is desirable for the sub-center. Examples of a Medium Transit System are a Monorail and an Automated Guideway Transit system.

Feeder Transit System: The introduction of a Feeder Transit System is a rational decision because a Feeder Transit System could make full use of the SRT line. There are two stations

for the intermodal connection of the mass transit and Feeder Transit Systems: Lat Krabang Station and Wat Lanboon Station. The Feeder Transit System would require elevated structures to cross over the motorway, however the initial investment cost would be smaller than for the Medium Transit System. The Feeder Transit System would include both Bus and Light Rail Transit (LRT).

Express Bus: Express buses using the motorway and Krungthep Kritha-Romklao Road could transport the estimated number of commuters if exclusive lanes are provided. This would reduce the available traffic capacity on these two roads and increase traffic on other access roads.

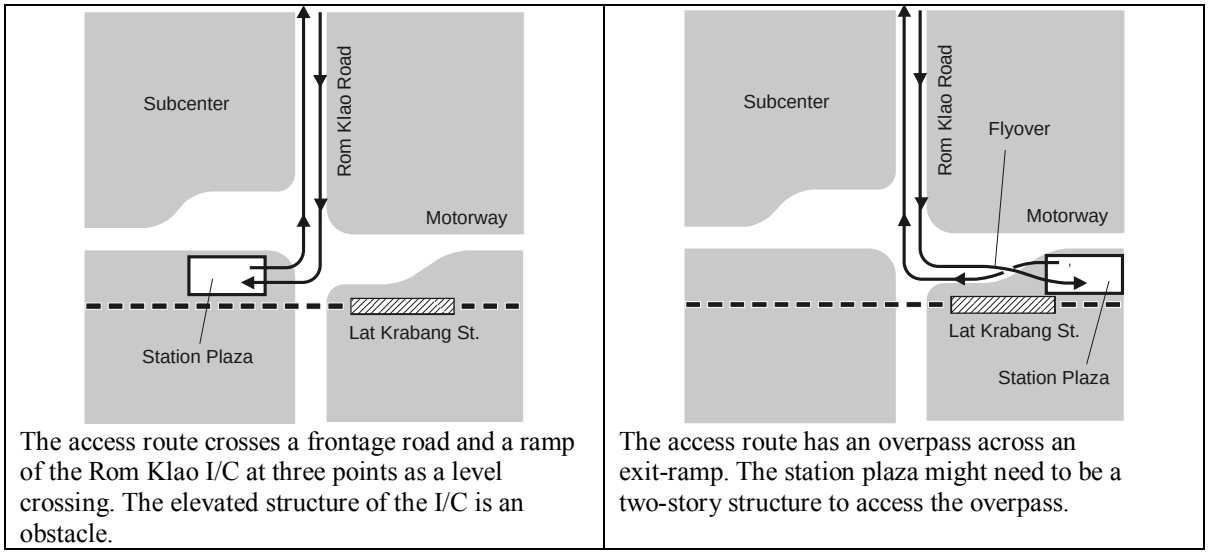
The volume of traffic on the roads will be too heavy to dedicate some lanes to express buses. At present, Wat Lanboon Street is not included in the future plan of the Red Line, so a feeder transit system from the station is an issue for the future. The Medium Transit System is a revised version of the Sky Train Extension and will attract investors and increase land values. **Therefore, the introduction of the Medium Transit System is recommended.**

(2) Intermodal Transit Facilities at Lat Krabang Station

The land development of the sub-center will start before the introduction of the Medium Transit System, while the SA Rail Link will soon start operating with Lat Krabang Station on the City Line. The passenger demand is forecasted to be 39,700 boarding in 2022. Lat Krabang Station is very near to the sub-center and could provide access to the sub-center before the Medium Transit System commences operation if an adequate feeder transit system is provided with Intermodal Transit Facilities (ITF), or "Station Plaza".

However, accessibility to Lat Krabang Station is poor and the space for an ITF is very limited; the area necessary for the Station Plaza for Lat Krabang Station is calculated to be 7,000 square meters. It has been proposed that the location of Lat Krabang Station should be moved to the west of Rom Klao Road where vacant land is available for a Station Plaza, however the SA Rail Link project has already started under its original plan. Therefore, it will be necessary to provide access from the station (to be located to the east of Rom Klao Road) to the sub-center. Considering Rom Klao Road is a major access route, several measures have been analyzed as follows.

Direct Access: If the station plaza is located in the east, an over pass would be required over the ramp. If the station plaza is located in the west, direct access would be very difficult because of elevated structures and the level crossing. These plans would prevent traffic flow on ramps between Rom Klao Road and the motorway.

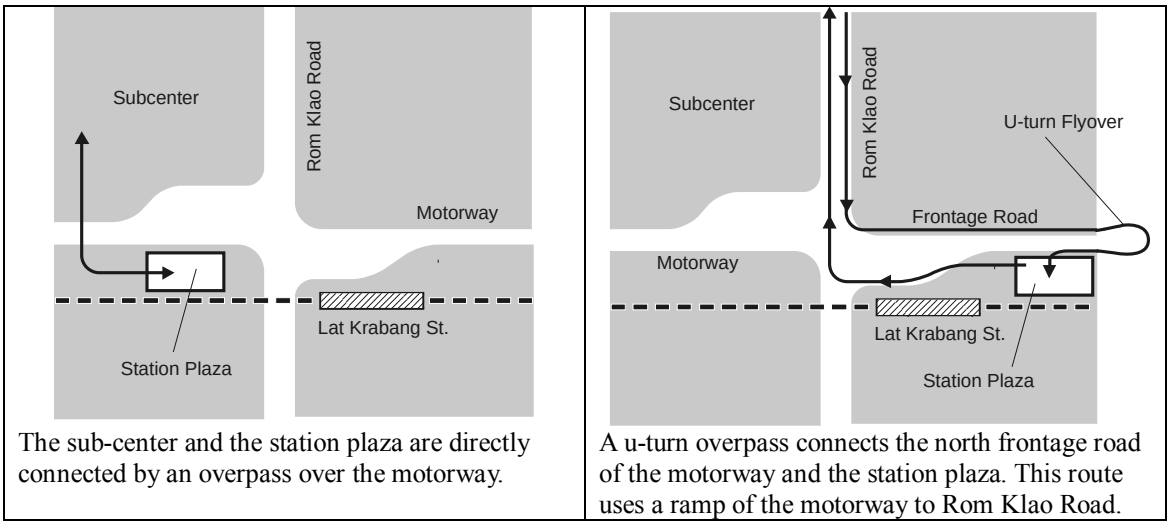


The access route crosses a frontage road and a ramp of the Rom Klao I/C at three points as a level crossing. The elevated structure of the I/C is an obstacle.

The access route has an overpass across an exit-ramp. The station plaza might need to be a two-story structure to access the overpass.

Figure 5.10: Direct Access from Rom Klao Road to Lat Krabang Station

Motorway Overpass: If the station plaza is located in the east, a u-turn overpass would enable access by a frontage road. If the station plaza is in the west, an overpass could directly connect the station plaza and the sub-center. At present, this plan (motorway overpass, western station plaza) concurs with the proposed land use plan for the Lat Krabang Sub-center.

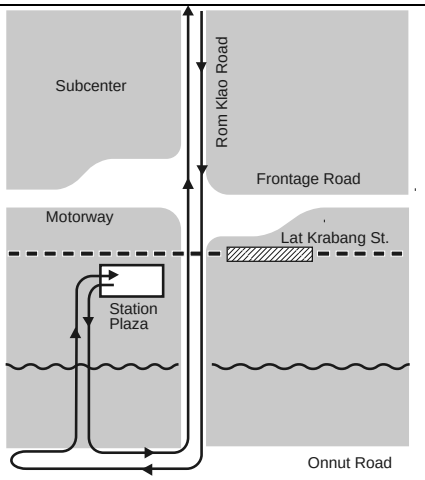


The sub-center and the station plaza are directly connected by an overpass over the motorway.

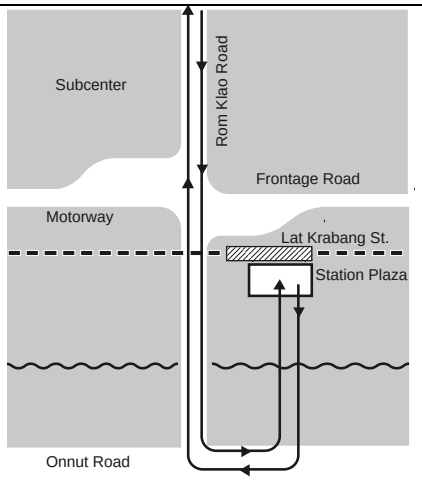
A u-turn overpass connects the north frontage road of the motorway and the station plaza. This route uses a ramp of the motorway to Rom Klao Road.

Figure 5.11: Access by Motorway Overpass

Onnut Access: The station plaza is located to the south of railway. The access routes use Onnut Road and a new road over a canal. If the station plaza is located in the east, land acquisition and resettlement is required.



The access route requires the construction of a new access road from Onnut Road to the station plaza. The station plaza should be in the south.



The access route requires the construction of a new access road from Onnut Road to the station plaza. The station plaza requires land acquisition in a residential area.

Figure 5.12: Access to Lat Krabang Station from Onnut Road

The evaluation of these alternatives is summarized as follows:

Table 5.4: Evaluation of Access Route to Lat Krabang Station (Rank)

	Location of ITF	Civil Work	Cost	Resettlement	Intermodal Transfer *1	Traffic Impact	Property Develop.*2	Total
Direct Access	West	6	6	1	4	6	3	6
	East	5	5	1	2	5	4	5
Motorway Overpass	West	1	3	4	4	1	2	1
	East	1	4	1	2	4	4	2
Onnut Access	West	1	1	4	6	3	1	2
	East	1	2	6	1	2	4	2

*1: A pedestrian deck would be constructed over Rom Klao Road, and passengers would walk over the deck between the station plaza and the station in the case of the "West" location.
*2: Property development is difficult in the case of the "East" location because of the BMA's land use policy

As a whole, the motorway overpass combined with the west station plaza is the best way to provide access to Lat Krabang Station. However, there still remain other options for the station plaza and access route, excluding the option of Direct Access. There is a high potential for land development near the station to the west of Rom Klao Road, with large empty lots. **Therefore, it is proposed to construct the station plaza to the west of Rom Klao Road with the urban development.**

5.2.4 Planning of Roads

(1) Principal Issues in the Planning of Roads

1) Classification of Roads

In this report, road networks are classified into the following two categories.

Major road network: This category includes roads which form a part of regional arterial roads, and secondary roads. Internal principle roads, which provide the main access to the regional arterial roads, are also included in this category. A right of way (ROW) width of 60 meters for regional arterial roads, and 45 meters for internal principle roads is considered to be applied.

Supplemental road network: This category includes all internal roads that supplement the above major road network. This includes internal secondary roads that connect the major roads, and feeder roads for access to communities.

Road cross-section: The cross-sections of the primary and secondary roads that will form the principal road network in the study area are planned to include a median strip and stopping lanes which will provide the right of way for the railway system in the ultimate stage of the sub-center development. Typical cross-sections of the primary and secondary roads are proposed as shown in the figures below.

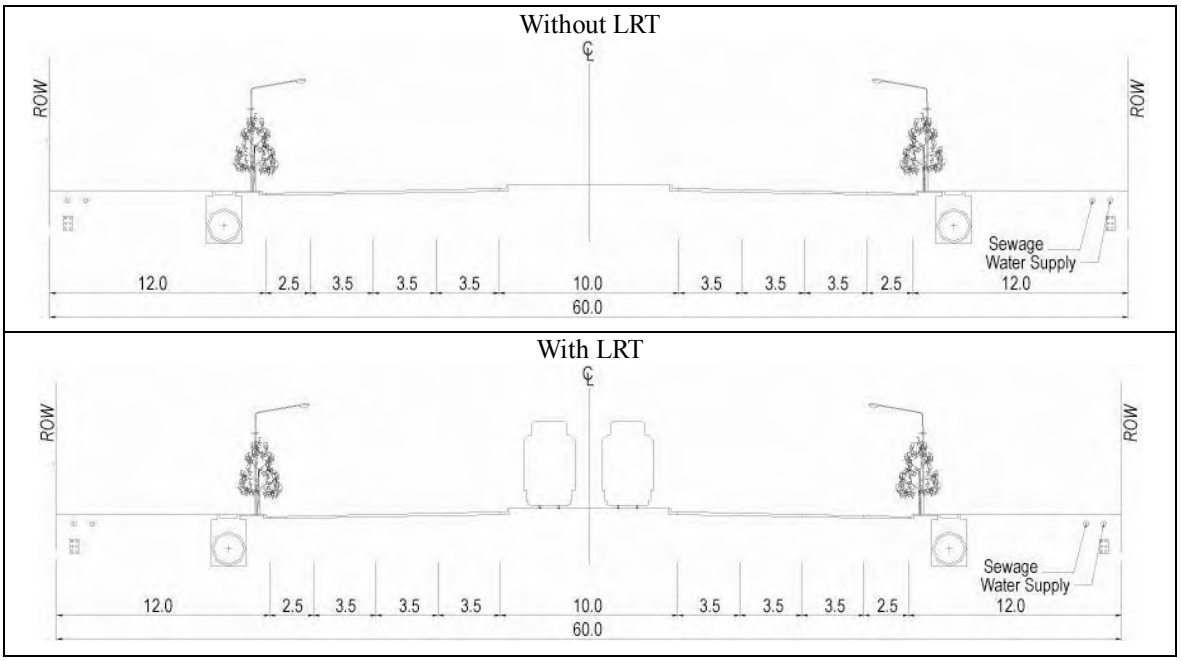


Figure 5.13: Typical Cross-section of a Primary Road (Type A: ROW = 60m)

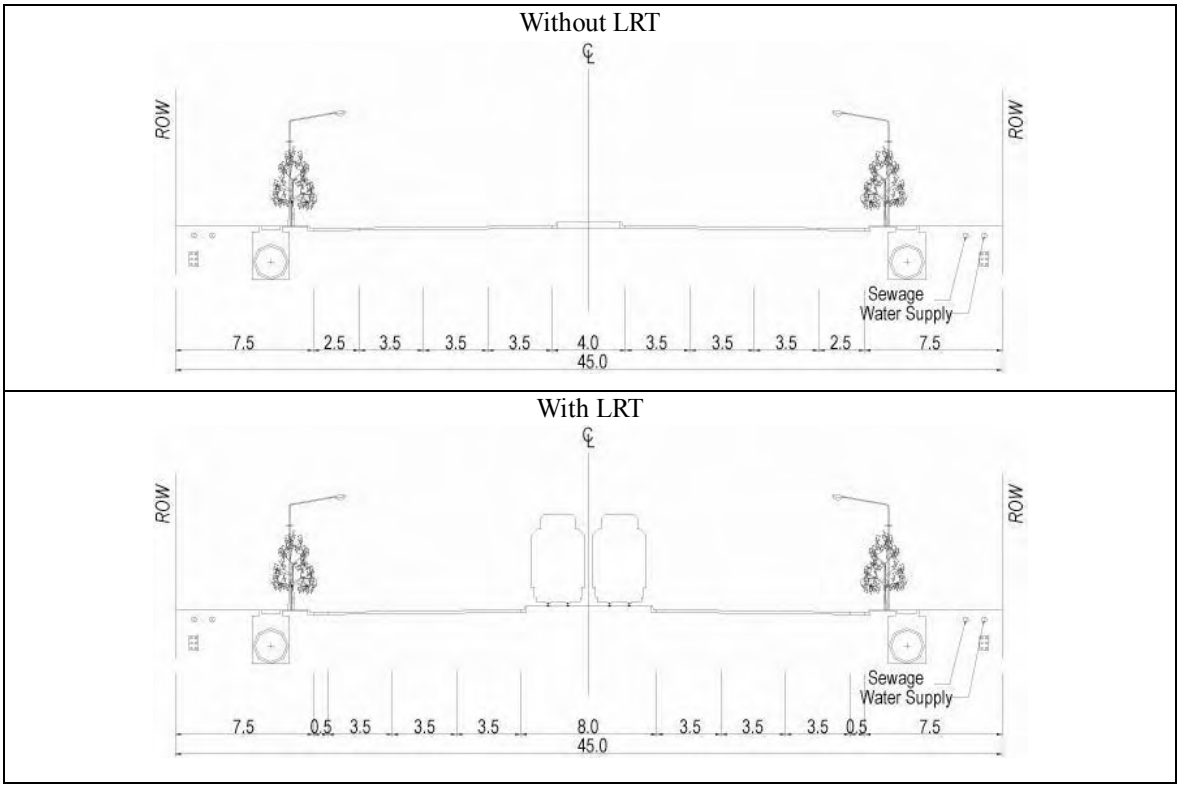


Figure 5.14: Typical Cross-section of a Primary Road (Type B: ROW = 45m)

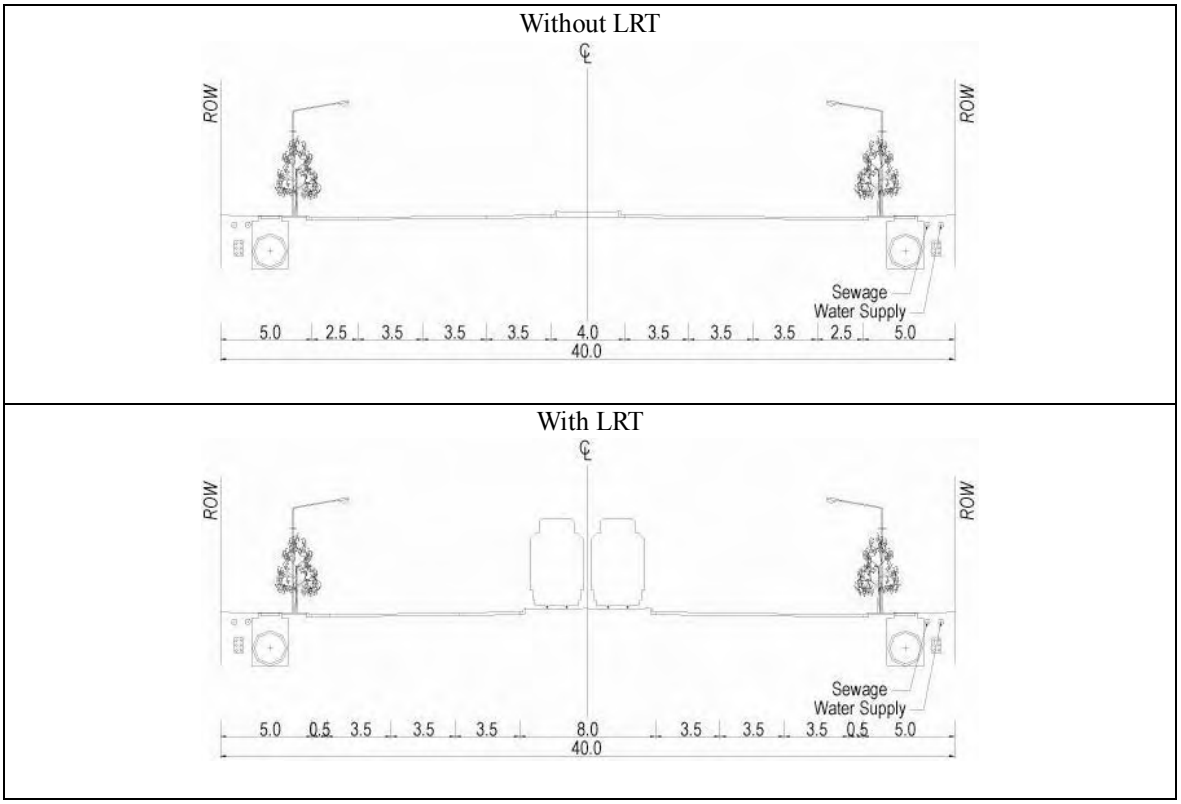


Figure 5.15: Typical Cross-section of a Primary Road (Type C: ROW = 40m)

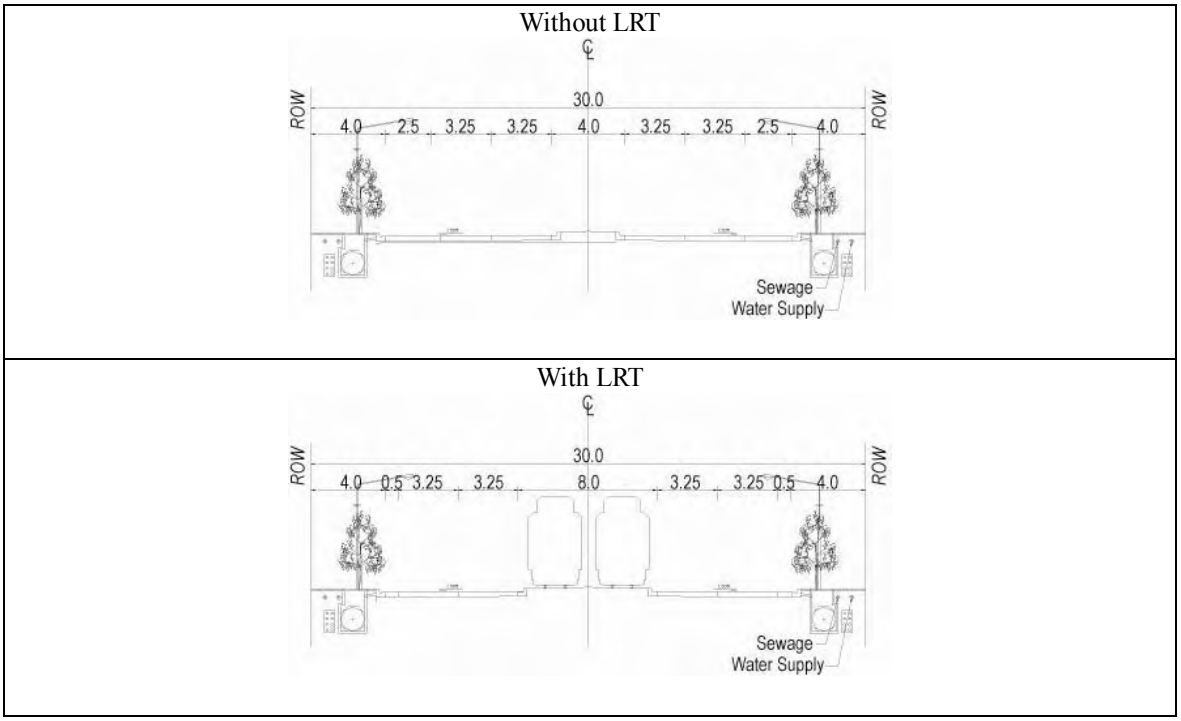


Figure 5.16: Typical Cross-section of a Secondary Road (D: ROW = 30m)

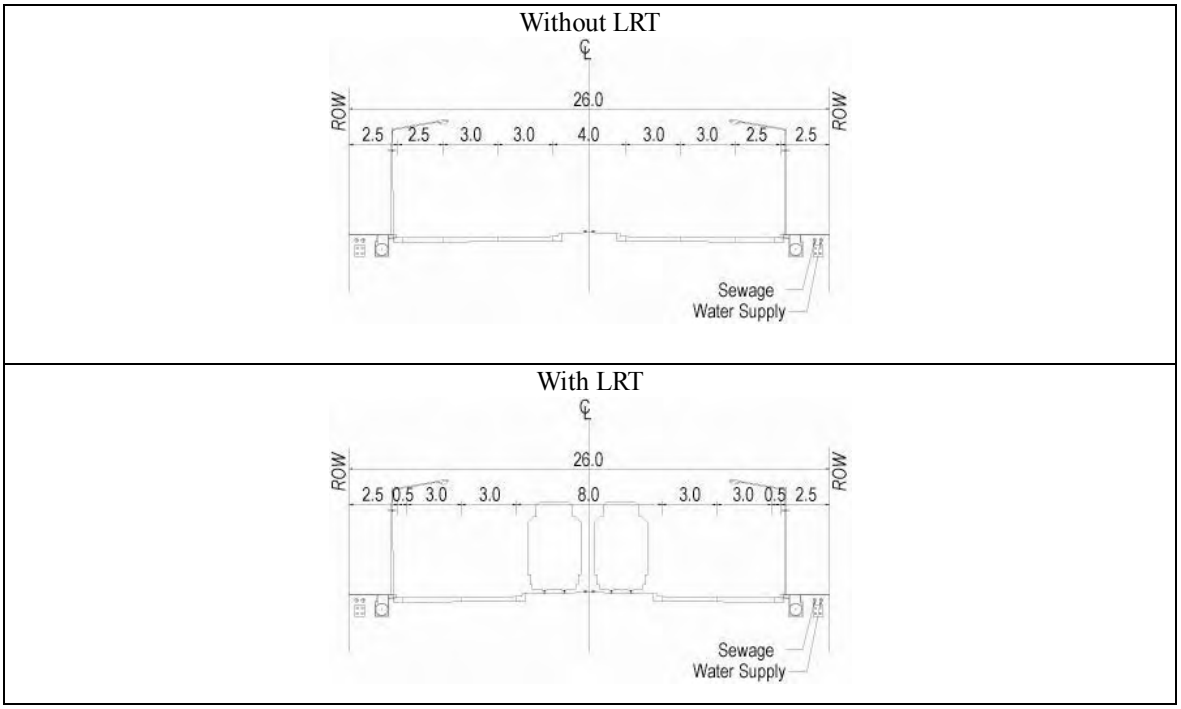


Figure 5.17: Typical Cross-section of a Secondary Road (Type E: ROW = 26m)

2) Major Road Network

Basic policies

- The route of the major roads that form a part of the regional arterial road network shall be set so that they agree with the routes proposed in the

Suvarnabhumi Aerotropolis Development Plan (SADP) and the BMA Comprehensive Plan-2 (BCP2).

- Routes shall be set so as to minimize negative social impacts such as resettlement and separation of local communities.
- Intersection/junction points shall be set so as to maintain the smooth flow of traffic.
- Maintain the necessary horizontal distance from canals in order to ensure stability of the soft ground.

Specific considerations for individual roads

NS-1 Road: This road is a principal regional road connecting Onnut Road and Ram Indra Road and runs parallel to the OBRR and Romklao Road. Specific considerations are as follows.

- Section between BMA Krungthep Kretha-Romklao Road and Sukhapiban2 Road: The availability of vacant land for the construction of a new road is very limited in this built-up area. The only land available for the construction of the new road is the land along the proposed route as shown in the figure. Therefore, the route will be fixed as shown in the figure.
- Connection to Onnut Road: As this area is densely built-up and the local community area is to be preserved, access points to Onnut Road are limited to two locations on either sides of the preserved community area. Considering this condition, the access point on the west side of the community area was selected.
  The road alignment for the NS-1 Road is almost the same as the route of the A3 road proposed in the SADP. The SADP also proposed another north-south road (A4 road) in parallel to Romklao Road. It will be impossible to build this road due to the limited land available. As the BCP2 proposed only one new north-south road in this area, BCP2's proposal can be satisfied by the construction of the NS-1 Road.

NS-2 Road: This road should provide the following functions.

- Access to Onnut Road from the project area.
- A major access route to Lat Krabang railway station for the new Airport Rail Link Line.

Considering the limited land available along Onnut Road, vacant land on the east side of the community area is considered to be a possible site for construction of the new road. The road shall be aligned along the east side of Klong Song to the south of the BCH and then swing around to run along the west side of Klong Song to the north of the BCH. This alignment will minimize negative social impacts (resettlement problems).

EW-1 Road: This road is a major internal east-west secondary road connecting two north-south arterial roads; Romkalo Road (existing) and NS-1 Road (proposed). The

route of the road depends on the location of the junction with Romklao Road and was selected based on the following conditions.

- To have sufficient open space for the construction of ramps for the new junction (a grade separated junction shall be applied).
- To have a sufficient distance from the Romklao Interchange of the BCH to maintain smooth traffic flow under merging traffic.

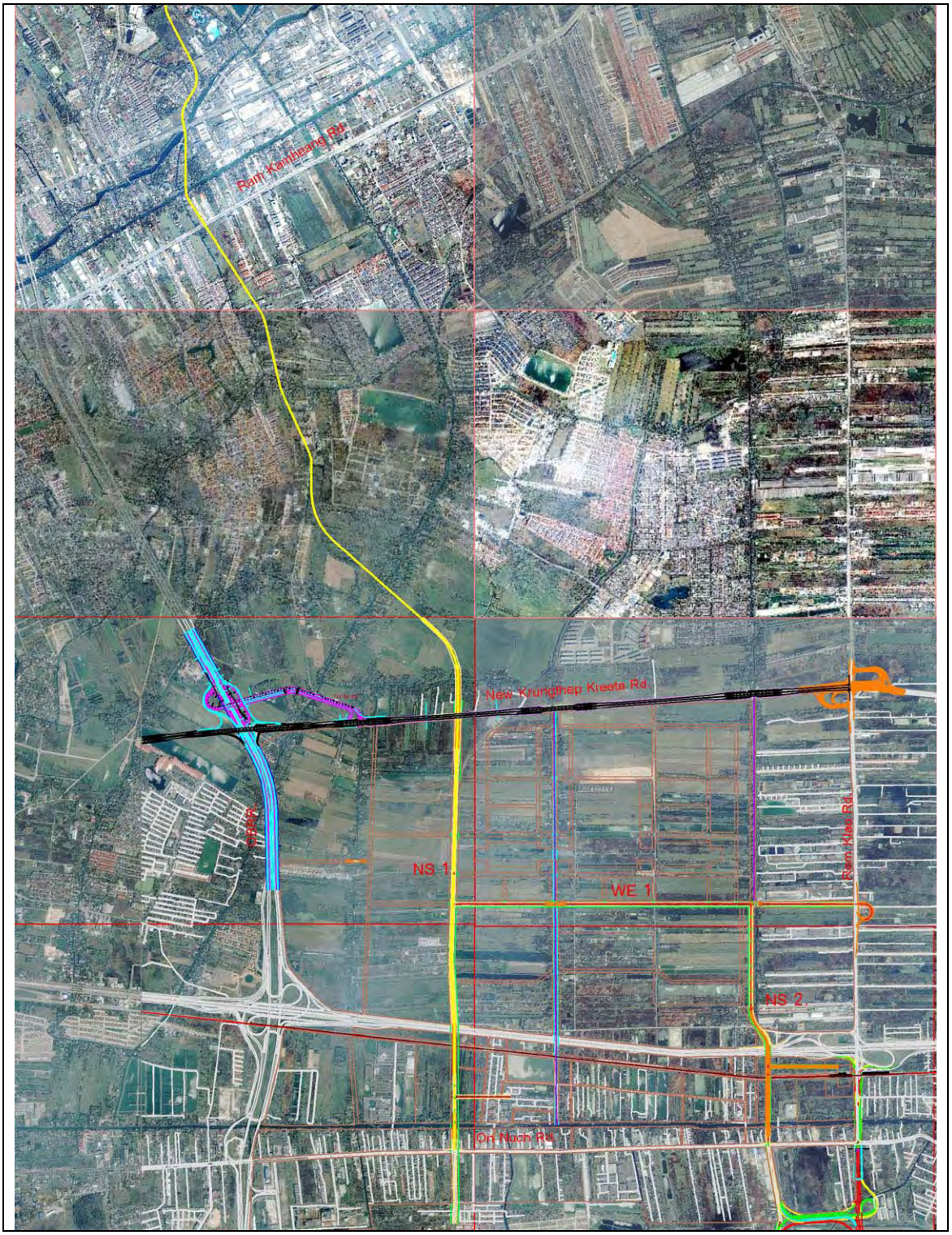


Figure 5.18: Major Road Network

3) Road Network in the Study Area

The road network in the study area shall be formed from primary roads (NS1, NS2, and EW1) and secondary roads, as shown in the figure below.

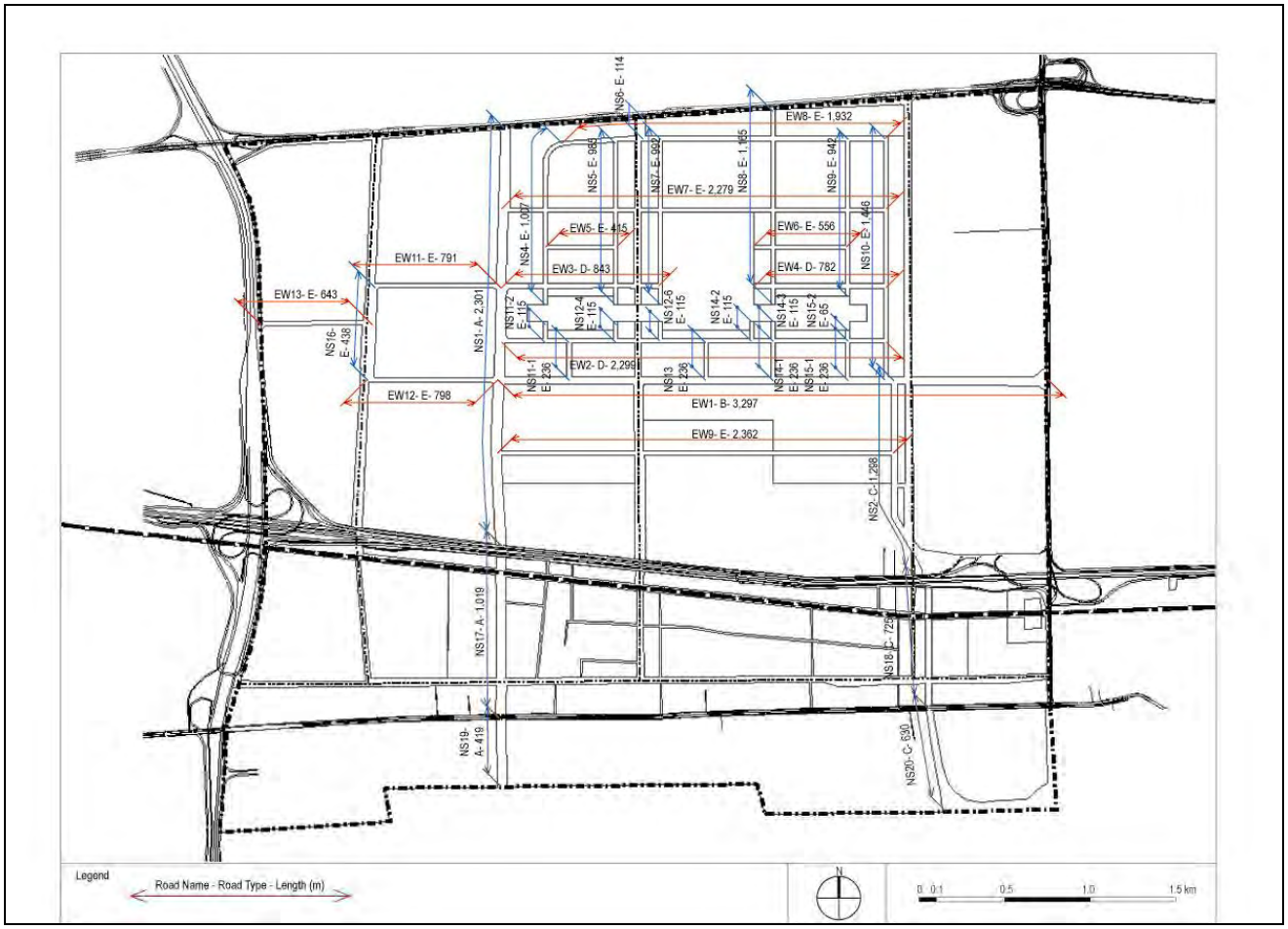


Figure 5.19: Road Network in the Study Area

5.2.5 New Interchange Linking with the OBRR

Under present conditions, there are two linkages between the OBRR and the BCH; Onnut interchange and Romklao interchange. The location of the Onnut interchange is the southernmost part of the project area, and therefore this interchange does not provide direct access from the motorway to the core sub-center area. While the Romklao interchange is located on the west side of the core sub-center area, it is crowded with traffic from Romklao Road and the ICD. Hence the construction of an additional linkage from the motorway to the sub-center core area is highly recommended. Considering the physical conditions in the project area, the most suitable location for the new interchange would be at the intersection of the OBRR and Krungthep Kretha-Romklao Road (under construction).

The design of the new interchange linking to the OBRR must meet the following requirements of the DOH.

1) A direct connection between the main carriageway and the frontage road is not allowed.

2) The frontage road should be maintained in a condition suitable for local traffic. Minor adjustments to the alignment are permitted in order to accommodate the new interchange.

3) A toll plaza for a closed toll system (in the future) should be considered.

4) The geometric design of the interchange must meet the DOH's major design criteria (as shown in the table).

After considering the local site conditions together with the requirements of the DOH, a trumpet-type interchange is recommended for the following reasons.

1) On Krungthep Kretha-Romklao Road, there are two u-turns (underneath the bridges crossing the canals) provided within a short distance of the interchange entrance. Hence the interchange would provide smooth access in all directions from both the OBRR and Krungthep Kretha-Romklao Road.

2) There is vacant land available on both sides of the OBRR for construction of the loop ramp.

3) There is one location for the toll plaza that could handle traffic from all directions, thus providing the most convenience in terms of operation.

Table 5.5: DOH Major Design Criteria for Interchanges

Design Element	Unit	Desirable Standard	Minimum Standard
Design Speed – Loop Ramp	kph	60	40
Design Speed – Directional Ramp	kph	90	70
Minimum Horizontal Radius – Loop Ramp	m	130	50
Minimum Horizontal Radius – Directional Ramp	m	335	155
Maximum Gradient (down) – Loop Ramp	%	5	7
Maximum Gradient (down) – Directional Ramp	%	4	6
Maximum Gradient (down) – Loop Ramp	%	4	6
Maximum Gradient (down) – Directional Ramp	%	3	5
Maximum Gradient – Flyover	%	3	5

Figure 5.20: Proposed New Interchange linking the OBRR and Krungthep Kretha-Romklao Rd.

5.2.6 Soft Ground Treatment

The Bangkok clay formation consists of soft marine clay deposits overlying medium marine clay deposits. These two layers are approximately 18-20 m thick and are highly compressible. The construction of roads under these ground conditions leads to concerns relating to ground stability and settlement. In addition, there is land subsidence at a rate of 2-5 cm per year due to the drawdown of the groundwater level in the Bangkok area.

Many soft ground treatment methods have been applied to road and airfield projects in the area such as Perforated Vertical Drains (PVD), soil-cement deep mixing (Cement Column) and bearing units on pile foundations. These methods have been found to effectively mitigate or solve the soft ground problems, however they are considered to be very costly measures.

At present, the BMA's principles on countermeasures against soft ground in the construction of roads are as follows:

1) To avoid high cost treatment methods such as bearing units, PVD and cement columns;

2) To maintain low embankment heights (less than 1.5 meters);

3) To apply the preloading method to accelerate settlement and improve stability;

4) To apply asphalt (flexible pavement) as a first stage pavement on the premise that concrete pavement (rigid pavement) will be provided after the first stage flexible pavement has been seriously damaged;

5) Instead of installing bearing units, to extend bridge structures to where embankment heights are less than 0.5 m.

The BMA's countermeasures are considered to be inexpensive and have been found to be effective for roads at low, medium, or even high traffic levels. Therefore the BMA's design principles are adopted for the construction of roads in the study area.

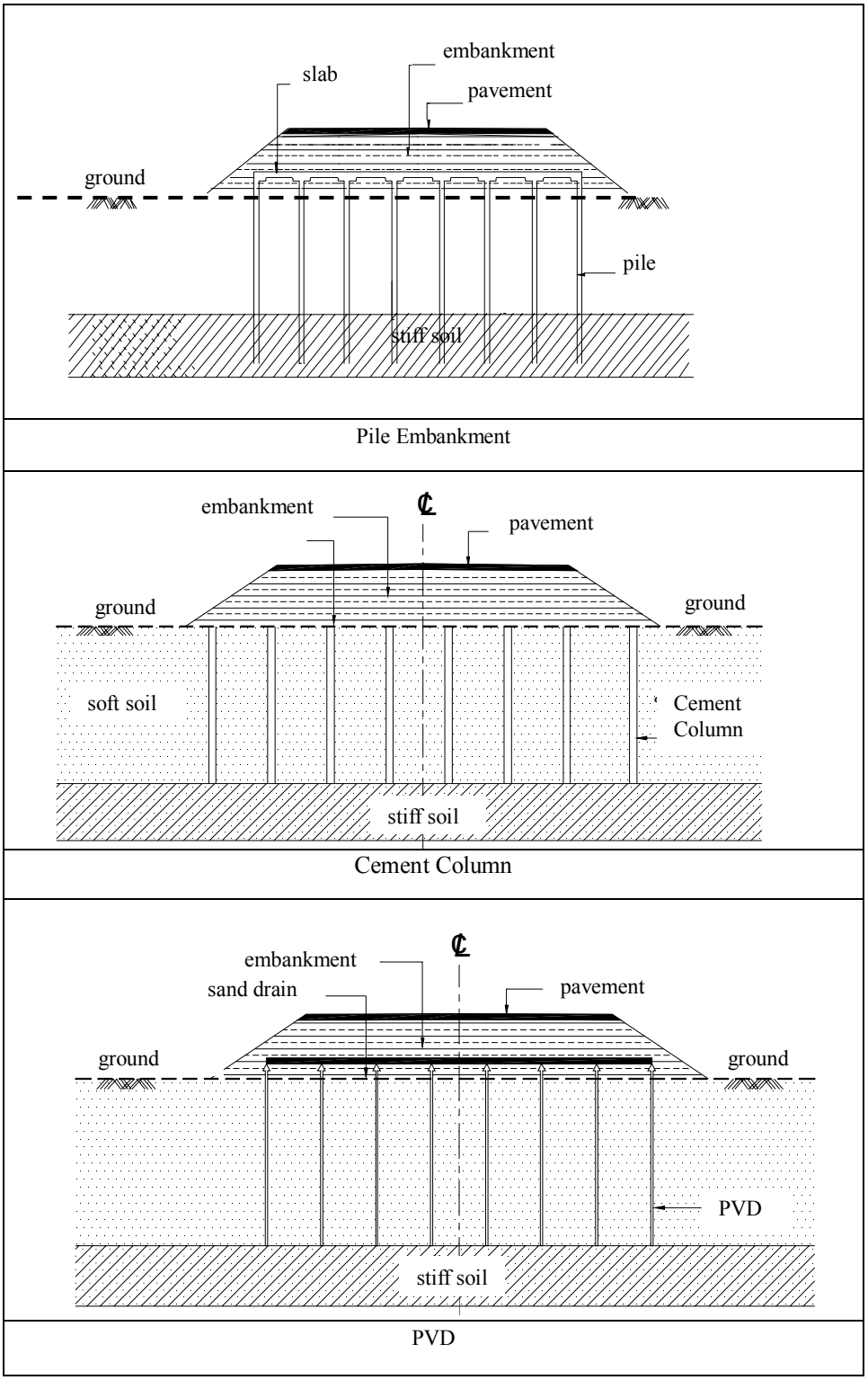
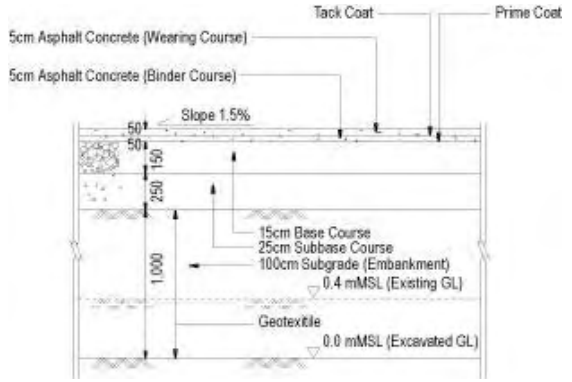


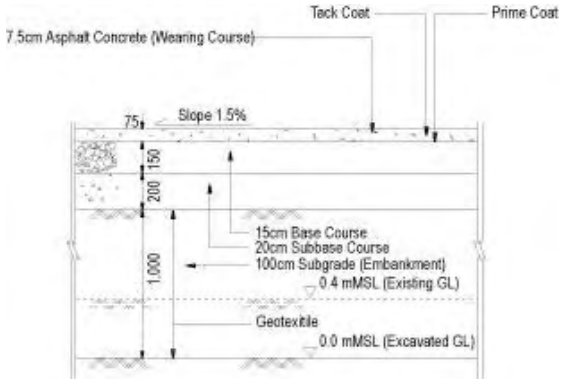
Figure 5.21: Alternatives for Ground Improvement Method

5.2.7 Pavement Design

Based on the BMA's design principles, the preliminary design of typical sections of asphalt concrete pavement (flexible pavement) and concrete pavement (rigid pavement) are illustrated in the figures below. The initial pavement will be a flexible pavement that will be improved to a rigid pavement in the later stages of development. The sub-grade of the initial pavement will be formed by the embankment of borrowed materials to 1.0 m in height over an excavated ground level of 0.0 m MSL. The stability of the embankment will be strengthened by geotextile layers. The thickness of the layer of flexible pavement is designed to accommodate traffic loadings for a period of 15 years.

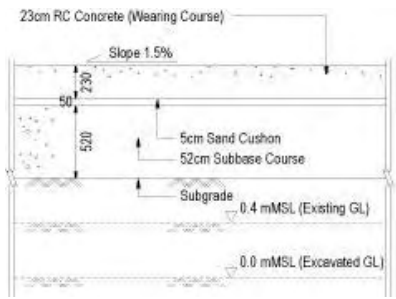


Road Type A, B, and C



Road Type D and E

1. Flexible Pavement for the Initial Stage



2. Rigid Pavement for Future Stages

Figure 5.22: Typical Section of Pavement

5.2.8 Considerations for Bridge Design

The following clearance levels are required for bridges over canals:

1) For small canals, a clearance of 1.50 meters above HWL is required to allow for the passage of small boats.

2) For large canals, a clearance of 3.00 meters above HWL is required to allow for boat transportation and canal dredging.

The routes of the NS-1 and NS-2 roads cross over the Bangkok-Chonburi Highway (BCH) and the SRT line. Therefore, flyover bridges must be constructed over the BCH and the SRT line with the following clearances.

1) For the BCH, the DOH requires 5.0 meters clearance.

2) The SRT plans to operate electrified commuter trains at ground level and therefore requires 6.20 meters clearance above the top of the rail.

Other geometric standards to be considered, such as gradient and radius, are the same as those provided in the highway design criteria.

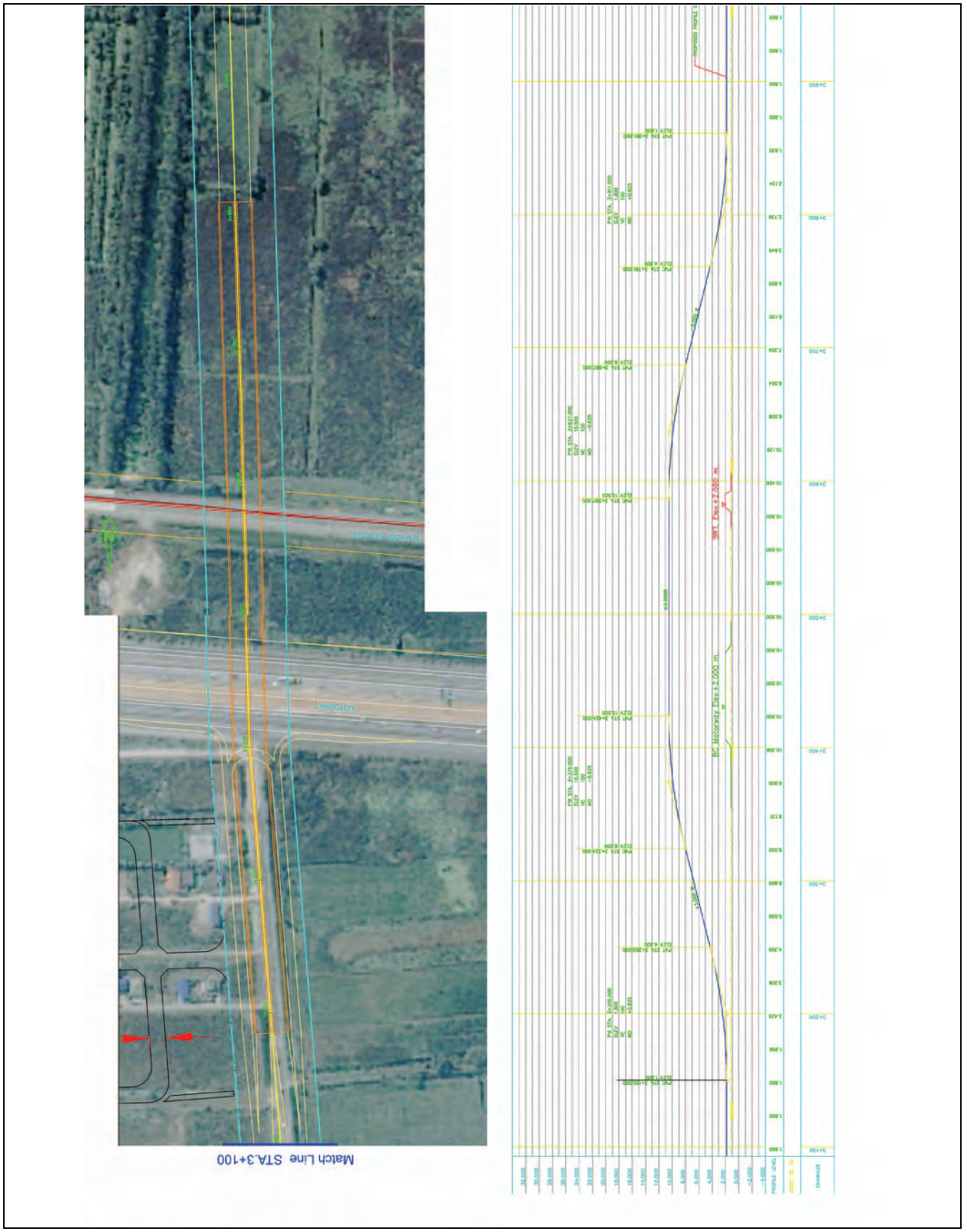


Figure 5.23: Plan and Profile of NS-1

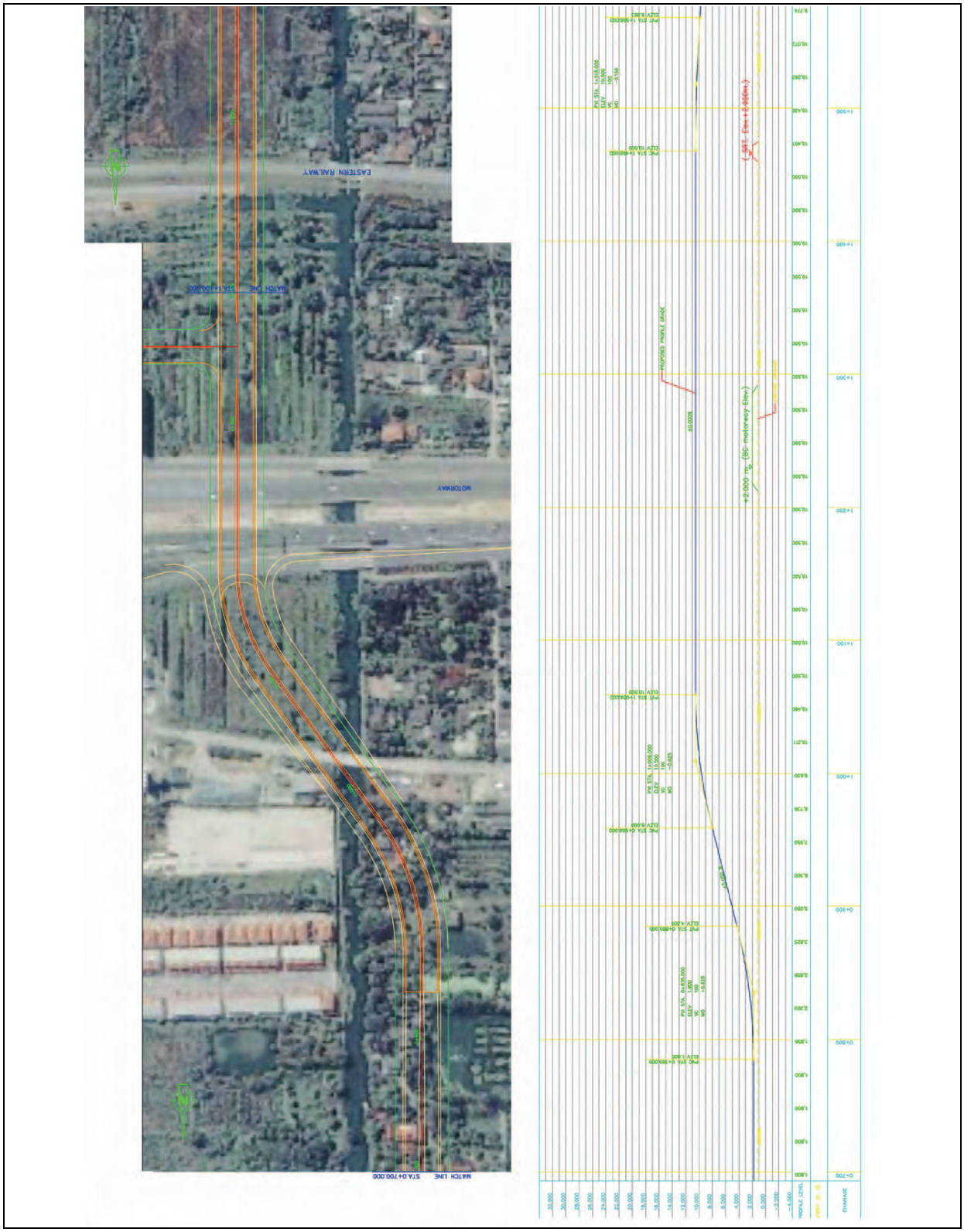


Figure 5.24: Plan and Profile of NS-2